Supply Chain Risk: Changes in Supplier Composition and Vertical Integration

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Using textual analysis of earnings conference calls, we quantify firms' supply chain risk and its sources. Our proxy for supply chain risk exhibits large cross-sectional and time-series variation that aligns with reasonable priors and is unprecedently high during the Covid-19 pandemic. Controlling for the first moment of supply chain shocks, we find that firms that experience an increase in supply chain risk establish relationships with closer and domestic suppliers and with suppliers that are industry leaders. In addition, firms that do not face financial constraints become more likely to engage in vertical mergers and acquisitions.

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Production relies on global and complex supply chains, which have often been optimized to reduce costs. Major events, such as the Sino-American trade war, the Covid-19 pandemic, the Suez Canal accident, or the 2011 Japanese earthquake, tend to disrupt supply chains and production. Existing literature has widely documented that even small negative shocks, such as bankruptcies or natural disasters, are transmitted to firms upstream and downstream (Hertzel, Li, Officer, and Rogers, 2008; Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi, 2012; Barrot and Sauvagnat, 2016; Carvalho, Nirei, Saito, and Tahbaz-Salehi, 2021).

However, even though both the academic literature and recent events highlight that supply chains shocks are an important source of disruption, we know little about whether firms systematically update their investors about the ex ante probability that such shocks may occur and any perceived changes in this source of risk. We are also unable to quantify the effects of supply chain risk on corporate policies. Concerns have been raised that due to the complexity of supply chains, firms are often unaware of the supply chain risks their suppliers are subject to (Choi, Rogers, and Vakil, 2020) and may consequently not be able to manage this source of risk.

Quantification of the supply chain risk faced by different firms and how this varies over time would be important, but it is extremely challenging because supply chain risk comes from many sources and multiple channels. For instance, firms may be indirectly exposed if their suppliers face bottlenecks. Similarly, firms may be exposed through their customers if downstream firms are unable to source complementary inputs and are forced to limit production. Furthermore, commercial data sources mainly focus on big customers and suppliers, providing limited coverage on the potential source of shocks over the supply network. While these data sources are useful for quantifying the effects of shocks propagation, they do not allow us to gauge how firms perceive

the supply chain risk and whether and how they adapt their strategies to mitigate supply assurance concerns.

Our objective in this paper is to develop a proxy for supply chain risk, that is, the second moment of any shocks related to the supply chain, using textual analysis while controlling for the first moment of supply chain shocks and negative realizations of this source of risk. Our newly developed measure enables us to study which firms are mostly affected by supply chain risk and the extent to which supply chain risk affects firms' policies and industrial structure.

To shed light on these issues, we perform a textual analysis of earnings conference calls to construct measures of the first two moments of supply chain shocks faced by US listed companies, using a methodology introduced by Hassan, Hollander, Van Lent, and Tahoun (2019) to quantify firm-level political risk. The focus on US companies allows us to verify, using corporate filings, that our newly developed measures do not depend on idiosyncrasies of the language of earnings conference calls. We measure the first moment of supply chain shocks as the sentiment of supply chain discussions and the second moment, supply chain risk, using the discussion of supply chain issues related to words capturing risk and uncertainty. We also use topic modeling analysis to quantify the sources of supply chain risk.

We start by quantifying the extent to which the supply chain is an important source of risk for firms and how this risk varies in response to various events and firm characteristics. We then use our proxy for supply chain risk to evaluate how firms manage this source of risk.

Basically, all US companies between 2002 and 2020 discuss topics related to supply chains in connection to risk and uncertainty. This indicates that supply chain risk is important and so far neglected in the economics and finance literature. Importantly, supply chain risk is positively correlated with stock price volatility, while supply chain sentiment is associated with negative

returns. While unsurprisingly supply chain risk and supply chain sentiment are negatively correlated, the actual correlation is only -4%, indicating that we can independently measure the first and second moment of supply chain shocks. Supply chain sentiment turns negative and supply chain risk increases on average in conjunction with events that are known to have disrupted supply chains, such as the 2011 Japanese earthquake and the Thai floods (Haraguchi and Lall, 2015; Carvalho et al., 2021). The increase in supply chain risk and drop in supply chain sentiment appear unprecedented during the Covid-19 pandemic. Furthermore, supply chain risk appears to be higher for firms in industries that use differentiated products as inputs, consistent with the intuition that these goods are hard to substitute and any delays and bottlenecks cause severe disruption.

Even though macroeconomic and industry level uncertainty matters, the way firms discuss supply chain risk appears to be highly idiosyncratic. Most of the variation in supply chain risk is explained by firm-specific shocks rather than time- or industry-specific shocks. This may largely depend on the fact that firms with different characteristics appear to have different exposures to supply chain risk. Supply chain risk is higher for firms that have suppliers in different continents and are small relative to their suppliers, suggesting that they have limited bargaining power. Firms that have many suppliers in a given industry are less exposed to supply chain risk, suggesting that hold-up problems and lack of diversification in input sources magnify supply chain uncertainty. Large firms, possibly having more complex supply chains, are more exposed to supply chain risk. Finally, firms that purchase differentiated products, which are presumably harder to substitute if negative shocks occur, appear more exposed to supply chain risk.

Having established that our proxy for supply chain risk exhibits cross-sectional and time-series variation that aligns with reasonable priors, we investigate what actions firms take to manage supply chain risk. First, firms appear to actively manage supply chain risk by investing more and

increasing the number of their suppliers. This finding is consistent with the theory of Elliott, Golub, and Leduc (2022), which predicts that firms will increase investment and multisource to reduce their dependence on specific suppliers and minimize the risk of production disruption. We also explore the characteristics of new suppliers. We find that firms that communicate more uncertainty about their supply chain subsequently establish relationships with suppliers that can be considered industry leaders and with nearby suppliers, suggesting that these firms attempt to increase the reliability of their supplier network.

In addition, we find that supply chain risk affects the boundaries of the firm and industrial structure. Firms that report high supply chain risk are involved in more vertical mergers and acquisitions (M&As), defined using alternative definitions of vertically related industries. This indicates that firms tend to acquire customers and suppliers when supply chain risk increases. Financial constraints limit firms' ability to perform M&As, potentially hampering their long-term competitive advantage.

Interestingly, changes in corporate policies are driven by supply chain risk and not by supply chain sentiment. Supply chain sentiment, which is presumably more closely related to the negative shocks affecting a firm's suppliers, has different or no effects on corporate policies, supplier composition, and vertical M&As. This is consistent with Ersahin, Giannetti, and Huang (2021), who find that supply chains are overall stable following negative shocks and suggest that financially flexible firms react when uncertainty increases, not when negative shocks occur.

Our results are robust to a battery of tests and alternative specifications. First, results are robust if we control for firm-level measures of political risk and climate risk, which are constructed with similar techniques and have been shown in previous literature to affect firms' policies (Hassan et al., 2019, 2020a, b; Sautner, Van Lent, Vilkov, and Zhang, 2022). These findings indicate that

our measure of supply chain risk captures a different source of shocks. More importantly, while firms appear to decrease investment when they face political risk and other sources of macroeconomic uncertainty (Baker, Bloom, and Terry, 2022), they increase investment and acquire customers and suppliers, when uncertainty arises from the availability of inputs, suggesting that supply chain risk deserves independent investigation.

Second, we address the concern that firms may discuss supply chain risk to justify vertical M&As and changes in their supplier composition. Thus, instead of using our textual measure of supply chain risk, we show that M&As with customers and suppliers as well as the number of suppliers that are geographically closer or industry leaders increased following exogenous increase in supply chain risk due to natural disasters, such as the Great East Japan earthquake and the Thailand floods.

Last, we show that results are robust if we perturb the definition of supply chain risk using regulatory filings or eliminating observations in which our proxy for supply chain risk may present more potential noise, which we identify from our topic modelling analysis.

Our work is related to several strands of the literature. First, we contribute to the literature on the boundaries of the firm. Production is believed to be coordinated within a firm, rather than through the market, when transaction costs and hold-up problems are severe (Coase, 1937; Klein, Crawford and Alchian, 1978; Grossman and Hart, 1986). A more recent strand of this literature focuses on global supply chains and explores the effects of demand and technological characteristics on the decision to integrate different stages of production (e.g., Antras and Chor, 2013; Alfaro, Antràs, Chor, and Conconi, 2019), but neglects the effects of risk. While it is well recognized that mergers favor collaboration especially in innovative industries (Bena and Li, 2014; Hsu, Li, Liu, and Wu, 2022), there are few empirical studies exploring vertical mergers. Existing

work focuses on the role of industry shocks (Ahern and Harford, 2014), cash-flow uncertainty (Garfinkel and Hankins, 2011), and R&D incentives (Fan and Goyal, 2006; Fresard, Hoberg, and Phillips, 2020).

The role of supply chain risk in vertical integration decisions, first highlighted by Williamson (1971), has been largely neglected, even though theoretically, supply assurance concerns are known to affect the decision to integrate vertically (Bolton and Winston, 1993). To the best of our knowledge, we are the first to show empirically that supply chain risk can be a driver of vertical integration.

Second, from a methodological point of view, we contribute to a nascent literature that uses textual analysis to measure risk and uncertainty. The most prominent contributions relate to measures of political risk (Baker, Bloom, and Davis, 2016; Hassan et al., 2019). Textual analysis has also been widely used in measuring climate risk and climate risk disclosure (Sautner et al., 2022; Li, Shan, Tang, and Yao, 2021) as well as cyber risk (Florackis, Louca, Michaely, and Weber, 2022). To the best of our knowledge, we are the first to construct a measure of supply chain risk based on textual analysis. We also show that this source of risk warrants independent investigation not only because it is not subsumed by earlier proxies of uncertainty, but also because it has different effect on firms' investment decisions.

Finally, the literature on networks highlights the importance of complementarities between different phases of the production process (Kremer, 1993).[1] While empirical work typically studies the consequences of negative realizations of supply chain risk, recent theories acknowledge that companies' decisions to diversify the source of inputs reflect disruption risk in a way that is not necessarily socially optimal (Bimpikis, Fearing, and Tahbaz-Salehi, 2018). To the best of our

[1] Cen and Dasgupta (2021) provide a review of supply chain linkages.

knowledge, we are the first to develop a proxy for supply chain risk and explore how firms manage their supply chains in response to this source of risk. This contrasts with previous literature that typically takes the supply chain as given and explores how shocks are transmitted given current customer supplier links focusing on natural disasters (e.g., Barrot and Sauvagnat, 2016; Carvalho et al., 2021), credit shocks (Alfaro, Garcıa-Santana, and Moral-Benito, 2021; Costello, 2020), data breaches (Crosignani, Macchiavelli, and Silva, 2022), or pandemic closures (Bonadio, Huo, Levchenko, and Pandalai-Nayar, 2021). Using our newly developed proxy for supply chain risk, we capture firm level perceived supply chain uncertainty potentially arising from any of the above shocks, while controlling for supply chain negative shock realizations using supply chain sentiment and other proxies.

1. Data Sources

We combine a variety of data sources. First, we collect 194,561 transcripts of conference calls held in conjunction with an earnings release (hereafter, earnings calls) by 5,723 public firms listed in the United States from 2002 to 2020 through Refinitiv Eikon database to construct our firm-level proxies for the first and second moments of supply chain shocks.

Firms generally hold quarterly earnings conference calls to inform investors and analysts about the firm's performance. Presentation by the management is followed by a question-and-answer session. Conference calls have been widely used to construct proxies for corporate culture (Li, Mai, Shen, and Yan, 2021) as well as to quantify firms' exposure to political risk (Hassan et al., 2019), Covid-19 (Hassan et al., 2020a), Brexit (Hassan et al., 2020b), cyber risk (Florackis et al., 2022), and climate risk (Sautner et al., 2022; Li et al., 2021). We construct our proxies using

the entire conference call including both the presentation and the question-and-answer session, following the approach introduced by Hassan et al. (2019).

While our approach can be easily extended to an international sample, by focusing on US companies, we are able to verify that our measurements and findings are not driven by the idiosyncratic nature of questions and answers and the ambiguity of the language during earnings conference calls using regulatory filings.

Second, we obtain information on supply chains from Factset Revere, including specific supplier-customer pairs and their locations. Factset Revere collects relationship information from primary public sources, such as SEC 10-K annual filings, investor presentations, and press releases, and classifies the relationship types. Factset Revere spans the period 2003 – 2020 and limits our sample period. On average, for the sample firms, we observe 8 suppliers and 10 customers.

Third, we use the Securities Data Company (SDC) U.S. Mergers and Acquisitions database for M&As. To identify whether the target and the acquirer are in vertically related industries, we use the Bureau of Economic Analysis's (BEA) Input-Output tables, which provide the dollar flow of goods and services between producing and purchasing industries. Our objective is to explore whether vertical integration is more likely to arise when supply chain risk increases and bottlenecks may arise due to the delayed delivery of any input, regardless of its cost relative to other inputs used in the production process. We thus use all the links between industries, regardless of the size of the flows between industries. We show that our results are robust when we only consider vertically integrated industries with significant flows.

Finally, we use Compustat for firm-level variables. We construct outcome variables, including inventory, sales growth, capital expenditures, and employment, to measure firm policy changes in response to supply chain risk. We also construct control variables, including size,

Tobin's Q, cash holdings, cash flow, and Whited-Wu (2006) and Hadlock-Pierce (2010) financial constraints measures.

Table 1 summarizes the main variables that we introduce as we progress with the analysis. All variables are defined in Appendix A.

2. Measuring Supply Chain Sentiment and Risk

Empirical analysis of supply chain related topics typically relies on specific customer-supplier linkages available from corporate filings and commercial datasets. These sources reveal the most important customers and suppliers of a company and have allowed in-depth analysis of how negative shocks such as natural disasters and liquidity shocks are transferred to customers and suppliers.

In contrast to previous literature that documents how negative or occasionally positive shock realizations spread, we aim to quantify uncertainty on the reliability of the supply chain. Quantifying the uncertainty associated with the reliability of supply chains using major customers and suppliers is more challenging. First, large companies have thousands of suppliers. Since inputs are highly complementary in most production processes, supply chain uncertainty may be high even if the major suppliers, which we typically observe from commercial datasets, are fully reliable. Second, and perhaps more importantly, while it is straightforward to establish when a supplier is affected by a negative shock, it is fuzzier to understand when firms may have concerns about the ability of their suppliers to timely satisfy their needs in the future. As shown by recent events, this may depend not only on the operating difficulties faced by a firm's suppliers but also on the functioning of ports, transportation costs, and geopolitical events. Firms may also choose to

prioritize different customers and different markets, which could lead to different exposure to supply chain risk even for firms that share the same suppliers.

