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Till Death Do Us Part: Relationship shocks, supply chain organization and firm performance*

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Abstract

Within modern economies firms are embedded in often complex supply chains, creating strong interdependencies between firms. But what happens when these supply chains are disrupted, what changes does this bring about? We answer these questions, focusing on what happens when connections between companies exogenously break because of the unexpected death of the CEO within one of the firms. We rely on detailed data from the TSR which provides firm-level measures of start and exit dates of CEOs along with buyer-supplier linkages. This data is matched to detailed statistics on Japanese firms which enables us to identify the effects of such leadership changes on supplier networks and subsequent performance. We find that such deaths promote the churning of suppliers but not of customers of the firm and therefore that these shocks propagate towards upstream firms through the supply chain. There is also evidence that this affects the short-term performance of indirectly affected firms as the shock propagates backwards along the supply chain.

Keywords: CEO change, supply chain, Japan, firm, productivity
JEL classification: D22, L23, L25, M12, O33

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1. Introduction

The supply chains that support the production of goods and services in any modern economy rely on a dense web of interdependencies between firms. These become more complex as the firms involved become larger, more productive, and the goods and services being produced rely on advanced technologies. The economics literature has understood these networks using the concept of incomplete contracts in intermediate good and service production (Helpman, 2006). But what happens when these supply chains are disrupted, what types of change do they bring about? Are the effects negative? Where do the effects of the shock end-up? And are these effects persistent? Those are the questions that we seek to answer in this paper.

Research on these issues is difficult due to a lack of representative datasets on firm input-output linkages. Even when such data exists, controlling for endogeneity bias remains a substantial hurdle. Firms do not make changes to their supply chains without sound business reasons and are likely to do so only if the benefits of a new supplier exceed the costs of finding and adjusting to them. Relationships between firms can break for many different reasons including the transmission of negative productivity shocks along the existing supply chain or other unobservable changes such as the under-investment in production processes and failures in its management.[1] Aspects of the performance of firms may therefore deteriorate for reasons unobservable to the econometrician that may also cause breaks in business relationships.

The objective of this paper is to shed light on the nature of supplier networks and examine the extent to which exogenous breaks the firm's buy-supplier relationships impact subsequent performance. This study starts by using rich firm-level input-output information in Japan to study

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[1] For example, when Nissan Motor Corporation, which had been struggling with poor performance in the 1990s, became a subsidiary of French automaker Renault, the existing parts suppliers were substantially reorganized under the leadership of Chief Operating Officer Carlos Ghosn, who was sent from Renault. Ghosn announced the "Nissan Revival Plan" in 1999, in which Nissan and Renault promoted joint purchasing of parts and decisively implemented reforms to reduce the number of parts suppliers by 40% and purchasing costs by 20%. These reforms led to a V-shaped recovery in Nissan's business performance in a short period of time. While Nissan's major suppliers are said to have been severely affected by the reforms, there has been some progress in business restructuring on the parts suppliers, such as expanding supplies to non-Nissan automakers and pursuing strategic alliances with overseas competitors to utilize the management resources of other companies.

supply-chain links, data previously used by Carvalho et al. (2021) and Boehm et al. (2019). Our identification strategy relies uses unexpected death of CEOs to confront the endogeneity of supply chain changes. Within the business literature it has long been recognized that in order to build and maintain the necessary trust and methods of working that are mutually beneficial, supply-chain relationships are supported by the intangible investments the parties make in building and maintain human relationships. This could include the purchase of gifts, business dinners, but may take many and varied forms. Typically, the investments made in these human relationships are made between more senior levels of management the greater is importance the input in the overall production process and to the sales of one of the firms. Unexpected deaths within the senior management, we focus on the death of the CEO, exogenously reduce the stock of goodwill between firms and therefore make it more likely that the business relationship will end. We use these unexpected CEO deaths to predict supply chain changes by firms that are suppliers to this affected firm. These are firms that are only affected by the CEO death through their supply-chain connection, and then study how the performance of the firm responds.

The use of CEO deaths to identify changes in network structures is rare, but the broader idea of unexpected deaths has been used to study questions as varied as the productivity of researchers in science (Azoulay et al., 2019). One of the few exceptions can be found in Intintoli et al. (2017), who, using data from U.S. listed companies, show that human relationships to be important within supply chains. When the CEO of a major customer is replaced, the supplier firm's sales to that customer decreased significantly.