For all these reasons, we use textual analysis to directly quantify the supply chain risk a firm is exposed to from managerial statements in conference calls.

2.1 Textual Analysis

We build on recent work that uses the proportion of the conversations during a conference call that is centered on a particular topic as a source for identifying various risks and opportunities (Hassan et al., 2019, 2020a, b). Specifically, we follow Hassan et al. (2019), who study firm level political risk and determine signal bigrams by comparing training libraries of a political textbook to bigrams appearing in nonpolitical texts, specifically an accounting textbook.[2] We thus construct a training library of bigrams related to supply chains using the textbook, *Supply Chain Management: Strategy, Planning, and Operation* (6th edition; Chopra and Meindl, 2016). We also construct another training library of non-supply-chain topics using the financial accounting textbook, *Financial Accounting* (10th edition; Libby, Libby, and Hodge, 2020), which allows us to capture words used in the discussion of general finance and accounting issues.

We define the training library archetypical of the discussion of supply chain issues, *S*, and the other training library of general corporate financial issues, *N*. Each training library is the set of all adjacent two-word combinations (bigrams) contained in the respective supply chain and financial accounting texts (after removing all punctuation, numbers, pronouns, shortened pronouns, adverbs, and single words except for "a"). We then decompose all the conference calls of firm *i* in

[2] We consider bigrams, as opposed to single words, that can be considered related to discussion of supply chain issues because previous research suggests that text-classification results generally improve by applying n-grams (usually bigrams) of words as opposed to single words (unigrams) (Tan, Wang, and Lee 2002; Bekkerman and Allan 2004).

year *t* into a list of bigrams contained in the filings, $b = 1, ..., B_{it}$. We assign a score to each quarterly earnings call transcript and take the annual average because firms are likely to face switching and search costs when changing suppliers or deciding whether to vertically integrate. Since any reactions are likely to take more than a quarter, measuring supply chain risk at a higher frequency would be likely to just increase noise.

We consider as related to supply chain issues all bigrams that appear in the supply chain textbook but not in the financial accounting textbook; in addition, since there is some overlap between supply chain and financial accounting topics, and the bigram "supply chain" naturally appears in the financial accounting textbook, we include in our supply chain training library any bigrams that are at least 30 times more frequent in the supply chain textbook than in the financial accounting textbook.

Using this methodology, we identify a total of 70,820 bigrams associated with supply chain discussions, of which only 59 also appear in the financial accounting textbook, but are enormously more frequent in the supply chain book. Interestingly, almost all firms discuss supply chain topics indicating that this is an important issue, so far largely neglected in the literature.

To define the second moment of supply chain shocks, we count the number of occurrences of bigrams indicating discussion of supply chains within the set of 10 words surrounding a synonym for "risk" or "uncertainty" on either side in the earnings calls performed during year *t*, and divide by the total number of bigrams in the transcript:

$$SCRisk_{i,t} = \frac{\sum_{b}^{B_{i,t}} I[b \in S \backslash N] \times I(|b - r| < 10) \times \frac{f_{b,S}}{B_S}}{B_{i,t}},$$

where I[•] is the indicator function, $B_{i,t}$ is the set of bigrams contained in *S*, but not *N*, *r* is the position of the nearest synonym of risk or uncertainty, $f_{b,S}$ is the frequency of the term *b* in the

supply chain training library, and B_S is the total number of terms in the supply chain training library. The numerator thus simply counts the number of bigrams associated with discussion of supply chains, but not other corporate finance topics, that occur within 10 words to a synonym for risk or uncertainty. Terms are given a larger weight if they recur in the training library more often. The denominator captures the total number of bigrams in the transcript of firm *i* in year *t*.

Following a procedure similar to that for the construction of *SCRisk*, we define the mean of supply chain shocks considering the sentiment used in the discussion of supply chain topics. Specifically, we condition on the proximity to positive and negative words, identified from Loughran and McDonald's (2011) dictionary of words related to sentiment in financial texts. The first moment of supply chain shocks is thus defined as:

$$SCSentiment_{i,t} = \frac{\sum_{b}^{B_{i,t}} \{I[b \in S \backslash N] \times \sum_{c=b-10}^{b+10} S(c) \times \frac{f_{b,S}}{B_S}\}}{B_{i,t}},$$

where *S(c)* is a function that assigns a value of +1 if bigram c is associated with positive sentiment and a value of -1 if bigram c is associated with negative sentiment; *S(c)* takes value zero otherwise. $\sum_{c=b-10}^{b+10} S(c)$ calculates the net sentiment among the ten words surrounding bigram b. Also in this case, we weigh words based on their frequency in the training library.

Table 2 lists the top 100 supply chain bigrams in the training library along with their weights. "Safety Inventory," "Product Availability," and "Transportation Cost(s)" figure among the top 100 bigrams together with bigrams related to inventory management and demand uncertainty. In Table IA.1, we report the list of synonyms of risk words derived from Oxford Dictionary, following Hassan et al. (2019).

To confirm that we are not simply capturing idiosyncrasies of the language used in earnings calls, we verify the reliability of conference calls as a source of information about supply chain

risk using 8-Ks and exhibits, which we download from January 2002 to December 2020 through the Security and Exchange Commission's (SEC) EDGAR website.

The SEC requires firms to disclose any material information such as earnings projections, bankruptcy, officer departures, material definitive agreements, or shareholder vote results within four business days, making 8-K filings a critical source of information for investors and analysts. In line with this, 8-K filings are among the most viewed filings on EDGAR website and lead to significant market reactions (Gibbons, Iliev, and Kalodimos, 2021; Lerman and Livnat, 2010; He and Plumlee, 2020).

We run our code to extract any information about supply chains contained in 8-K filings and construct our firm-level proxies for the first and second moments of supply chain shocks as we did for the earnings calls. As shown in Figure IA.1, the time-series of the supply chain risk measures constructed from earnings calls and 8-K filings have a correlation in excess of 90 percent, confirming that firms provide similar discussions of supply chain issues in these two very different outlets.

Finally, we address the concern that supply chain risk may appear higher in the later part of the sample period because the textbook that we use to construct the list of bigrams related to supply chain is recent and the vocabulary may have changed. For this reason, we use an older version of the supply chain textbook, *Supply Chain Management: Strategy, Planning, and Operation* (3rd edition; Chopra and Meindl, 2006) to create the list of supply chain bigrams. We find that the supply chain risk and sentiment measures constructed from the older textbook are highly correlated (correlation coefficient of 0.99) with our main measures. The plot of SCRisk and SCSentiment using the older textbook in Figure IA.2 clearly shows that changes in language are unlikely to affect our findings.

2.2 Properties of SCRisk and SCSentiment

SCSentiment and SCRisk are our proxies for the first and the second moment of a firm's supply chain shocks during a year, respectively. The mean SCRisk is 0.006; fewer than one percent of the sample firms never discuss supply chains in conjunction with risk and uncertainty, indicating that this is an important topic so far neglected in the literature. Naturally, the first and second moments of supply chain shocks appear to be negatively correlated. When a firm receives news that the provision of some inputs is disrupted, it simultaneously faces a lower mean and higher uncertainty on the future stability of its supply chain. However, the correlation between SCSentiment and SCRisk is low at around -4%, indicating that these two proxies have independent sources of variation.

Table 3, Panel A lists excerpts from the conference calls of firms that exhibit the highest SCRisk and considers also episodes predating the Covid-19 pandemic. The excerpts also illustrate why the sources of supply chain uncertainty may be hard to quantify in the absence of our proxy. For instance, Mercury Systems, Inc., a technology company providing services to the aerospace industry, lists among the concerns in the 2020 earnings calls the financial vulnerability of the suppliers as well as disruptions, shutdowns, and other operational difficulties due to the pandemic at the suppliers' facilities. Concerns are driven by the potential for supply disruptions, rather than by actual negative shocks.

Tariffs and the inability to predict customers' demand also figure prominently in the excerpts in Table 3 Panel A. Selected Interior Concepts, Inc, a company providing building products and services, mentions the risks arising from the fragmentation of its supply chain. Besides concerns arising from the COVID-19 pandemics, suppliers' financial reliability, hesitancy

in expanding operations, and shortages of components feature prominently, also at the beginning of our sample.

Panel B of Table 3 presents excerpts of earnings call transcripts with high SCSentiment. The excerpts state positive or negative realized events in connection with supply chains indicating that SCSentiment can help to capture negative realization of supply chain risk and the effects of shock propagation. Specifically, firms frequently state realized supply chain disruptions, shortages, or disasters. However, supply chain shocks are not one-sided. For instance, Hanesbrands, Inc. mentions strategic acquisitions and self-owned supply chains as important factors behind increasing earnings in the second fiscal quarter of 2014.

2.3 How do Firms Discuss Supply Chain Risk?

To provide a more systematic understanding of the determinants of supply chain risk, we consider the snippets in which firms discuss supply chain risk and classify the topics that firms discuss together with supply chain risk using machine learning. Specifically, we use topic modeling analysis, which has been used in similar contexts to explore the determinants of risks (see, e.g., Li, Liu, Mai, and Zhang, 2021; Dasgupta, Harford, Ma, Wang, and Xie, 2020).

We apply a probabilistic modeling approach, which is a type of unsupervised machine learning, to snippets that are within 50 words from one of our supply chain bigrams if the latter have been mentioned in association with at least one synonymous of risk and uncertainty.

Topic modeling does not rely on predetermined keywords to search for specific topics, but rather uncovers thematic structures and discriminates topics based on how words are distributed in the documents and their correlation. It requires assuming a number of potential topics, an assumption that typically trades-off between the interpretability of the topic outcomes and the

statistical goodness-of-fit (Chang, Gerrish, Wang, Boyd-Graber, and Blei, 2009). While interpretability usually favors fewer topics, statistical fitness in general favors more. We experiment with varying the number of topics from 30, to 50, to 100 and, ultimately, settle for 50.

Applying the above algorithm, we obtain (1) a list of the words most likely to be related to a given topic, from which we can infer the source of exposure to supply chain risk (2) the topic prevalence, that is, how much of a document is devoted to a topic.

We assign meaningful labels to the topics by inspecting the list of words and discounting common words that appear across topics. Since some of the identified topics share a common theme, we consolidate them to obtain seven word-clouds, which allows us to illustrate how firms discuss enhanced supply chain risk.

We present the word clouds in Figure 1. Importantly, uncertainty appears to matter for many of the reasons that have been explored in the extensive literature on shock propagation. Supply chain risk is linked to uncertainty about commodity price risks and more generally input costs; technology and cyber attacks; the environment, climate risk, and the pandemics.

Firms also discuss supply chain risk in conjunction with investment policies providing an idea of how they attempt to manage supply chain risk and the constraints they face. Investment and acquisitions feature in two distinct topics, suggesting that firms manage this source of risk by updating their lines of production to accommodate new suppliers and even consider vertical integration. Firms however face constraints when managing supply chain risk: Low liquidity and difficult access to loans constraint their ability to invest and vertically integrate thus leaving firms more exposed to supply chain disruptions.

Finally, firms appear to discuss supply chain risk in conjunction to general financial issues, which are common in earnings conference calls. This indicates that supply chain risk is important

for earnings, but it can also capture noise associated with general discussions in earnings conference calls. For this reason, in what follows, we will show that our conclusions are qualitatively invariant if we abstract from discussions of supply chain risk that are associated with high probability to general analysts and financial issues.

In what follows, we exploit the insights that we obtain from topic modeling to guide our empirical analysis on how firms manage supply chain risk.

3. Validation

3.1 Variation across Industries

To validate our newly developed proxies, we start exploring whether they exhibit cross-sectional and time-series variation which aligns with reasonable priors. Table 4 lists the industries in which on average during our sample period, firms appear to have higher SCRisk. It is evident that manufacturing industries, which rely on global supply chains, score higher in terms of supply chain risk than nontradable industries and services that mostly rely on local inputs and demand.

To further validate our measure, we also compare the most affected industries as reported in Table 4 with third party reports on supply chains. We mainly focus on two sources: Boston Consulting Group's report (BCG report) on global supply chains and reports from Euromonitor International, a leading provider of business intelligence and market analysis.

Euromonitor reports a list of manufacturing industries that are most sensitive to supply chain risks in 2019, which includes textiles, machinery, hi-tech, and mineral products, and exhibit significant overlap with the top industries for SCRisk in Table 4. BCG also documents that the semiconductor industry is one of the industries most affected by the supply chain problems

associated with the Covid-19 pandemic. The semiconductor industry is included in the two-digit SIC code 36, which is among the top industries for supply chain risk according to our metrics.

Table 5 provides more systematic evidence that SCRisk exhibit meaningful variation across industries. We conjecture that firms that require specialized inputs for their production process should be more exposed to supply chain risk. Differentiated products are more likely to be specialized and hard to substitute (Giannetti, Burkart, and Ellingsen, 2011; Barrot and Sauvagnat, 2016). Following the same methodology in Barrot and Sauvagnat (2016), we compute the share of differentiated goods purchased by firms in an industry. We use Rauch (1999) inputs classifications and Input-Output (IO) tables provided by the Bureau of Economic Analysis (BEA). Rauch (1999) sorts inputs produced by different industries into three groups: those that are traded in an organized exchange, goods with a reference price, and differentiated inputs. The IO tables provide dollar flows between producing and purchasing industries in the U.S.

Consistent with our conjecture, Panel A of Table 5 shows that firms that purchase more differentiated inputs that are presumably hard to substitute tend to have higher supply chain risk. In Panel B, the share of differentiated goods purchased by firms in an industry does not appear to be associated with supply chain sentiment, providing further evidence that we are able to measure the first and second moment of supply chain shocks independently.

3.2 Variation over Time

Figure 2 describes how the mean of SCRisk and SCSentiment vary over time. It is again comforting that supply chain risk appears to be heightened and, to a somewhat lower extent, supply chain sentiment becomes more negative in connection to events that are widely known to have disrupted global supply chains, such as the 2011 great East Japan earthquake and the Thailand

floods, the Sino-American trade war, and more recently with the Covid-19 outbreak. More surprisingly, the 2003 SARS outbreak does not appear to be associated with an increase in supply chain risk or a decrease in sentiment.

From the plot of SCSentiment, it emerges that, differently from what existing literature emphasizing natural disasters seems to imply (see, e.g., Barrot and Sauvagnat, 2016; Carvalho et al., 2021), supply chain risk is not one-sided. Specifically, there are firms and periods with positive supply chain sentiment. As discussed in Subsection 2.2., these instances largely refer to firms that exploit opportunities for outsourcing to reduce costs. There are also periods of negative sentiment when concerns about bottlenecks and the reliability of the supply chain emerge.

Figure 3 relates the yearly mean of SCRisk with a measure of supply chain strains based on transportation costs, developed by Benigno, di Giovanni, Groen, and Noble (2022). The two measures evolve similarly, even though supply chain risk and average transportation costs also exhibit noticeable differences, indicating that supply chain risk does not simply arise from transportation costs. Both measures show that supply chain risk reached unprecedented levels in 2020. Importantly, though, SCRisk captures meaningful variation also before because 2020 because the results we report hereafter are robust if we exclude 2020 or exploit cross-sectional differences between firms by including year fixed effects.

3.3 Residual Variation in Supply Chain Risk

Overall, the timing of the peaks in supply chain risk and negative shock realizations, the cross-sectional differences among industries, and the excerpts of texts associated with the highest levels of SCRisk provide strong support that our proxy captures actual supply chain risk. However, only a limited proportion of supply chain risk is explained by time or industry specific shocks. To

reach this conclusion, Table 6 presents the variance decomposition of SCRisk and SCSentiment. Economy-wide shocks, as captured by time-fixed effects, overall explain very little of the first and second moments of supply chain shocks, as the R-squared is about 6 percent for supply chain uncertainty and 1 percent for the sentiment measure. Three-digit industry fixed effects and, more relevantly, interactions of three-digit industry and time fixed effects explain about 10 to 20 percent of the first and second moments of supply chain shocks, suggesting that firms within an industry may perform very differently in response to widespread supply chain disruption.[3] Interestingly, most of the variation in SCSentiment and especially SCRisk appears to be driven by idiosyncratic firm shocks. When we include firm fixed effects, together with the interactions of industry and year fixed effects, the R-squared increases to 37 percent for SCRisk and to 54 percent for SCSentiment, suggesting that some firms appear to be more exposed to supply chain shocks. Yet, the largest component of SCRisk appears to consist of firm-specific shocks. This feature of SCRisk is common to similarly constructed proxies for political risk and climate risk.

To evaluate whether the idiosyncratic variation in our proxies is meaningful, in Section 3, we explore how SCRisk and SCSentiment depend on firm characteristics. Here, we relate our two proxies to the firm's stock price volatility and SCSentiment to the firm's stock performance. We measure a firm's realized volatility as a firm's standard deviation of daily returns during a given year. Table 7, Panel A presents estimates of Fama-MacBeth regressions of a firm's realized volatility on contemporaneous SCRisk. In column 1, it is apparent that firms with higher SCRisk tend to have higher realized volatility. A one-standard-deviation increase in SCRisk is associated with an increase in realized volatility equivalent to 2.76% of the standard deviation. In column 2,

[3] We also use 2-digit and 4-digit SIC codes to define industry and report the results in Table IA.2. The R-squared varies from 13% when we consider interactions of 2-digit SIC codes and time dummies to 27% when we consider interactions of 4-digit SIC codes and time dummies.

we control for SCSentiment, which is negatively related to stock price volatility. Thus, negative supply chain shocks as other negative shocks also increase stock price volatility.

Finally, in column 3, we evaluate whether our proxy for supply chain risk captures independent sources of risk, by running a horse race with the firm-level proxy for political risk of Hassan et al. (2019) and the proxy for climate risk of Sautner et al. (2022). This is particularly important because supply chain risk partially arises from events increasing political risk and natural disasters, which in turn depends on climate risk. Our proxy remains statistically significant and its coefficient is barely affected, indicating that we are capturing a genuinely different source of risk by isolating the effects of political and climate risk that go through a company's supply chain. While political risk also contributes positively to stock price volatility, we do not find that this is the case for the climate risk proxy of Sautner et al. (2022).

We also investigate whether supply chain sentiment is associated with lower returns. Since earnings conference calls focus on the determinants of earnings and are therefore backward looking, we test how sentiment is associated with past stock returns. It is also plausible that the conversation is focused on the latest shocks. For this reason, in Panel B of Table 7, the dependent variable is *30-day average return*, computed as the average market model abnormal stock returns for the 30 days prior to the earnings call date, which we average over the year. We again run Fama-MacBeth regressions. In column 1, we find a positive and significant relationship between average returns and SCSentiment. In column 2, we control for supply chain risk, while in column 3, we control for political risk and climate risk. We continue to find that higher supply chain sentiment is associated with higher stock returns.

3. Firms' Exposure to Supply Chain Risk

Table 8 relates the first and second moments of supply chain shocks to contemporaneous firm characteristics to understand which firms are relatively more exposed. This test also allows us to evaluate whether the idiosyncratic firm-level variation in SCRisk indeed captures different levels of supply chain uncertainty or is an artifact of the algorithm we apply. For this reason, throughout the analysis, we control for interactions of industry and year fixed effects thus capturing that inputs in some industries may be hard to source, leading to more supply chain shocks. Also, by controlling for industry-specific shocks, we hold constant that the number and type of suppliers of a firm depend on the industry's demand for different inputs.

The estimates indicate that the idiosyncratic variation in SCRisk is related to firm characteristics in a meaningful way and assuage concerns that it is just noise. Supply chain risk is higher for firms that report a higher fraction of suppliers in other continents and large firms that tend to have more complex supply chains. A one-standard-deviation increase in the fraction of suppliers located in other continents is associated with a 4.7% increase in our measure of supply chain risk relative to the sample median. Similarly, a one-standard-deviation increase in firm size is associated with a 3.7% increase in supply chain risk. These findings suggesting that distance and supply chain complexity increases supply chain risk further corroborate our proxy.

Supply chain risk also appears to be related to a company's bargaining power with its suppliers. For instance, companies that are large relative to their suppliers tend to exhibit less supply chain risk suggesting that they may benefit from being the most valued customers of their suppliers. The importance of bargaining power is also supported by the negative effect of a firm's average number of suppliers by input industry. Presumably, these firms have multiple providers of the same input and can more easily switch and substitute suppliers, suggesting that supply chain

diversification decreases supply chain risk. The effect is not only statistically, but also economically significant: On average, one more supplier by input industry decreases a firm's supply chain risk by 4.7% relative to the sample median.

Financial constraints do not affect supply chain risk, while firms with higher growth opportunities, which possibly rely more on knowledge and services than physical inputs for their production, face less supply chain risk. Finally, it does not appear that institutional owners push firms to discuss supply chain issues and risk, in particular, as institutional ownership is negatively related to our proxy for supply chain risk.

Interestingly, supply chain sentiment, but not supply chain risk, is more negative for firms that face a more competitive environment as proxied by a low market share, suggesting that these firms have more unstable supply chains and may more easily lose suppliers as well as customers. The estimated coefficient is not only statistically significant but also economically significant: a 10% decrease in market share is associated with a 3.5% decrease in supply chain sentiment.

4. How firms manage supply chain risk

4.1 Corporate Policies

After showing which firms are exposed to supply chain risk, we investigate how firms manage it. To do so, Table 9 explores how firms' policies and performance change following increases in supply chain risk during the previous year. Specifically, we relate firms' policies to the one year lag of the proxy for supply chain risk, while including firm fixed effects to capture that firm exposure to supply chain risk differs and to focus on the effects of changes in supply chain risk. We also absorb industry shocks that could drive changes in policies by including interactions of industries and year fixed effects.

To evaluate whether companies change their strategy to address supply chain risk, we first investigate whether there are any changes in investment policies when supply chain risk increases. Theories offer conflicting predictions. On the one hand, previous literature highlights that firms facing an uncertain environment tend to cut investment and employment, which is consistent with theories of precautionary behavior (Bernanke, 1983; Bloom, Bond, and Van Reenen, 2007; Bloom, 2009). On the other hand, firms may increase investment when supply chain risk increases in order to reduce its impact. For instance, Elliott, Golub, and Leduc (2022) predict that in the presence of idiosyncratic risk, besides multisourcing, firms may invest to make the relationships with their suppliers stronger. For instance, firms may acquire stakes in their suppliers or make other relationship-specific investments. These actions would increase a firm's capital expenditures.

Column 1 shows that supply chain risk does not lead to a drop in investment. The effect of supply chain risk on investment is not only positive and statistically significant but also economically relevant. Going from the median to the 95th percentile of SCRisk increases investment by 2.9% relative to the sample median.

Furthermore, in column 2, heightened supply chain risk is associated with higher inventories scaled by total assets, suggesting that firms react to high uncertainty on their supply chain's reliability by increasing inventories. The increase in inventories however may also result from the drop in sales that appears to be associated with supply chain risk in column 3.

Thus, firms appear to invest more to address supply chain concerns, for instance, by attempting to control adjacent stages of the production process and ensuring the availability of the inputs, an issue that we explore in the next section. Importantly, any changes in the sourcing of inputs and other relationship-specific investments do not appear to increase a firm's production costs, as the ratio of the cost of goods sold relative to sales does not appear to be associated with

supply chain risk in column 4. Moreover, firms do not appear to vary employment in response to supply chain risk (column 5).

While we observe changes in firms' policies due to supply chain risk and uncertainty, supply chain sentiment does not appear to be associated with firms' policies.

4.2 Supplier Composition

Another way through which firms can minimize the probability of supply chain disruption is by changing their supplier pool. Table 10 explores the effect of supply chain risk on the composition of the supply chain using specifications similar to those in Table 9.

Bimpikis, Fearing, and Tahbaz-Salehi (2018) and Elliott, Golub, and Leduc (2022) predict that firms may react to heightened supply chain risk by increasing the number of suppliers and multisourcing key inputs to reduce their dependency on specific suppliers. In column 1, firms indeed appear to increase the number of suppliers in response to supply chain risk. The estimated coefficient of interest is economically significant: going from the median to the 95th percentile of SCRisk leads to a 5.3% increase in the number of suppliers.[4]

Firms address supply chain risk not only through the quantity, but also through the quality of their suppliers. Elliott, Golub, and Leduc (2022) argue that firms can minimize the probability of production disruption through the reliability of the supplier network or by forming stronger relationships with their suppliers. One way to do this is through geographical proximity. First, uncertainty about transportation costs or travel damages increases as the physical distance between a firm and its supplier increases (Schmitt and Van Biesebroeck, 2013; Bray, Colak, and Serpa, 2019). Second, firms can better monitor physically closer plants, which can help them maintain a

[4] The results are robust to the use of Poisson regressions.

consistent product quality (Giroud, 2013). Finally, being able to monitor more frequently coupled with more face-to-face communication can help firms build trust with their suppliers (Schmitt and Van Biesebroeck, 2013). Therefore, we would expect that firms establish relationships with geographically closer suppliers when supply chain risk increases.

We test this conjecture in columns 2 and 3. We look at the number of suppliers in the same continent and in the U.S., respectively. The estimated coefficients on SCRisk are positive and statistically significant at the 1% confidence level and imply that following an increase in supply chain risk, U.S. public firms start working with an increasing number of suppliers located in the same continent, mainly in the U.S.

Another way to increase the reliability of the supplier network is to work with suppliers that are leaders in their industries. We define industry leaders as firms with a high market share in an industry. Industry leaders are expected to have a stronger reputation to be able to deliver on their commitments, which should be particularly important when firms have concerns about the ability to source their inputs.[5] We test this conjecture in column 4. We classify firms as industry leaders if their sales are above the median of other firms in their 3-digit industry. The positive coefficient of interest shows that firms establish relationships with suppliers that are leaders in their industries when supply chain risk increases.

Taken together, Table 10 shows that firms make significant changes to their supplier pool, when they face heightened supply chain risk. Not only the number but also the composition of suppliers changes, as firms establish new relationships with geographically closer suppliers and suppliers that are industry leaders. This analysis also shows that firms strategically choose their suppliers to minimize the risk of costly production disruption (Elliott, Golub, and Leduc, 2022).

[5] At the earnings call for the third fiscal quarter of 2020, Mark Aslett, the President and CEO of Mercury Systems, Inc., describes this firm behavior as "flight to quality suppliers."

Interestingly, supply chain sentiment does not contribute much to explain changes in supply chain composition. We simply find some weak evidence that firms add more domestic suppliers following increases in supply chain sentiment. To the extent that supply chain sentiment captures (the inverse of) negative realizations of supply chain risk, this finding is consistent with evidence that supply chains remain stable following negative shocks (Ersahin, Giannetti, and Huang, 2021).

4.3 Vertical Integration

Supply chain risk can affect not only the composition of suppliers but also the firms' boundaries. Theories of the boundaries of the firm suggest that supply assurance concerns may lead firms to integrate vertically (Williamson, 1971; Bolton and Whinston, 1993). When supply chains uncertainty increases and bottlenecks become more likely, the intensity of hold up problems between a firm and its suppliers intensifies, making vertical integration more desirable (Grossman and Hart, 1986). For these reasons, we may observe more vertical M&As, when supply chain risk increases. Specifically, we expect that a firm experiencing heightened supply chain risk should have a higher probability to acquire firms in an upstream industry to have better control over the access to inputs. We expect the probability of the acquisition of firms in downstream industries to increase as well, because the identity of the acquirer and the target depends on technological reasons affecting their relative size and on their liquid holdings and access to external finance. For a firm to integrate with a supplier, it may just be optimal to become a target.

Table 11 explores whether firms engage in more vertical M&As when supply chain risk increases. Throughout the analysis, we include interactions of three-digit industry and year fixed effects to control for industry shocks, which are known to lead to merger waves (e.g., Ahern and

Harford, 2014). As in our previous specifications, we also include firm fixed effects throughout the analysis.