There is a small but growing literature on supply chains, at least for the relatively small number of countries that make available data of this type. In particular country is Japan which is the context for this study. The central question in much of this analysis has been the role that supply chains play in generating aggregate fluctuations to the economy and therefore how resilient supply chains are in the event of such shocks and their propagation through supply chains. These are largely driven by questions of interest within macroeconomics and therefore the resulting research has focused on large and catastrophic negative events. Below is a summary of the papers in this literature along with key findings.

An important starting point when studying the effects of supply chain disruptions is to first identify who is affected by shocks of this type, are the effects confined to firms directly affected by the event or did they spread along supply chains. The evidence appears to point to both. A number of studies have shown that when firms were affected by natural disasters, there was a negative impact not only on the affected firms but also on the sales and production of their downstream/upstream firms (e.g., Barrot and Sauvagnat 2016, Boehm et al. 2019, Kashiwagi et al. 2021). Carvalho et al. (2021) found that sales of firms that are customers or suppliers of firms affected by the Great East Japan Earthquake declined. Barrot and Sauvagnat (2016) find that customers of suppliers hit by a natural disaster experienced a drop in sales growth following the event. Moreover, they find that the negative impact is significantly stronger when the affected supplier produces differentiated goods. Boehm et al. (2019) show that US firms that imported intermediate inputs from Japan suffered large drops in production following the 2001 Tohoku earthquake, suggesting that in input linkages with strong complementarities it is unable to substitute to alternative inputs in the short run. Kashiwagi et al. (2021) find that direct links with suppliers and customers suffered from a hurricane decreased the sales growth of firms within the United States, while the effect on firms outside the United States was not significant. Kashiwagi et al.'s (2021) results suggest that negative economic shocks by a hurricane propagate through domestic supply chains, which is consistent with the evidence from the Great East Japan Earthquake (Carvalho et al., 2021). We build off of this literature by digging below the aggregate surface and exploiting micro-level shocks within buyer-supplier relationships to examine how this reshapes networks both directly and indirectly.

Direct and indirect shocks do not necessarily have only negative effects though. Sudden shocks may promote business restructuring and firms may therefore end up in a better position in the long run. Although there are scattered examples of such cases, empirical evidence based on statistical analysis using large-scale data is still scarce. One of the few exceptions can be found in the previously mentioned paper by Intintoli et al. (2017). They show that when the CEO of a major customer is replaced, the supplier firm's sales to that customer decreased significantly. These losses are greater when an incumbent customer CEO is more likely to be entrenched and stem largely from the successor divesting assets. Finally, they document that losses in sales following a customer CEO turnover lead to declines in a supplier's financial performance and that suppliers experience negative abnormal stock returns to announcements of customer CEO departures.

We also build on a small literature studying the effects of sudden CEO deaths, although these have all been on the effects directly on the affected firm. Lee et al. (2020) assess the implications of a founding CEOs' sudden deaths in public firms. They find that the exogenous change from a founder CEO to a professional CEO is associated with a 43.8% decrease in a firm's citation-weighted patent count, suggesting that founder CEOs are better managers of innovations than professional CEOs. Izumi and Kwon (2015) find that CEO forced turnover is led by return on assets (ROA) deterioration in both the United States and Japan. However, CEO forced turnover is followed by ROA improvement only in the United States. CEO age is also found to negatively influence firm risk. For example, large decreases in CEO age after sudden CEO deaths lead to significant increases in stock return volatility (Trabert 2023).[2] The results also imply that the higher stock return volatility associated with younger CEOs can be attributed to the increased uncertainty due to the market's lack of knowledge about the new CEOs' abilities.