Column 1 evaluates the probability that a firm is involved in an M&A with a firm in an upstream industry, while column 2 considers M&As with firms in downstream industries. In both cases, we find that an increase in SCRisk leads to a higher probability of M&As. In particular, going from the 25th percentile to the 75th percentile of SCRisk increases the probability of an M&A with a supplier or a customer by 26.8% and 25.3% relative to the baseline merger probability of 0.51% and 0.43%, respectively. In column 3, we find no evidence that the firms engage in M&A in industries that are not vertically related when supply chain risk increases.

So far, we have defined upstream and downstream industries considering input-output tables. Specifically, any industries that exhibit a bilateral flow are considered vertically related. In this way, we capture that limited availability of any input can cause bottlenecks in the presence of production complementarities. One may think however that inputs that are larger proportions of an industry's costs of production matter most. In Table IA.3, we repeat our tests considering as vertically related only upstream (downstream) industries that account for at least one percent of purchases (sales) as Garfinkel and Hankins (2011) do to define vertical M&As. Our results are qualitatively invariant.

We also control for supply chain sentiment. Negative sentiment decreases the probability of vertical M&As in a significant way: going from the 25th percentile to the 75th percentile of supply chain sentiment decreases the probability of an M&A with a supplier and a customer by 19.8% and 20%, respectively. This finding highlights the importance of distinguishing supply chain risk from the first moment of supply chain shocks and negative shock realizations. Specifically, firms are likely to experience cash shortfalls and incur in financial constraints

following negative supply chain shocks. This in turn should limit the possibility of engaging in M&As.

We exploit that financial constraints prevent companies from engaging in vertical M&As to improve our identification. In principle, firms could just discuss supply chain risk because they wish to vertically integrate, not because they are experiencing higher supply chain uncertainty. If instead SCRisk captures an actual increase in supply chain uncertainty, we should observe that its effect on the probability to vertically integrate is reduced for financially constrained firms. Put differently, financially constrained firms should be affected as much as other firms by supply chain shocks and risk but should be less able to react to them.

In Table 12, we use two measures of financial constraints to test this conjecture: The index based on size and age introduced by Hadlock and Pierce (2010) in Panel A and the Whited-Wu index proposed by Whited and Wu (2006) in Panel B. We classify firms as financially constrained (unconstrained) if their index value is above (below) the median. In columns 1 and 2 of panels A and B, the estimated coefficients on the interaction terms are negative and statistically significant, which shows that financially constrained firms are significantly less likely to be involved in vertical M&As when supply chain risk increases.

This finding implies that financial constraints hamper firms' ability to hedge their operations against supply chain risk and resonates with empirical evidence showing that airlines approaching financial distress engage less in fuel price hedging and thus remain more exposed to oil price movements (Rampini, Sufi, and Viswanathan, 2014). Importantly, this mechanism appears relevant not only for the financial hedges highlighted in previous literature, but also for operational hedges that as vertical integration involve even larger costs.

4.4 Identification: Exogenous Variation in Supply Chain Risk

Finally, Table 13 revisits the concerns that management may use supply chain risk to justify vertical M&As or changes in supplier composition. To obtain exogenous increases in supply chain risk, similarly to Baker, Bloom and Terry (2022), we rely on natural disasters. Specifically, we exploit the Thai floods and the Great East Japan Earthquake, which led to an exogenous increase in supply chain risk for firms with suppliers in Thailand and Japan, respectively (Haraguchi and Lall, 2015; Carvalho et al., 2021). If supply assurance concerns really lead to more vertical integration or changes in supplier composition, we should observe that these firms are more likely to be involved in vertical M&As or to establish relationships with geographically closer and industry leader suppliers following these shocks.

To isolate the effects of these natural disasters on supply chain uncertainty, we also control for the supply chain sentiment reported by the firm to try to distinguish the effect of supply chain uncertainty from that of the negative shocks, which affect the suppliers and propagate downstream. This task is made easier by our previous findings showing that supply chain sentiment is unrelated to or has different effects on supply chain composition from supply chain uncertainty. Hence, observing that the Thai floods and the Japanese earthquake have similar effects as SCRisk on the changes in supply chain composition and vertical integration for exposed firms would allow us to attribute the effects to an exogenous increase in supply chain uncertainty.

We consider firms with suppliers in Japan or Thailand as treated. The dummy *Post* takes value equal to one from 2011 to 2014 to capture that heightened supply chain uncertainty may have persisted following the pervasive natural disasters. The estimates in Table 13 show that firms with suppliers in Japan and Thailand become more likely to be involved in vertical M&As as well

as work with more suppliers, with suppliers that are geographically closer and that are industry leaders following the Thai floods and the Great East Japan Earthquake.

Table IA.4 confirms these results while controlling for a firm's sales to further capture any effects of shock propagation, which, as highlighted by Barrot and Sauvagnat (2016), reduce the sales of downstream firms. Firms appear to increase the number of suppliers and establish relationships with suppliers that can be considered more reliable because they are close or high quality when their sales are higher, not when they face negative shocks, further mitigating concerns that our coefficient of interest captures the effects of shock propagation.

Overall, the positive and significant coefficient on the interaction capturing firms exposed to the Thai floods and the Great Japanese earthquake suggests that an exogenous increase in supply chain uncertainty leads firms to diversify their suppliers as well as to establish relationships with closer and higher quality suppliers. Exogenous increases in supply chain uncertainty also appear to lead to a higher probability of vertical M&As. We can thus conclude that our findings are not due to reverse causality.

4.5 Robustness

Table 14 explores to what extent supply chain risk is distinct from political risk and climate risk as these other sources of risk may also impact firms through the supply chain. Our results in Table 9 and Table 10 are robust to the inclusion of the political and climate risk proxies developed by Hassan et al. (2019) and Sautner et al. (2022), respectively. Furthermore, in Panel A and Panel B, we see that contrary to supply chain risk, political and climate risk have a negative or no effect on vertical integration. Climate and political risk are also unrelated to changes in supplier composition. Not only does this confirm that our proxy for supply chain risk captures a different

source of risk, but also that supply chain risk has considerably different effects on corporate policies and industrial structure in comparison to other more widely studied sources of risk.

In Table IA.5, we report results controlling for the overall sentiment of the transcripts. One might be concerned that when times are bad or the firm performs poorly, managers blame supply chain issues. If this were true, the supply chain risk could capture general negative conditions. However, if we control for the overall sentiment of the earnings calls, we continue to find similar results suggesting that SCRisk does not capture general negative sentiment.

Another potential concern is that SCRisk is measured with noise from the earnings call transcripts. For instance, as noted in Subsection 2.3, one of the topics identifies discussions of supply chain risks in the context of general financial and analyst-related issues that are typical of earnings conference calls. A potential concern is that these snippets do not reflect an actual increase in supply chain risk, but rather noise. As a result, potential noise could contaminate our findings. Taking advantage of the topic analysis, we consider supply chain risk to be measured with noise for a firm if during a year more than half of the snippets that incorporate supply chain risk discussions are associated with a probability of discussing general financial and analysts issues in the top quartile.

We implement two strategies to account for this potential noise. First, we replace SCRisk that we identify as potential noise with the two-digit industry median SCRisk during the same year. We find qualitatively similar results in Table IA.6. Second, we drop the observation if SCRisk is identified as measured with potential noise. In Table IA.7, we again report similar findings to our main results.

Finally, we perform the main analysis on firm policies as in Tables 10 and 11 using the supply chain risk and sentiment measures constructed from 8-K filings. We report the results in

Table IA.8. The supplier composition and vertical integration findings are robust, confirming that earnings calls are a reliable source of information on firms' supply chain.

5. Conclusions

Supply chains and input availability are crucial determinants of comparative advantage. We develop a novel proxy for supply chain uncertainty based on textual analysis and explore how supply chain uncertainty affects corporate policies.

We show that firms facing more supply chain uncertainty diversify their suppliers by establishing new relationships. Firms also establish relationships with suppliers in the same continent and suppliers that are industry leaders. More importantly, firms that face more supply chain risk are more likely to become vertically integrated by entering into M&As with their customers and suppliers.

These results suggest that higher supply chain uncertainty could be associated with changes in the geography and organization of economic activity with protracted long-term effects on the performance of different geographical areas. Exploring these issues is an exciting area for future research.

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Figure 1
This figure presents the word cloud for the nine topics derived from supply chain risk related snippets. For each topic, we create a word cloud that shows the words with the highest frequencies.



Costs and commodity price risk



Technology and Cyber Attacks Risk



Climate Risk and Pandemics



Uncertainty, demand and financial R&D



Liquidity



Analysts and Financial Issues



Acquisitions

Figure 2
This figure shows the mean of SCRisk and SCSentiment along with indicators for key events related to supply chain shocks.

Panel A. SCRisk



Panel B. SCSentiment

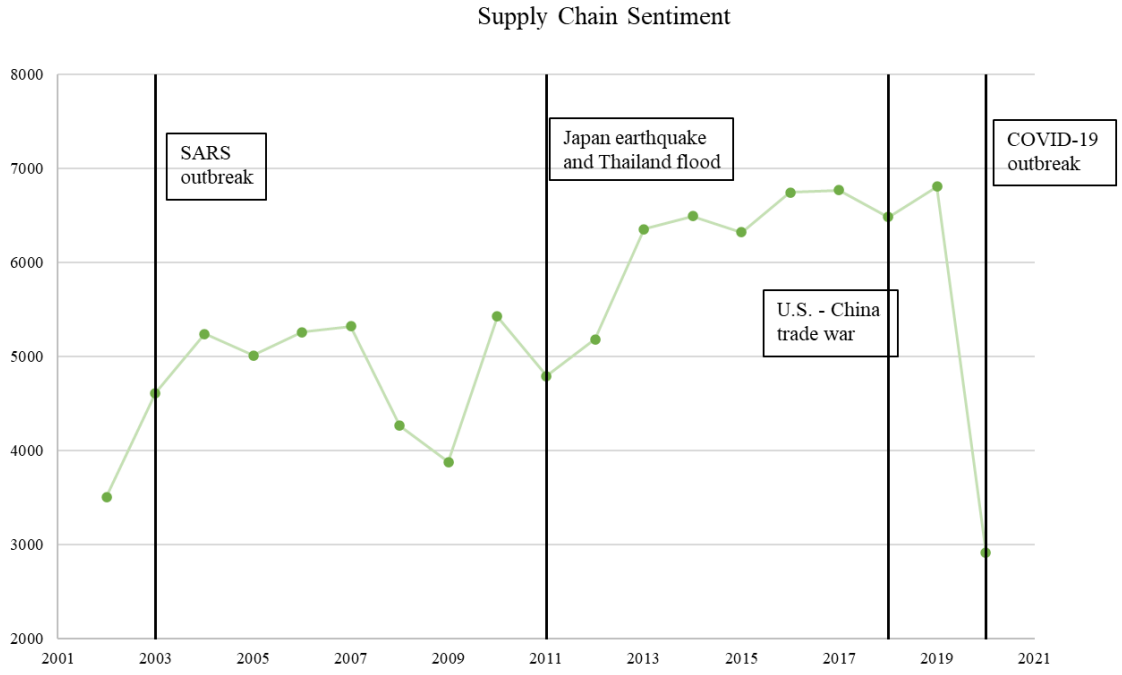


Figure 3
This figure shows the mean of SCRisk and the global transportation costs index (transportation costs) developed by Benigno et al. (2022).

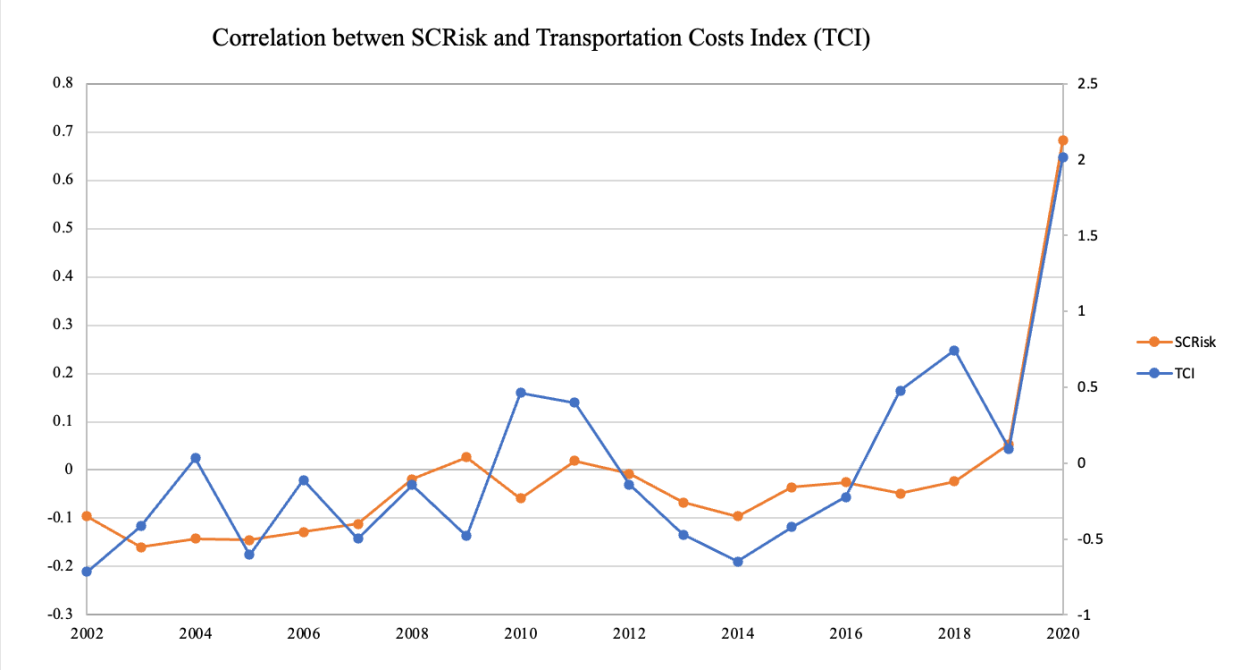


Table 1. Summary statistics

This table presents summary statistics for the main variables used in our analysis. All variables are defined in Appendix A.

Variables	(1) N	(2) Mean	(3) SD	(4) P25	(5) P50	(6) P75
SCRisk	33,920	0.0060	0.0083	0.0023	0.0037	0.0061
SCSentiment	33,920	0.0612	0.0967	0.0150	0.0377	0.0731
Different continents	33,920	0.1455	0.2454	0	0	0.2222
Relative size	33,920	0.7706	8.4310	0.0065	0.0337	0.2384
Average number of suppliers in an input industry	33,920	1.5076	0.9047	1	1.1724	1.5909
Market share	33,920	0.1055	0.2103	0.0012	0.0129	0.0902
Financial constraint	33,920	0.5322	0.4990	0	1	1
Institutional ownership	33,920	0.5778	0.3607	0.2595	0.6925	0.8777
Size	33,920	6.7511	1.8499	5.4331	6.6771	7.9526
Tobin's Q	33,920	2.1894	1.5288	1.2302	1.6799	2.5542
Cash holdings	33,920	0.2262	0.2353	0.0454	0.1364	0.3334
Cash flow	33,920	-0.0145	0.1965	-0.0223	0.0375	0.0782
Inventory	33,920	0.0956	0.1223	0	0.0516	0.1463
Sales growth	33,920	0.1246	0.3730	-0.0190	0.0690	0.1867
COGS	33,920	0.9152	1.9847	0.4253	0.6339	0.8157
CapEx/K	33,920	0.3189	0.3503	0.1240	0.2130	0.3775
Log(emp)	33,920	1.5474	1.3137	0.4337	1.2423	2.3418
Number of suppliers	33,920	8.2304	11.7143	1	3	10
Number of suppliers in the same continent	33,920	4.0289	6.3667	0	1	5
Number of U.S. suppliers	33,920	3.8864	6.0831	0	1	5
Number of industry leader suppliers	33,920	3.7407	5.3745	0	1	5
M&A with supplier	33,920	0.0051	0.0710	0	0	0
M&A with customer	33,920	0.0043	0.0655	0	0	0
Unrelated M&As	33,920	0.1611	0.3677	0	0	0
Political risk	33,920	0.0011	0.0012	0.0004	0.0007	0.0014
Climate risk	33,920	0.0021	0.0068	0	0	0

Table 2. Top 100 bigrams and their weights

This table reports the 100 bigrams with the highest frequency in the training library used for the construction of SCRisk. The weight column reports the number of occurrences of the bigram across all earning calls filings.

Bigram	Weight	Bigram	Weight	Bigram	Weight
supply_chain	761.63	third_party	52.66	of_scale	31.34
the_supply	281.15	demand_and	52.66	supply_and	30.03
a_supply	146.23	given_by	52.66	demand_during	30.03
safety_inventory	143.19	cycle_inventory	50.49	if_demand	30.03
the_retailer	133.18	mean_of	50.05	the_aggregate	29.59
of_demand	104.89	size_of	47.44	to_improve	29.59
the_manufacturer	104.89	the_season	45.26	fill_rate	29.16
the_optimal	100.97	the_quantity	44.83	the_lot	29.16
lead_time	98.79	chain_surplus	42.22	chain_is	28.72
standard_deviation	98.79	demand_in	40.91	chain_profits	28.72
demand_is	93.14	fraction_of	40.04	cycle_service	28.29
deviation_of	86.61	and_demand	39.6	forecast_error	27.85
product_availability	80.95	revenue_management	38.73	see_worksheet	27.85
of_product	79.21	of_transportation	38.73	weekly_demand	27.85
lot_size	77.03	chain_management	38.3	customer_order	27.42
the_demand	74.42	response_time	37.43	store_manager	27.42
in_table	74.42	is_thus	36.99	annual_cost	26.98
holding_cost	71.81	demand_uncertainty	36.99	spot_market	26.98
the_supplier	71.81	service_level	36.56	is_likely	26.98
transportation_cost	64.41	the_forecast	36.12	network_design	26.55
in_figure	60.06	aggregate_planning	36.12	time_is	26.55
normally_distributed	59.62	aggregate_plan	35.69	is_obtained	26.11
in_period	58.32	management_review	35.25	quantity_discounts	25.68
using_equation	57.01	order_size	33.95	chain_performance	24.81
of_supply	56.58	customer_demand	33.95	demand_from	24.81
transportation_costs	56.58	economies_of	33.51	low_demand	24.81
seven_eleven	56.14	order_is	33.08	replenishment_lead	24.37
an_order	55.71	eleven_japan	32.64	chain_in	23.94
distributed_with	55.27	strategic_fit	32.64	milk_runs	23.94
a_mean	54.84	of_safety	32.21	the_lead	23.94
expected_profit	53.53	chain_to	31.77	lead_times	23.94
supply_chains	52.66	the_goal	31.34	harvard_business	23.5
a_standard	52.66	to_order	31.34		

Table 3. Excerpts from Earnings Calls

This table reports firm name, earnings call date, and excerpts from earnings calls with high SCRisk and SCSentiment (both positive and negative) in panels A and B, respectively.

Firm Name	Date of Report	Text
Panel A: Excerpts based on SCRisk		
Mercury Systems, Inc.	April 28, 2020	The key supply chain issues that we're facing are twofold. The first is that suppliers may be financially vulnerable. This applies more so to those suppliers that are heavily exposed to the commercial aerospace sector. As you know, commercial aerospace has been significantly more impacted by COVID than defense. The other **major supply chain risk** is the potential for COVID-related manufacturing **disruptions**, that is temporary site **shutdowns** that could affect the supply of U.S. sourced components to Mercury. We're also facing other **operational risks**, the first being the potential for COVID-related disruptions within Mercury's own manufacturing facilities…That said, the **risk** does remain elevated.
Select Interior Concepts, Inc.	November 05, 2020	As we look at international supply chain, it's fairly fragmented. And you have **considerable risk** with respect to tariffs, **supply chain**, work stoppages at ports, those kinds of things.
NeoPhotonics Corp	April 30, 2020	While we believe there is immediate demand to increase network bandwidth capacity to handle the increased traffic, we continue to see **supply chain risks**. We have included approximately $10 million of impacts to Q2 revenue in our outlook due to **concerns about supplier shutdowns** as they comply with their local public health orders. We expect the **supply chain risks to continue** into the second half of the year.
SBE, Inc.	May 2006, 2005	Our customers don't provide much **forecast visibility** resulting in **hesitancy** throughout the **supply chain**.
Science Applications International Corp	December 08, 2016	The biggest **variability** this quarter, and in our portfolio as a whole, is in the **supply chain** and materials business.
Insteel Industries, Inc.	July 19, 2018	… **uncertainty** surrounding the availability of our **primary raw material**, hot-rolled steel wire rod, resulted in speculative purchasing throughout the **supply chain** and sharp price

		increases reflecting the 25% tariff that was eventually applied to practically all imports of carbon steel products.
Entegris, Inc	April 26, 2016	As I was mentioning in my prepared remarks, we are seeing **increased level of complexity, increased risk** of contamination of critical materials in the **supply chain** at the leading-edge.
IEC Electronics Corp	May 09, 2018	This brings me to another topic: the ongoing **global supply chain component constraints**. As you know, in fiscal 2018 Q1, we mentioned that one of our challenges, which is affecting the entire industry, was associated with difficult in producing -- in **procuring** certain electronic components and in some cases, facing long lead times or allocation restrictions due to **limited global supplies**. These **shortages** can impact our ability to fulfill our customers' orders and lengthen production times as well as add some amount of **unpredictability** as we wait for a specific component to complete a job.

Panel B: Excerpts based on SCSentiment

		Positive sentiment
LightInTheBox Holding Co., Ltd.	April 21, 2016	**Stronger** than expected holiday sales were primarily a result of our **improved supply chain** management and the **stronger** support of our suppliers with discounts and sourcing prices for the holiday season.
Coty Inc.	November 9, 2020	Third, our focus and enhancements over the last year to our **supply chain** continue **to support our growth** while allowing us to **successfully** navigate the COVID-19 pandemic. We added another co-packer to our network during the third quarter, providing further capacity, flexibility and the ability to service our customers.
Vitria Technology, Inc.	October 24, 2006	Second, one of our customers, MasterBrands won "Network World's" 2006 Enterprise All-Star Award for its **innovative supply chain** management application. Powered primarily by Vitria's BusinessWare products, MasterBrands was able to dramatically speed order fulfillment, provide **exceptional** handling and enable visibility across the **supply chain**, earning the company an Enterprise All-Star Award
Tuniu Corporation	August 28, 2019	In the travel industry, the **supply chain** is the vital component that connects the supply and demand. We made **strong progress** during the last few years in further **strengthening** our **supply chain**. We continue to **consolidate procurement** across the company in order to **maximize our bargaining power** with **suppliers** and minimize risk, while better sharing inventory across our various business units.

Hanesbrands, Inc.	July 23, 2014	Q2 was another **great** quarter for Hanesbrands. We **expanded** operating margins by 210 basis points and **grew** our earnings 44% to $1.71 per share, providing further evidence that when you combine our Innovate-to-Elevate strategy, **our self-owned supply chain**, and strategic acquisitions, we have a **great** formula for **creating shareholder value**.
		Negative sentiment
Newell Brands Inc.	May 1, 2020	In the month of April, the **supply chain disruptions**, the **retail closures** and the consumer purchase pattern shifts contributed to an estimated **sales decline** in the 25% sales range, which has informed our call out for a challenging second quarter.
Reed's, Inc.	November 7, 2018	First quarter revenues **declined** 7.7% on a like-for-like basis, as we encountered temporary **supply chain headwinds**. Alongside the previously flagged **supply chain issues** affecting Consumer Beauty and Professional Beauty, our Luxury division was also impacted in Q1 by a **disruption** in European warehouse, by the U.S. hurricane and by **component shortages at certain external suppliers**.
Micrel Semiconductor, Inc.	April 21, 2011	Consistent with our pre-announcement of preliminary first quarter results on April 11, our top line was impacted by an unanticipated **reduction in sales** to a Korean wireless handset and consumer electronic device manufacturer which moderated product deliveries during the quarter to control inventory levels. The Company also experienced a **reduction in overall demand** toward the end of the quarter related to **disruptions** in the worldwide electronics **supply chain** as a result of the **earthquake** and **tsunami** in Japan in March.
Corning, Inc.	January 27, 2009	The **supply chain** actually reacted faster and **more severely** than we anticipated in quarter four. We had thought the supply chain would reduce 75 million square feet in Q4 with the risk of the additional 50. **The reality turned out to be far bigger**. **Supply chain reduced** 230 million square feet of glass in quarter for. When you combine the retail weakness and **supply chain contraction**, you will understand why our glass volumes were **down** so much in Q4. And by the way, these numbers I'm discussing here were for the entire industry. **So it was a difficult and disappointing quarter**.
Ocean freight, Inc.	May 27, 2011	Let's shift gears now and look at the recent developments in the **dry bulk market**. The market for the first quarter of 2011 resulted in a **very low** freight rate environment, in many cases, even **below breakeven levels**. Let's see why… Second reason is events in Japan have **disrupted the supply chain** on both raw and finished materials.

Table 4. Industry Level Supply Chain Exposure

This table reports the top and bottom 10 industries in terms of our measure of overall supply chain risk, SCRisk. Industry-year average of firms' SCRisk is used to rank the industries.

SIC2	Top 10 industries	SIC2	Bottom 10 industries
14	Nonmetallic Minerals, Except Fuels	21	Tobacco Products
22	Textile Mill Products	27	Printing & Publishing
25	Furniture & Fixtures	41	Local & Interurban Passenger Transit
33	Primary Metal Industries	48	Communications
35	Industrial Machinery & Equipment	53	General Merchandise Stores
36	Electronic & Other Electric Equipment	54	Food Stores
37	Transportation Equipment	58	Eating & Drinking Places
50	Wholesale Trade – Durable Goods	72	Personal Services
52	Building Materials & Gardening Supplies	79	Amusement & Recreation Services
75	Auto Repair, Services, & Parking	82	Educational Services

Table 5. Input Specificity

This table reports the effects of input specificity on SCRisk and SCSentiment in Panels A and B, respectively. The main independent variable is Input Specificity, which is constructed based on input-output tables and Rauch (1999). Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)
Panel A: Dependent variable - SCRisk					
Input Specificity	0.0825***	0.0786***	0.2025***	0.3356***	0.1993***
	(0.0156)	(0.0156)	(0.0396)	(0.0398)	(0.0395)
Size					0.0560
					(0.0470)
Tobin's Q					-0.1228***
					(0.0422)
Cash holdings					-0.4653
					(0.3423)
Cash flow					1.0116***
					(0.3108)
Observations	30,878	30,878	30,878	30,878	30,878
Adjusted R-squared	0.0035	0.0658	0.0879	0.0256	0.0896
Year FE		Y		Y	Y
Industry FE			Y	Y	Y
Panel B: Dependent variable - SCSentiment					
Input Specificity	1.0952***	1.0336***	-0.8239	0.5636	-0.8079
	(0.2570)	(0.2597)	(0.5926)	(0.5899)	(0.5859)
Size					3.4033***
					(0.7081)
Tobin's Q					0.6441
					(0.6858)
Cash holdings					-19.1755***
					(4.8732)
Cash flow					-13.0484***
					(4.9748)
Observations	30,878	30,878	30,878	30,878	30,878
Adjusted R-squared	0.0046	0.0160	0.0924	0.0796	0.0975
Year FE		Y		Y	Y
Industry FE			Y	Y	Y

Table 6. Variance decomposition of SCRisk and SCSentiment

This table reports adjusted R-squared and R-squared from the projection of SCRisk and SCSentiment in Panel A and Panel B, respectively, on various sets of fixed effects, as indicated in the table. Industries are classified at the three-digit level.