Research on supply chain linkages also relates to the literature on the boundaries of the firm. Indeed, research studying complex patterns in the international trade of intermediate inputs that result from these different offshoring strategies spurred on the development of new theories of international trade. The basis for many of these models of offshoring, including those by Antras (2003), Antras and Helpman (2004), has been the property rights models of firm boundaries outlined in Grossman and Hart (1986) and Hart and Moore (1990). Important within this approach are the concepts of incomplete contracts and the idea that some investments are highly specific to the production of a particular input (Helpman, 2006). Those parties with a weak outside option, and therefore weak bargaining power in the ex-post renegotiation to set prices and bargain over rents that occurs, fear being 'held-up' and not receiving the full marginal return on their investment. For inputs where these investments are a feature, the optimal integration strategy depends on the

[2] Trabert (2023) addresses the endogeneity issue using the propensity score matching method and conducts the PSM-DID analysis.

party realizing the specific investment, where that party should control ownership rights. The more important is the relationship specific investment made by the purchaser of the input, the more likely it is that the optimal allocation of property rights will point to supply through a vertically integrated affiliate. In contrast, when the relationship specific investment made by the supplier is the relatively more important, the more likely it is that the firm will outsource production of the input.

Tests of the property rights model of firm boundaries as applied to offshoring are typically conducted using the share of trade between affiliates in total imports as the dependent variable (see for example Antras, 2003; Yeaple, 2006; Marin, 2006; Bernard et al., 2010 and Costinot et al., 2009). The share of trade between affiliates and the extent of vertical integration has been found to positively correlate with variables believed to capture the relationship specific investments made by the supplier. The measures of supplier relationship specific investments used in these models include the capital intensity of the export industry (Antras, 2003; Yeaple, 2006; Marin, 2006; Bernard et al., 2010 and Costinot et al., 2009) human capital (Antras, 2003; Yeaple, 2006; Nunn and Trefler, 2008 and Bernard et al., 2010), R&D (Yeaple, 2006; Costinot et al., 2009), and product contractibility of the input, measured by the level of intermediation (Bernard et al., 2010).

This positive relationship between relationship specificity and the share of intra-firm trade in total imports found in many of the above studies, contrasts with evidence for domestic outsourcing versus domestic vertical integration reported by Acemoglu et al. (2010). Using a combination of information on the industry of UK firms, the industry of their UK plants and input output tables, Acemoglu et al. (2010) generate a measure of the mode of supply according to whether a firm owns a domestic plant producing an input used in the production of a given product. Their results show that the probability of vertical integration in the domestic economy is negatively correlated with both the R&D and capital intensity of the input supplier.

To preview the main results from the paper. Focusing initially on the firms in which the unexpectedly CEO dies (in practice, we focus on the unexpected CEO changes due to sudden death or illness because only focusing on CEO death cases reduces the sample size substantially), our results suggests this promotes the churning of suppliers. There is an increase in both the number of new suppliers and dropped suppliers, leaving the overall number of suppliers unchanged. There is no similar effects on the number of customers. This type of shocks therefore propagates backwards through the supply chain. We also consider the how the performance of these firms is affected by the death of their CEO, finding no effects. This is important as it suggests that any effects on the performance of other firms are explained by changes in business relationships rather than other types of shocks within the directly affected firm spilling out to other firms.

Given the evidence that firms in which the CEO dies are more likely to change their suppliers, we next focus our attention on what happens to the performance of these suppliers. The results suggest that firms respond to the death of the CEO in their top customer by reducing employment and material purchases in the short-run. This results in increases in value added and therefore both labour and total factor productivity. Other than an effect on material purchases these short-run effects disappear over the longer-run, suggesting no long lasting impact. There is also some evidence of heterogeneity in these effects, with the more negative employment and material purchase changes occurring in initially large firms (when measured by employment). Of interest when accounting for heterogeneity associated with initial size there is evidence of longer lasting impacts on performance. The change in material purchases and value added suggests that firms push the short-run effects of the shock further back along the supply chain. We find evidence consistent with this. Upstream shocks tend to promote churning of the number of customers of the indirectly affected firm.

The rest of the paper continues as follows. The next section discusses the data used for our analysis while section 3 presents our empirical framework. The results are assessed in section 4 reports the results and a summary of the main results and policy considerations are given in section 5.

2. Data

2.1 The Tokyo Shoko Research (TSR) data

Our main source of data on buyer-supplier relationships and names of firms' CEO, board members and shareholders come from Tokyo Shoko Research Ltd. (TSR), a private credit rating agency in Japan. Firms provide information to TSR to obtain credit scores for loans. Covering almost all firms with over 4 employees in Japan, the TSR data contains annual information on roughly 1 million firms, including employment, sales, location, its founding year, number of establishments and their main (4-digit) industry (up to 3).[3] According to Kodama and Li (2018), the 2014 TSR data covers 66% of firms and 70% of employment, compared to the 2014 Economic Census for Business Frame.