	(1)	(2)	(3)	(4)
		Panel A: SCRisk		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0593	0.0344	0.1196	0.2113
R-squared	0.0598	0.0405	0.1960	0.3722
		Panel B: SCSentiment		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0114	0.1311	0.1478	0.4187
R-squared	0.01119	0.1365	0.2223	0.5372

Table 7. Supply Chain Risk, Firm Volatility, and Returns

This table reports estimates of Fama-MacBeth regressions of firms' yearly realized volatility and 30-day average abnormal return on SCRisk and SCSentiment during the year in Panels A and B, respectively. The dependent variable in Panel A is *Realized Volatility*, computed as a firm's standard deviation of daily returns in that year. The dependent variable in Panel B is *30-day average abnormal return*, computed as the average abnormal stock return for the 30 days prior to the earnings call date, then averaged within the year. Firm level abnormal returns are obtained by estimating the market model over the [-255, -31] day interval. The Political risk measure is from Hassan et al. (2019). The Climate risk measure is from Sautner et al. (2022). All variables are defined in Appendix A. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)
Panel A: Dependent variable - realized volatility			
Supply chain risk	4.6674**	5.2526**	4.3746**
	(1.8656)	(1.8916)	(1.8212)
Supply chain sentiment		-0.7967***	-0.7648***
		(0.1213)	(0.1153)
Political Risk			27.9838***
			(8.5564)
Climate Risk			1.7479
			(1.8369)
Number of Firms	2,672	2,672	2,672
Number of Years	18	18	18
Panel B: Dependent variable – 30-day average abnormal return			
Supply chain sentiment	0.0008***	0.0008***	0.0008***
	(0.0002)	(0.0002)	(0.0002)
Supply chain risk		-0.0043*	-0.0048**
		(0.0024)	(0.0020)
Political Risk			0.0000
			(0.0000)
Climate Risk			-0.0334
			(0.3658)
Number of Firms	2,672	2,672	2,672
Number of Years	18	18	18

Table 8. Firm characteristics, supply chain risk, and supply chain sentiment

This table relates SCRisk and SCSentiment in Panel A and Panel B, respectively, to contemporaneous firm characteristics in an annual panel. The main independent variable in columns (1) is *Different continents*, which is the fraction of a firm's suppliers who are located in a different continent over the total number of suppliers. The additional independent variable in column (2) is *Relative Size*, defined as a firm's total assets divided by the average total assets of its suppliers. The additional independent variable in column (3) is *Size*, defined as the natural logarithm of the firm's total assets. The additional independent variable in column (4) is *Average number of suppliers by industry*, defined as the average of a firm's number of suppliers within each of the three-digit industries for which we observe suppliers from Factset Revere. The additional independent variable in column (5) is *Market Share*, defined as a firm's sales divided by the total sales in the firm's industry. The additional independent variable in column (6) is *Financial constraint*, which is an indicator variable that equals one if the Whited-Wu (2006) proxy for firm-level financial constraints is above the median of our sample. The additional independent variable in column (7) is *Institutional ownership*, which is the fraction of the firm's shares owned by financial institutions, which we obtain from 13F filings. The additional independent variable in column (8) is *Tobin's Q*, defined as assets minus cash and cash equivalent securities plus book value on equity scaled by assets. The unit of observation is a firm-year. Industries are classified at the three-digit level. Independent variables are scaled up by 1,000 for readability. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: Supply chain risk				
Different continents	0.7115***	0.7115***	0.6207**	0.6253**	0.6251**	0.6282**	0.5839**	0.5871**
	(0.2754)	(0.2754)	(0.2715)	(0.2713)	(0.2713)	(0.2712)	(0.2726)	(0.2714)
Relative size		-0.0039*	-0.0054***	-0.0048***	-0.0051***	-0.0051***	-0.0053***	-0.0052***
		(0.0020)	(0.0019)	(0.0018)	(0.0019)	(0.0019)	(0.0019)	(0.0018)
Size			0.0742*	0.1136**	0.0939**	0.0760	0.1174**	0.0913*
			(0.0401)	(0.0443)	(0.0450)	(0.0505)	(0.0523)	(0.0527)
Average number of suppliers				-0.1741**	-0.1738**	-0.1689**	-0.1931***	-0.1638**
by industry				(0.0694)	(0.0695)	(0.0696)	(0.0699)	(0.0701)
Market share					0.3366	0.3242	0.2806	0.2701
					(0.3084)	(0.3089)	(0.3067)	(0.3064)
Financial constraint						-0.1182	-0.1316	-0.1309
						(0.1441)	(0.1437)	(0.1440)
Institutional ownership							-0.6064***	-0.5057***
							(0.1857)	(0.1882)
Tobin's Q								-0.1738***
								(0.0388)

Industry x year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	33,901	33,901	33,901	33,901	33,901	33,901	33,901	33,901
Adjusted R-squared	0.1048	0.1048	0.1050	0.1052	0.1053	0.1053	0.1057	0.1065

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel B: Supply chain sentiment				
Different continents	0.0006	0.0006	-0.0042	-0.0042	-0.0042	-0.0042	-0.0040	-0.0040
	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0032)
Relative size		0.0000	-0.0001*	-0.0001*	-0.0001**	-0.0001**	-0.0001**	-0.0001**
		(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Size			0.0039***	0.0037***	0.0029***	0.0029***	0.0027***	0.0028***
			(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0008)	(0.0008)
Average number of suppliers				0.0010	0.0010	0.0010	0.0011	0.0010
by (input) industry				(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Market share					0.0133**	0.0133**	0.0136**	0.0136**
					(0.0055)	(0.0056)	(0.0056)	(0.0056)
Financial constraint						0.0003	0.0004	0.0004
						(0.0024)	(0.0024)	(0.0024)
Institutional ownership							0.0035	0.0031
							(0.0033)	(0.0032)
Tobin's Q								0.0007
								(0.0007)
Industry x year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	33,901	33,901	33,901	33,901	33,901	33,901	33,901	33,901
Adjusted R-squared	0.0981	0.0981	0.1026	0.1026	0.1034	0.1034	0.1035	0.1036

Table 9. Supply chain risk and firm policies

We explore how SCRisk and SCSentiment at *t-1* affect firms' inventories, sales growth, investment, cost of goods sold, and employment at *t+1*. Firm controls include size, Tobin's Q, cash holdings, and cash flow. The unit of observation is a firm-year. Industries are classified at the three-digit level. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1) CapEx/K	(2) Inventories	(3) Sales Growth	(4) COGS	(5) Log(emp)
Supply chain risk	0.4935*	0.0807**	-0.4517*	0.7733	0.0266
	(0.2814)	(0.0374)	(0.2711)	(0.8783)	(0.1876)
Supply chain sentiment	0.0247	0.0073	0.0299	0.0348	0.0378
	(0.0212)	(0.0049)	(0.0215)	(0.0538)	(0.0230)
Size	-0.0363***	-0.0178***	-0.0418***	0.0199	0.3559***
	(0.0064)	(0.0014)	(0.0082)	(0.0362)	(0.0100)
Tobin's Q	0.0536***	0.0010***	0.0518***	-0.0046	0.0244***
	(0.0037)	(0.0004)	(0.0040)	(0.0252)	(0.0028)
Cash holdings	0.4001***	-0.0913***	0.1201***	0.6118***	-0.1298***
	(0.0288)	(0.0047)	(0.0323)	(0.1654)	(0.0234)
Cash flow	0.2780***	0.0044	-0.3486***	-1.1775***	-0.1305***
	(0.0243)	(0.0029)	(0.0388)	(0.2001)	(0.0145)
Firm FE	Y	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y	Y
Observations	31,130	31,130	31,130	31,130	31,130
Adjusted R-squared	0.3927	0.9389	0.2111	0.5947	0.9768

Table 10. Supply chain risk and the composition of supply chains

This table reports estimates of the effects of a firm's SCRisk and SCSentiment at *t-1* on its number of suppliers at *t*. The dependent variables in columns 1 to 4 are the number of suppliers, the number of suppliers in the same continent as the firm, the number of U.S. suppliers, and the number of suppliers that are industry leaders, respectively. Industry leaders are defined as suppliers with sales above the median of their 3-digit SIC industry. Firm controls include size, Tobin's Q, cash holdings, and cash flow. The unit of observation is a firm-year. Industries are classified at the three-digit level. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	12.6021**	9.4728***	9.2587***	4.6798*
	(5.8838)	(3.3094)	(3.1661)	(2.6617)
Supply chain sentiment	0.8698	0.5228	0.6286*	0.4089
	(0.7005)	(0.3614)	(0.3451)	(0.2856)
Size	1.9314***	1.0597***	1.0011***	1.0127***
	(0.1969)	(0.0991)	(0.0926)	(0.0853)
Tobin's Q	0.0554	-0.0097	0.0158	0.0300
	(0.0586)	(0.0291)	(0.0269)	(0.0247)
Cash holdings	-0.0622	-0.5455*	-0.4832*	-0.5770**
	(0.5047)	(0.2931)	(0.2734)	(0.2365)
Cash flow	-1.6498***	-0.9261***	-0.9290***	-0.8932***
	(0.3047)	(0.1873)	(0.1759)	(0.1442)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	31,130	31,130	31,130	31,130
Adjusted R-squared	0.8570	0.7989	0.8033	0.8590

Table 11. Supply chain risk and vertical M&As

This table reports estimates of the effects of SCRisk at *t-1* on the probability that a firm is involved in M&As at *t*. The dependent variables in columns (1) and (2) are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm in an upstream or downstream industry, respectively. The dependent variable in column (3) is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is not in an upstream or downstream industry. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.3591***	0.2793**	0.2501
	(0.1330)	(0.1236)	(0.3025)
Supply chain sentiment	-0.0174***	-0.0148**	0.0007
	(0.0064)	(0.0062)	(0.0294)
Size	-0.0026**	-0.0032***	0.0056
	(0.0012)	(0.0009)	(0.0067)
Tobin's Q	0.0006*	0.0005	0.0074***
	(0.0004)	(0.0003)	(0.0023)
Cash holdings	0.0015	0.0003	0.1740***
	(0.0033)	(0.0031)	(0.0272)
Cash flow	0.0048**	0.0049***	0.1293***
	(0.0020)	(0.0017)	(0.0152)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1168	0.1059	0.2109

Table 12. Supply chain risk, financial constraints, and vertical integration

This table reports estimates of the effects of SCRisk at *t-1* on firms' M&As at *t* using different measures of firms' financial constraints. Panel A and B use the Hadlock and Pierce (2010) and Whited-Wu (2006) measures, respectively, to define financial constraints. The dependent variables in columns (1) and (2) are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column (3) is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm from neither an upstream nor a downstream industry. The unit of observation in each regression is a firm-year. Firm controls include supply chain sentiment, size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Panel A: Hadlock-Pierce financial constraint measure			
Supply chain risk	0.5598***	0.4308**	0.6535
	(0.2071)	(0.1928)	(0.4137)
HP FC dummy	0.0020	0.0016	-0.0183*
	(0.0023)	(0.0023)	(0.0106)
Supply chain risk x HP FC dummy	-0.5072**	-0.3830*	-1.0116*
	(0.2213)	(0.2074)	(0.5653)
Firm controls	Y	Y	Y
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1173	0.1062	0.2112
Panel B: Whited-Wu financial constraint measure			
Supply chain risk	0.5973***	0.4977**	0.5451
	(0.2254)	(0.2169)	(0.4544)
WW FC dummy	0.0003	0.0006	-0.0089
	(0.0019)	(0.0018)	(0.0084)
Supply chain risk x WW FC dummy	-0.4873**	-0.4471*	-0.5976
	(0.2462)	(0.2302)	(0.5894)
Firm controls	Y	Y	Y
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1174	0.1064	0.2110

Table 13. Exogenous variation in supply chain risk and corporate policies

We capture an exogenous increase in supply chain risk due to the 2011 Great East Japan earthquake and the Thailand floods and consider the effects on firms' M&As and supply chain composition in Panel A and Panel B, respectively. We consider supply chain risk to increase between 2011 and 2014, as captured by the dummy *Post*, for firms with suppliers in Thailand or Japan, as captured by the dummy *Treated*. In Panel A, the dependent variables in columns (1) and (2) are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or a downstream industry, respectively. Upstream and downstream industries are defined according to the Bureau of Economic Analysis's (BEA) Input-Output tables. The dependent variable in column (3) is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm from neither an upstream nor a downstream industry. In Panel B, the dependent variables in columns 1 to 4 are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. Firm controls include supply chain sentiment, size, Tobin's Q, cash holdings, and cash flow. The unit of observation is a firm-year. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms'M&As			
	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Treated x post	0.0062**	0.0058**	0.0113
	(0.0027)	(0.0026)	(0.0110)
Supply chain sentiment	-0.0232**	-0.0211**	0.0029
	(0.0105)	(0.0100)	(0.0443)
Size	0.0008	-0.0001	0.0098**
	(0.0009)	(0.0008)	(0.0045)
Tobin's Q	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0001)
Cash holdings	0.0001	0.0003	0.1003***
	(0.0019)	(0.0016)	(0.0134)
Cash flow	0.0000	0.0001	0.0004
	(0.0001)	(0.0001)	(0.0006)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	28,026	28,026	28,026
Adjusted R-squared	0.1273	0.1024	0.2463

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Treated x post	2.1257***	0.4561**	0.3305*	0.6708***
	(0.6005)	(0.2224)	(0.1986)	(0.2183)
Supply chain sentiment	1.4477	0.1026	0.3243	0.0863
	(1.3542)	(0.7338)	(0.4655)	(0.6357)
Size	0.9063***	0.4638***	0.5081***	0.4535***
	(0.1747)	(0.0712)	(0.0678)	(0.0688)
Tobin's Q	0.0057***	0.0029***	0.0029***	0.0023***
	(0.0020)	(0.0008)	(0.0007)	(0.0007)
Cash holdings	-0.5740	-0.4155***	-0.4063***	-0.3323**
	(0.5694)	(0.1505)	(0.1421)	(0.1624)
Cash flow	-0.0380	-0.0313***	-0.0308***	-0.0312***
	(0.0257)	(0.0116)	(0.0091)	(0.0105)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	28,026	28,026	28,026	28,026
Adjusted R-squared	0.8586	0.9396	0.9489	0.9154

Table 14. Supply chain risk vs political risk and climate risk

This table reports estimates of the effects of SCRisk at *t-1* on firms' M&As and number of suppliers at *t* in Panel A and Panel B, respectively, controlling for two other sources of risk, political risk and climate risk. The Political risk measure is taken from Hassan et al. (2019). The Climate risk measure is taken from Sautner et al. (2022). The dependent variables in columns (1) and (2) of Panel A are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column (3) of Panel A is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is neither in an upstream nor a downstream industry. The dependent variables in columns 1 to 4 of Panel B are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As			
	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.3614***	0.2804**	0.2604
	(0.1328)	(0.1233)	(0.3027)
Supply chain sentiment	-0.0176***	-0.0150**	0.0003
	(0.0064)	(0.0061)	(0.0294)
Size	-0.0026**	-0.0032***	0.0057
	(0.0012)	(0.0009)	(0.0067)
Tobin's Q	0.0006*	0.0005	0.0074***
	(0.0004)	(0.0003)	(0.0023)
Cash holdings	0.0014	0.0003	0.1741***
	(0.0033)	(0.0031)	(0.0272)
Cash flow	0.0047**	0.0048***	0.1292***
	(0.0019)	(0.0017)	(0.0152)
Political risk	-0.4856	-0.2497	-2.1370
	(0.4881)	(0.4551)	(2.3332)
Climate risk	-0.1485*	-0.1408*	0.0418
	(0.0891)	(0.0755)	(0.3479)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1169	0.1060	0.2109