In this paper, we use both the TSR Company Information Database and the TSR Company Linkage Database where importantly for this work, the latter importantly provides information on firm-to-firm relationships. Each firm surveyed by the TSR was asked to report the names of its top 24 suppliers, top 24 customers, and 3 main shareholders. To avoid the "top 24" cutoff from limiting the sample coverage of the production network, we use a two-way matching method to maximize the number of links, using information reported by a customer about its suppliers and vice versa. Since a relationship with a customer or supplier can be reported by either end of a relationship, the number of customers (suppliers) of a supplier (customer) can be much greater than 24. In fact, the top supplier (customer) in our constructed network data in Japan has over 11,000 customers (12,000 suppliers) in 2019. The average numbers of customers and suppliers are 6.1 and 5.9 firms, respectively in 2019. The distribution of the customer-supplier links is very skewed, with most of the firms having substantially fewer customers and suppliers.

Although the TSR Company Linkage Database covers many small firms, there is no information on the value of transaction for each customer-supplier link unfortunately. While the 2006 TSR Company Linkage Database provides the ranking of customers or suppliers for each

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[3] The TSR coverage has improved over the sample period encompassing roughly 1.14 million firms in the 2007 and 1.51 million firms in 2019.

firm in order of transaction value, the Data since 2007 does not include information on rank order of transaction value. Therefore, by using the ranking information as of 2006 and assuming that the ranking did not change over time, we identify major suppliers/customers for each firm.

2.2 CEO death and illness information

Our data on CEO resignations due to sudden deaths or illness is taken from the Nikkei Telecom database. The Nikkei Telecom 21 database contains news article information from both the Nihon Keizai Shimbun (The Nikkei) along with other industry-specific newspapers and magazines published by Nikkei Inc.[4] The dataset therefore collates information from the leading sources of business and financial news in Japan.

Using this rich dataset, we identify CEO resignations due to sudden death or illness, and identified 258 cases (99 deaths and 159 illness cases) for the period from 2007 to 2019. Of these we exclude the cases where the age of the departing CEO was over 70, given that older CEOs might behave with a view to retiring in the near future (41 cases out of the 258 cases are dropped because of the CEO age). The names of firms and CEOs are used to merge the data CEO death/illness to the firm-level data in the TSR Company Information Database. In doing so, we are able to identify whether a firm experienced a change in their CEO due to sudden death and/or illness.[5]

2.3 The METI (Ministry of Economy, Trade and Industry) data

To capture standard measures of firm performance we use firm-level panel data collected annually by the Ministry of Economy, Trade and Industry (METI) with the Basic Survey of

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[4] Izumi and Kwon (2015) also utilize the Nikkei Telecom database to identify the cases of forced CEO replacement.

[5] In the TSR data, we observe the characteristics of "daihyousha," which is transplated as "representative of the firm." Although the definition of the "representative" is vague, most of firms report the name of "daihyo torishimariyaku" which can be translated into English as "representative directors" of a firm. In Japanese corporation law, a representative director is a person who can make decisions for the company and legally represent the company. In the TSR data, approximately 80% of firms report the name of "representative director" as the "representative" while 10+% of firms report that name of "manager" as the "representative." We assume that the "representative of the firm" in the TSR data is the CEO of the firm. For more details on the TSR's definition of a firm's "representative," see Appendix in Kodama and Li (2018).

Japanese Business Structure and Activities (BSJBSA). The survey contains detailed firm-level information such as their 3-digit industry, the number of employees, sales, purchases, exports, imports, the number of domestic and overseas affiliates or subsidiaries. The BSJBSA also contains information on firm financials including costs, profits, investment, debt, assets and R&D expenditures.

The survey is compulsory, covering all firms with at least 50 employees and 30 million yen of paid-in capital (roughly $300,000 USD) in the manufacturing, mining, wholesale and retail and other services sectors. Our sample period is between 2007 to 2019, covering approximately 23,000 firms annually, 10,000 of which are in the manufacturing sector.

2.4 TSR-BSJBSA-Matched Data

We match the METI's BSJBSA data with the CEO and customer/supplier information taken from the TSR data, using Corporate Numbers designated by the Japanese National which is a unique identifier to each firm. Since 2018, Statistics Bureau of Japan provided a business register, which provides correspondence tables between the Corporate Numbers and the firm identification codes in various firm-level databases.

As a result, we start by matching the BSABJA and the TSR data for the years 2018 and 2019, using the correspondence table between the permanent firm IDs in the BSJBSA and the Corporate Number and that between the permanent firm IDs in the TSR data and the Corporate Number. Because both the BSJBSA and the TSR data provide permanent firm ID codes, we can then match both datasets at the firm-level for the years prior to 2018. For firms where the Corporate Number was not available in 2018 and/or 2019, we match the BSJBSA and the TSR using firm names, telephone numbers, and mailing addresses.

While matching rates are considerably high at the start of the sample period (2007) at 94.4% this improves even further by the end of the sample period (2019) at 99.0%. Moreover, it is important to note that we focus on firms in the industries where the BSJBSA coverage is the highest. Namely, firms in manufacturing industries, wholesale and retail sectors, accommodation and food service activities, publishing, audiovisual and broadcasting activities, IT and other information services, legal and accounting activities, and administrative and support service activities. The number of treatment group firms and their industry distribution are shown in Table A1 in the Appendix.

3. Empirical Strategy

This paper relies on unexpected CEO changes due to their death or serious illnesses as an exogenous shock to predict of changes to supply chains. The first part of the analysis examines how unexpected CEO changes affect the organization of supply chain networks (as shown by Figure 1), and are able to rule out potential impacts through changes in firm demand for inputs or supply of their production. Namely, we focus on Firm A in Figure 1 and analyze how Firm A's CEO change affects the number of Firm A's suppliers or customers and Firm A's performance. The second part of our analysis examines the impact of these changes on downstream or upstream firms. In particular, we show how suppliers are affected by unexpected CEO changes in their major customers, as shown by Figure 2. We analyze how Firm A's major customer's CEO change affects Firm A's performance as well as Firm A's supplier/customer networks. We focus on supply chain impacts and present analysis of customer networks in the Appendix.