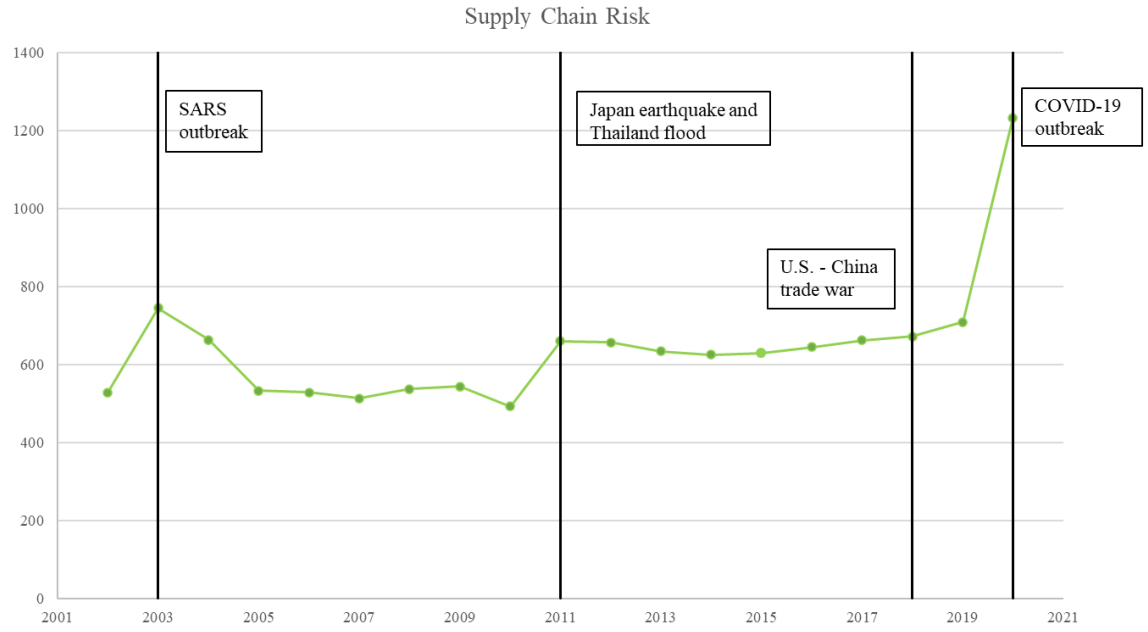
Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	12.4817**	9.3635***	9.1420***	4.6009*
	(5.8746)	(3.3069)	(3.1636)	(2.6590)
Supply chain sentiment	0.8768	0.5274	0.6328*	0.4134
	(0.7007)	(0.3615)	(0.3451)	(0.2855)
Size	1.9301***	1.0592***	1.0008***	1.0118***
	(0.1969)	(0.0991)	(0.0925)	(0.0853)
Tobin's Q	0.0552	-0.0096	0.0160	0.0298
	(0.0586)	(0.0291)	(0.0269)	(0.0247)
Cash holdings	-0.0624	-0.5466*	-0.4848*	-0.5772**
	(0.5047)	(0.2931)	(0.2734)	(0.2365)
Cash flow	-1.6469***	-0.9249***	-0.9283***	-0.8914***
	(0.3047)	(0.1873)	(0.1758)	(0.1442)
Political risk	25.2149	22.5938	24.0107	16.5069
	(37.9486)	(23.7291)	(22.1246)	(16.4078)
Climate risk	2.3376	-1.3165	-2.6434	1.3297
	(6.3511)	(3.7087)	(3.2780)	(2.5213)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	31,130	31,130	31,130	31,130
Adjusted R-squared	0.8570	0.7989	0.8033	0.8590

Appendix A Variable definitions

Variables	Definition
SCRisk	Firm-level supply chain risk measure constructed from 8K filings
SCSentiment	Firm-level supply chain sentiment measure constructed from 8K filings
Realized Volatility	Firm's standard deviation of daily returns in a year
Different continents	Fraction of a firm's suppliers located in a continent different from that of the firm over the total number of suppliers
Relative size	Total assets of the focal firm scaled by the average total assets of its suppliers
Average number of suppliers by industry	The average of a firm's number of suppliers by input industry
Market share	Firm's sales scaled by the 3-digit SIC industry's total sales
Financial constraint	A dummy variable that equals one if the firm's Whited-Wu (2006) measure for financial constraints is above sample median
Institutional ownership	Fraction of shares owned by financial institutions
Size	Natural logarithm of total assets
Tobin's Q	Assets minus cash and cash equivalent securities plus book value on equity scaled by assets
Cash holdings	Cash and cash equivalent securities scaled by total assets
Cash flow	Operating cash flow scaled by total assets
Inventories	Inventories scaled by total assets
Sales growth	Growth rate of sales from year t-1 to year t
COGS	Cost of goods sold scaled by total sales
CapEx/K	Capital expenditures scaled by property, plant and equipment
Log(emp)	Natural logarithm of the number of employees
Number of suppliers	A firm's total number of suppliers
Number of suppliers in the same continent	The total number of suppliers in the same continent as the firm
Number of U.S. suppliers	A firm's total number of suppliers in the U.S.
Number of industry leader suppliers	A firm's total number of suppliers with sales above the median of their 3-digit SIC industry
M&A with supplier	A dummy variable that equals one if the firm conducts an M&A with a firm from an upstream industry according to the Bureau of Economic Analysis's (BEA) Input-Output tables.
M&A with customer	A dummy variable that equals one if the firm conducts an M&A with a firm from a downstream industry according to the Bureau of Economic Analysis's (BEA) Input-Output tables.
Unrelated M&As	A dummy variable that equals one if the firm conducts an M&A with a firm from neither an upstream nor a downstream industry
Political risk	Political risk measure from Hassan et al. (2019)
Climate risk	Climate risk measure from Sautner et al. (2022)

Internet Appendix
Figure IA.1
This figure shows the mean of SCRisk and SCSentiment, constructed using the 8K filings, along with indicators for key events related to supply chain shocks.

Panel A. SCRisk



Panel B. SCSentiment

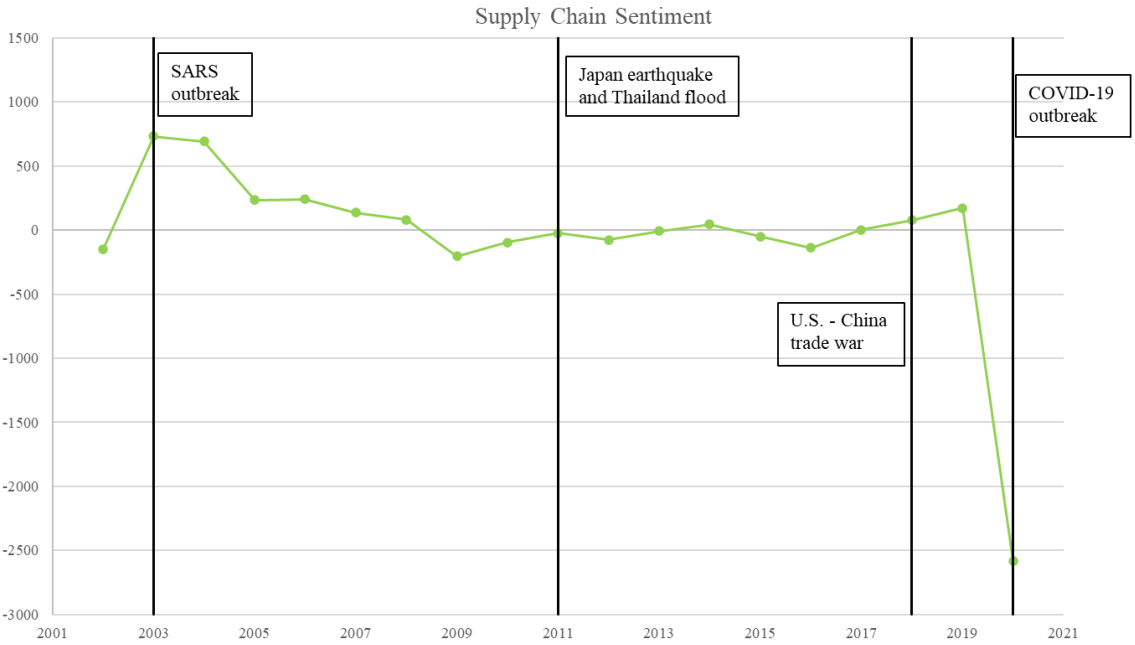
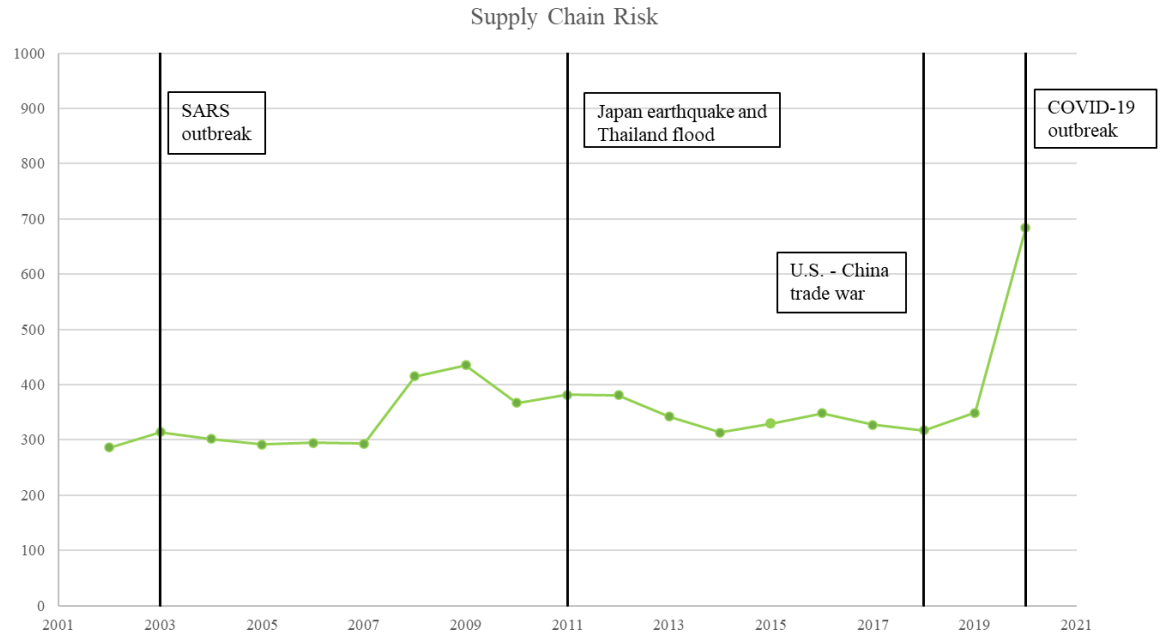


Figure IA.2
This figure shows the mean of SCRisk and SCSentiment, constructed using bigrams from the 3rd edition of the supply chain textbook, along with indicators for key events related to supply chain shocks.

Panel A. SCRisk



Panel B. SCSentiment



Table IA.1. Synonyms of risk words

This table reports all synonyms of "risk," "risky," "uncertain," and "uncertainty" found when constructing SCRisk. Oxford Dictionary is used to identify the synonyms following Hassan et al. (2019).

Synonyms of risk words			
ambivalence	fear	niggle	treacherous
ambivalent	fickleness	oscillating	tricky
apprehension	fitful	parlous	uncertain
bet	fitfulness	pending	uncertainties
chance	fluctuant	peril	uncertainty
chanciness	fluctuating	perilous	unclear
chancy	gamble	perilousness	unconfident
changeability	gnarly	possibility	undecided
changeable	hairy	precarious	undependable
changeableness	halting	precariousness	undetermined
changeful	hazard	probability	unforeseeable
chariness	hazardous	prospect	unknown
danger	hazy	qualm	unpredictability
dangerous	hesitancy	quandary	unpredictable
debatable	hesitant	queries	unreliability
defenseless	hesitating	query	unreliable
dicey	iffy	reservation	unresolved
diffidence	imperil	risk	unsafe
diffident	incalculable	risked	unsettled
dilemma	incertitude	riskier	unstable
disquiet	inconstancy	riskiest	unsure
disquietude	indecision	riskiness	unsureness
dodgy	indecisive	risking	untrustworthy
doubt	insecure	risks	vacillating
doubtful	insecurity	risky	vacillation
doubtfulness	instability	scruple	vague
dubiety	irregular	skepticism	vagueness
dubious	irresolute	speculative	variability
endanger	irresolution	sticky	variable
equivocating	jeopardize	suspicion	varying
equivocation	jeopardy	tentative	venture
erratic	likelihood	tentativeness	wager
exposed	menace	threat	wariness
faltering	misgiving	torn	wavering

Table IA.2. Variance decomposition of SCRisk and SCSentiment – alternative industry definitions

This table reports adjusted R-squared and R-squared from the projection of SCRisk and SCSentiment in Panel A and Panel B, respectively, on various sets of fixed effects, as indicated in the table. Industries are classified at the two-digit SIC code level in Panels A and B, and at the four-digit SIC code level in Panels C and D.