Figure 1. Unexpected CEO changes and supplier or customer chains

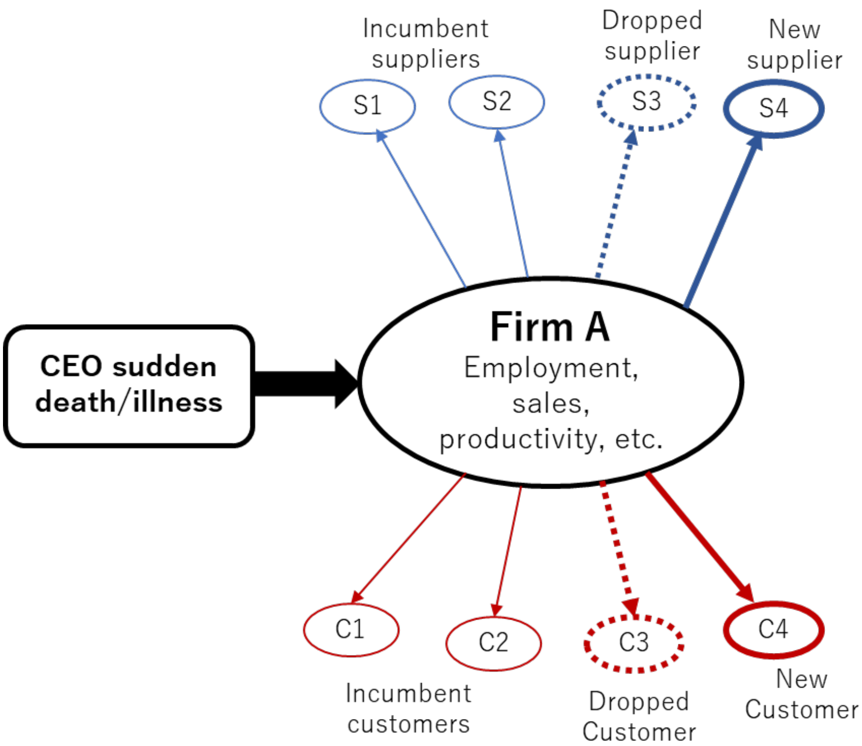
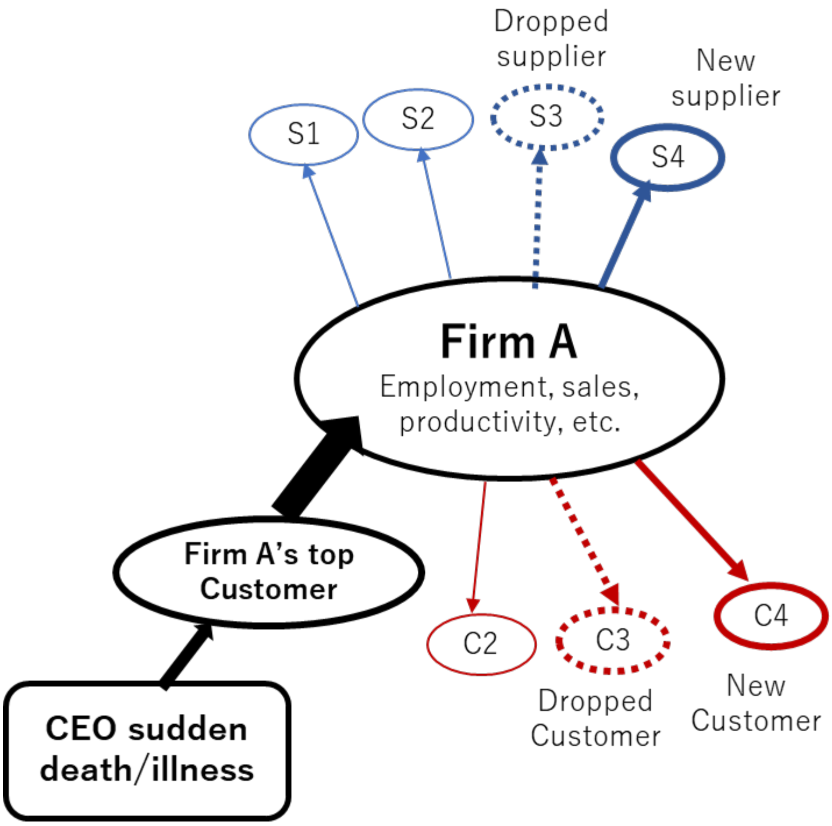


Figure 2. Effect of a firm's major customer's CEO death or illness on the firm's supplier or customer chains: Downstream shock



3.1 Unexpected CEO Changes and Supply Chain Reorganization

Our estimating equation relates reorganization in firm i's supply chains ($\Delta Supply\_Chain_{it}$) to unexpected CEO changes (ΔCEO_Death_{it}):

$$\Delta Supply\_Chain_{it} = \beta_0 + \beta_1 \Delta CEO\_Death_{it} + FE_t + \varepsilon_{it} \quad (1)$$

where Δ reflects a 1-year or a 5-year difference operator, $\Delta Supply\_Chain_{it}$ refers to a variety of measures of supply chain organization including: changes in the number of new suppliers added during the period or the number of dropped suppliers or the total number of suppliers per firm i, which allows us to contrast potential impacts on supply chains through demand/supply shocks versus the changes in the composition of these networks. We focus on log changes in our baseline specification but examine robustness with the log-like inverse hyperbolic sine transformation, which has the advantage of avoiding adding one to avoid dropping zero values (which we report in the Appendix)ΔCEO_Death_{it} takes the value one to reflect the unexpected CEO change during the same 1- or 5-year period and zero otherwise. FE_t denotes year fixed effects and standard errors are clustered at the firm-level.

We also examine the relationship between firm i's performance and unexpected CEO change by estimating the following equation:

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta CEO\_Death_{it} + FE_t + \varepsilon_{it} \qquad (2)$$

where Δ reflects a 1 year or a 5-year difference operator, ΔY_{it}, reflects various measures of firm performance including sales, employment, materials (M), value added (VA), labor productivity (LP) and total factor productivity (TFP)[6]. Our estimation uses differences within-firms, which accounts for any unobserved or slow-moving firm-level factors, as an alternative to including firm fixed effects. A recent literature has highlighted that two-way fixed effects (TWFE) estimation (for instance, through the inclusion of firm fixed effects) can be biased in the presence of staggered treatment effects, due to the presence of past-treated firms in the control group (e.g. Callaway and Sant'Anna, 2021). Our specification allows us to readily exclude firms treated in earlier periods, i.e. our estimation compares firms who experience an unexpected CEO change between *t-5* (or t-1) and *t* (but never experienced a CEO change up to *t*), to those that never experienced a CEO change for the whole period.