	(1)	(2)	(3)	(4)
		Panel A: SCRisk – 2-digit SIC		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0593	0.0241	0.1013	0.2022
R-squared	0.0598	0.0257	0.1272	0.3169
		Panel B: SCSentiment – 2-digit SIC		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0114	0.0831	0.1001	0.4016
R-squared	0.0119	0.0846	0.1259	0.4876
		Panel C: SCRisk – 4-digit SIC		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0593	0.0409	0.1381	0.2250
R-squared	0.0598	0.0502	0.2470	0.4143
		Panel D: SCSentiment – 4-digit SIC		
Year FE	Y			
Industry FE		Y		
Industry x year FE			Y	Y
Firm FE				Y
Adjusted R-squared	0.0114	0.1467	0.1640	0.4277
R-squared	0.0119	0.1550	0.2696	0.5675

Table IA.3. SCRisk and vertical M&As – alternative definitions of upstream and downstream industries

This table reports estimates of the effects of SCRisk on the probability that a firm is involved in an M&A. The dependent variables in columns (1) and (2) are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. A target firm is considered to be supplier (customer) if the acquirer's industry purchases (sells) at least one percent of its inputs (outputs) from (to) the target's industry. The dependent variable in column (3) is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is not in an upstream or downstream industry. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.2974**	0.1561*	0.0310
	(0.1261)	(0.0926)	(0.0405)
Supply chain sentiment	-0.0137**	-0.0107***	-0.0026*
	(0.0062)	(0.0041)	(0.0014)
Size	-0.0031***	-0.0012**	0.0001
	(0.0009)	(0.0005)	(0.0001)
Tobin's Q	0.0006	0.0006*	0.0000
	(0.0003)	(0.0003)	(0.0000)
Cash holdings	0.0020	-0.0027*	0.0001
	(0.0030)	(0.0014)	(0.0008)
Cash flow	0.0049**	0.0021**	0.0004
	(0.0019)	(0.0011)	(0.0004)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1000	0.0668	0.0587

Table IA.4. Exogenous variation in supply chain risk and firm policies-- Controlling for the propagation of negative shocks using sales

This table reports estimates of the effects of two natural disasters, the 2011 Great East Japan earthquake and the Thailand flood, which exogenously increased supply chain risk, on firms' M&As and supply chain composition in Panel A and Panel B, respectively. In Panel A, the dependent variables in columns (1) and (2) are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or a downstream industry, respectively. The dependent variable in column (3) is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm from neither an upstream nor a downstream industry. In Panel B, the dependent variables in columns 1 to 4 are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The independent variable, *Treated*, equals one for firms with a supplier in Japan or Thailand. The independent variable, *Post*, equals one between 2011 and 2014. Firm controls include supply chain sentiment, size, Tobin's Q, cash holdings, cash flow, and sales. The unit of observation in each regression is a firm-year. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As			
	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Treated x post	0.0062**	0.0058**	0.0113
	(0.0027)	(0.0026)	(0.0110)
Supply chain sentiment	-0.0234**	-0.0212**	0.0016
	(0.0105)	(0.0100)	(0.0443)
Size	0.0003	-0.0004	0.0062
	(0.0008)	(0.0008)	(0.0049)
Tobin's Q	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0001)
Cash holdings	0.0006	0.0006	0.1038***
	(0.0019)	(0.0017)	(0.0134)
Cash flow	0.0000	0.0001	0.0004
	(0.0001)	(0.0001)	(0.0006)
Sales	0.0008*	0.0005	0.0061*
	(0.0005)	(0.0004)	(0.0033)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	28,026	28,026	28,026
Adjusted R-squared	0.1272	0.1024	0.2463

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Treated x post	2.1259***	0.4565**	0.3309*	0.6712***
	(0.6004)	(0.2224)	(0.1985)	(0.2183)
Supply chain sentiment	1.4202	0.0618	0.2842	0.0552
	(1.3572)	(0.7344)	(0.4647)	(0.6365)
Size	0.8269***	0.3462***	0.3924***	0.3637***
	(0.2009)	(0.0756)	(0.0715)	(0.0737)
Tobin's Q	0.0054***	0.0025***	0.0025***	0.0020***
	(0.0020)	(0.0008)	(0.0007)	(0.0007)
Cash holdings	-0.4957	-0.2995*	-0.2923**	-0.2439
	(0.6032)	(0.1559)	(0.1475)	(0.1692)
Cash flow	-0.0375	-0.0306***	-0.0301***	-0.0306***
	(0.0256)	(0.0116)	(0.0090)	(0.0104)
Sales	0.1335	0.1977***	0.1945***	0.1509***
	(0.1159)	(0.0508)	(0.0489)	(0.0442)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	28,026	28,026	28,026	28,026
Adjusted R-squared	0.8586	0.9396	0.9490	0.9154

Table IA.5. Supply chain risk vs overall sentiment

This table reports estimates of the effects of SCRisk at *t-1* on firms' M&As and number of suppliers at *t* in Panel A and Panel B, respectively, controlling for the overall sentiment of a firm's earnings calls during year *t-1*. Overall sentiment is constructed by calculating the net sentiment in the whole earnings call transcript. The dependent variables in columns (1) and (2) of Panel A are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column (3) of Panel A is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is neither in an upstream nor a downstream industry. The dependent variables in columns 1 to 4 of Panel B are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.3600***	0.2791**	0.2689
	(0.1329)	(0.1235)	(0.3021)
Supply chain sentiment	-0.0180***	-0.0148**	-0.0114
	(0.0064)	(0.0062)	(0.0295)
Size	-0.0025**	-0.0033***	0.0084
	(0.0012)	(0.0010)	(0.0067)
Tobin's Q	0.0006*	0.0005	0.0081***
	(0.0004)	(0.0003)	(0.0023)
Cash holdings	0.0016	0.0003	0.1763***
	(0.0033)	(0.0031)	(0.0271)
Cash flow	0.0047**	0.0049***	0.1278***
	(0.0020)	(0.0017)	(0.0152)
Overall sentiment	0.0063	-0.0009	0.1326***
	(0.0054)	(0.0048)	(0.0294)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1168	0.1059	0.2114

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	12.2324**	9.6236***	9.4882***	4.7631*
	(6.0794)	(3.3809)	(3.2327)	(2.7121)
Supply chain sentiment	0.9977	0.5316	0.6352*	0.4355
	(0.7249)	(0.3700)	(0.3543)	(0.2919)
Size	1.9659***	1.0820***	1.0200***	1.0271***
	(0.2067)	(0.1017)	(0.0944)	(0.0870)
Tobin's Q	0.0542	-0.0079	0.0166	0.0303
	(0.0607)	(0.0296)	(0.0275)	(0.0250)
Cash holdings	-0.0186	-0.5341*	-0.4785*	-0.5722**
	(0.5173)	(0.2978)	(0.2798)	(0.2394)
Cash flow	-1.6640***	-0.9376***	-0.9428***	-0.8968***
	(0.3112)	(0.1896)	(0.1788)	(0.1454)
Overall sentiment	-0.6587	0.1097	0.0238	-0.1057
	(0.6378)	(0.3559)	(0.3326)	(0.2817)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	31,130	31,130	31,130	31,130
Adjusted R-squared	0.8586	0.8000	0.8045	0.8616

Table IA.6. Supply chain risk – replace noise with industry median

This table reports estimates of the effects of SCRisk at *t-1*, replacing firm-year observations with potential noise with the 2-digit SIC industry median of SCRisk, on firms' M&As and number of suppliers at *t* in Panel A and Panel B, respectively. The dependent variables in columns 1 and 2 of Panel A are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column 3 of Panel A is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is neither in an upstream nor a downstream industry. The dependent variables in columns 1 to 4 of Panel B are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.3442**	0.2620**	0.3373
	(0.1381)	(0.1273)	(0.3169)
Supply chain sentiment	-0.0174***	-0.0148**	0.0007
	(0.0064)	(0.0061)	(0.0294)
Size	-0.0026**	-0.0032***	0.0056
	(0.0012)	(0.0009)	(0.0067)
Tobin's Q	0.0006*	0.0005	0.0074***
	(0.0004)	(0.0003)	(0.0023)
Cash holdings	0.0015	0.0004	0.1739***
	(0.0033)	(0.0031)	(0.0272)
Cash flow	0.0048**	0.0049***	0.1293***
	(0.0020)	(0.0017)	(0.0152)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	31,130	31,130	31,130
Adjusted R-squared	0.1166	0.1057	0.2110

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	15.7422**	11.3351***	10.8104***	5.9615**
	(6.2733)	(3.4837)	(3.3773)	(2.8649)
Supply chain sentiment	0.9362	0.5415	0.6378*	0.4254
	(0.7272)	(0.3704)	(0.3535)	(0.2920)
Size	1.9804***	1.0803***	1.0201***	1.0296***
	(0.2050)	(0.1014)	(0.0945)	(0.0871)
Tobin's Q	0.0586	-0.0082	0.0167	0.0311
	(0.0606)	(0.0296)	(0.0274)	(0.0249)
Cash holdings	-0.0126	-0.5384*	-0.4806*	-0.5722**
	(0.5174)	(0.2981)	(0.2800)	(0.2394)
Cash flow	-1.6710***	-0.9363***	-0.9425***	-0.8979***
	(0.3109)	(0.1897)	(0.1790)	(0.1454)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	31,130	31,130	31,130	31,130
Adjusted R-squared	0.8586	0.8000	0.8046	0.8616

Table IA.7. Supply chain risk – omit noise

This table reports estimates of the effects of SCRisk at *t-1*, omitting firm-year observations in which SCRisk is more likely to be measured with noise, on firms' M&As and number of suppliers at *t* in Panel A and Panel B, respectively. We identify potential noise as a high probability of discussin of general financial issues related to supply chain risk in a company's earnings calls during a year. The dependent variables in columns 1 and 2 of Panel A are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column 3 of Panel A is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is neither in an upstream nor a downstream industry. The dependent variables in columns 1 to 4 of Panel B are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As

	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.3582**	0.2748**	0.2739
	(0.1395)	(0.1286)	(0.3249)
Supply chain sentiment	-0.0177***	-0.0146**	0.0031
	(0.0068)	(0.0065)	(0.0307)
Size	-0.0026**	-0.0033***	0.0066
	(0.0013)	(0.0010)	(0.0070)
Tobin's Q	0.0004	0.0003	0.0085***
	(0.0004)	(0.0003)	(0.0024)
Cash holdings	-0.0001	-0.0013	0.1552***
	(0.0034)	(0.0032)	(0.0286)
Cash flow	0.0039*	0.0041**	0.1328***
	(0.0020)	(0.0017)	(0.0160)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	27,481	27,481	27,481
Adjusted R-squared	0.1148	0.1033	0.2082

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	14.7618**	9.8679***	10.3344***	5.4383*
	(6.3802)	(3.5498)	(3.4450)	(2.9024)
Supply chain sentiment	0.6449	0.4196	0.5329	0.3597
	(0.7516)	(0.3937)	(0.3781)	(0.3108)
Size	2.0074***	1.0784***	1.0049***	1.0234***
	(0.2059)	(0.1046)	(0.0970)	(0.0869)
Tobin's Q	0.0495	-0.0117	0.0186	0.0293
	(0.0615)	(0.0299)	(0.0272)	(0.0248)
Cash holdings	-0.0327	-0.6448**	-0.5707**	-0.6116**
	(0.5274)	(0.3066)	(0.2873)	(0.2423)
Cash flow	-1.7246***	-0.9470***	-0.9331***	-0.8867***
	(0.3166)	(0.1952)	(0.1822)	(0.1475)
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	27,481	27,481	27,481	27,481
Adjusted R-squared	0.8611	0.8019	0.8046	0.8639

Table IA.8. Supply chain risk – measured by 8-K filings

This table reports estimates of the effects of supply chain risk and supply chain sentiment, measured from 8-K filings, at *t-1* on firms' M&As and number of suppliers at *t* in Panel A and Panel B, respectively. The dependent variables in columns (1) and (2) of Panel A are *M&A with supplier* and *M&A with customer*, which are indicator variables that equal one if the firm conducts an M&A with a firm from an upstream or downstream industry, respectively. The dependent variable in column (3) of Panel A is *Unrelated M&A*, which is an indicator variable that equals one if the firm conducts an M&A with a firm that is neither in an upstream nor a downstream industry. The dependent variables in columns 1 to 4 of Panel B are number of suppliers, number of suppliers in the same continent as the firm, number of U.S. suppliers, and number of industry leader suppliers, respectively. The unit of observation in each regression is a firm-year. Firm controls include size, Tobin's Q, cash holdings, and cash flow. All variables are defined in Appendix A. Robust standard errors clustered by firm are in parentheses. Statistical significance at the 1%, 5%, and 10% level is denoted by ***, **, and *, respectively.

Panel A: Firms' M&As			
	(1) M&A with supplier	(2) M&A with customer	(3) Unrelated M&As
Supply chain risk	0.1559***	0.1440***	0.2505
	(0.0529)	(0.0485)	(0.2070)
Supply chain sentiment	-0.0101	-0.0086	0.0142
	(0.0071)	(0.0062)	(0.0361)
Size	-0.0007*	-0.0009***	0.0082***
	(0.0004)	(0.0003)	(0.0026)
Tobin's Q	0.0000	-0.0000	0.0001*
	(0.0000)	(0.0000)	(0.0000)
Cash holdings	0.0013	0.0008	0.0736***
	(0.0009)	(0.0008)	(0.0081)
Cash flow	0.0001**	0.0001***	0.0013***
	(0.0000)	(0.0000)	(0.0004)
Firm FE	Y	Y	Y
Industry x year FE	Y	Y	Y
Observations	65,098	65,098	65,098
Adjusted R-squared	0.1115	0.1014	0.2105

Panel B: Supply chain composition				
	(1)	(2)	(3)	(4)
	Number of suppliers	Number of suppliers in the same continent	Number of U.S. suppliers	Number of industry leader suppliers
Supply chain risk	10.7508***	3.8010*	3.3097*	3.4726**
	(3.2988)	(2.0019)	(1.9781)	(1.6106)
Supply chain sentiment	-0.7461	0.5911*	0.6143*	-0.0160
	(0.5987)	(0.3375)	(0.3390)	(0.2839)
Size	0.9949***	0.4733***	0.4675***	0.4756***
	(0.0567)	(0.0304)	(0.0295)	(0.0286)
Tobin's Q	0.0042***	0.0004	0.0004	0.0015***
	(0.0009)	(0.0006)	(0.0006)	(0.0004)
Cash holdings	-0.2456*	-0.2720***	-0.2732***	-0.2367***
	(0.1306)	(0.0735)	(0.0714)	(0.0655)
Cash flow	-0.0535***	-0.0497***	-0.0495***	-0.0329***
	(0.0088)	(0.0056)	(0.0055)	(0.0040)
	10.7508***	3.8010*	3.3097*	3.4726**
Firm FE	Y	Y	Y	Y
Industry x year FE	Y	Y	Y	Y
Observations	65,098	65,098	65,098	65,098
Adjusted R-squared	0.8339	0.7802	0.7879	0.8291