3.2 Impact on Upstream and Downstream Firms

We examine the downstream impact of these plausibly exogenous supply chains in two steps.

First, we present reduced form regressions on the impact of unexpected CEO changes in major customers ($\Delta Customer\_CEO\_Death_{it}$) on the performance of upstream firms (ΔY_{it}).:

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta Customer\_CEO\_Death_{it} + FE_t + \varepsilon_{it} \qquad (3)$$

[6] The TFP measure is estimated econometrically at the firm-level using the Wooldridge (2009) control function approach with value added as a measure of output.

where Δ reflects a 1 year or a 5-year difference operator, ΔY_{it} reflects various measures of firm performance including sales, employment, materials, value added, labor productivity and TFP. The key explanatory variable, $\Delta Customer\_CEO\_Death_{it}$ take the value one if at least one of the firm i's major customers experience a premature CEO death or major illness, and take the value zero otherwise. We use the TSR supply chain data at the start of our period (2006) to define major customers and employ various definitions: the largest customer, one of the largest 25% customers, and the largest 50% customers. Other terms are defined as in equation 1.

3.3 Exogeneity of Unexpected CEO Changes

We undertake a number of steps to justify that premature death or serious illness of CEOs is arguably exogenous. Firstly, out of a concern that CEO deaths may be anticipated, and so related to firm behavior before passing, we define premature as those deaths aged under 70 and examine robustness to using alternative thresholds following Azoulay et al (2019). Secondly, we check the data by hand to ensure that we exclude all the illnesses that may be the result of work-related stress and hence firm performance, such as suicide.

The Nikkei Telecom 21 database is the leading source of financial news in Japan, aggregating information from Nikkei financial newspapers and general national and regional newspapers. However, not all companies will release the news about their CEO death or illness to the press. To address the possible concern that the types of firms that release this news may have different trends to those that do not, we employ coarsened exact matching (CEM), following Azoulay et al (2019).

By employing the CEM method (Blackwell et al. 2009) we match our group of treatment firms (with unexpected CEO changes) to a control group (without CEO changes) that have similar initial characteristics. The control groups are selected such that these firms have similar age groups, size (employment), productivity, industry and initial numbers of customers and suppliers (see more details in the Appendix). Our choice of matching variables is motivated by Bernard et al (2019, 2022) and Trabert (2023) who find that these variables explain (cross-section) variation in buyer-supplier networks in Japan, the US and Belgium. Examine the robustness of our results to an alternative CEM approach, discussed in the Appendix. In regressions 2 to 4, we use unexpected CEO changes in downstream major customers. Here we define our control group, using the matched characteristics of major customers. Thus, our treatment group is suppliers that have an unexpected CEO change in a major customer and the control group is suppliers without CEO changes in their major customers (with similar matched characteristics).

Table 1 summarizes the key variables from the TSR-BSJBSA matched dataset for treatment group firms and control group firms identified by the CEM approach (CEM type 1 explained in the Appendix), the mean firm in our data has a log number of suppliers of 4.4, equivalent to 81 suppliers. Firms show limited churning compared to their number of suppliers over short time-horizons. The log number of new suppliers is 2.1 and dropped suppliers 1.8 over the next year, equivalent to 8.0 new suppliers and 6.2 dropped suppliers, around 6-8% of the total number of suppliers they have. Over a five-year time horizon supply chain changes are much more substantial, the number of new (dropped) suppliers over this horizon represents 44% (34%) of their total number of suppliers.

The mean firm in our data has a log number of employment of 5.9, equivalent to 365 employees. While the mean annual growth rate of the firm performance variables such as labor productivity and TFP is negative, the mean firm's productivity is improved by around 6% over a five-year time horizon. The death/illness of the CEO occurs unexpectedly for 1.3% of the firms in our data during a one-year period and for 6.4% of the firms in our data during a five-year period.

Table 1 Descriptive Statistics

Variable	Time Period	n	mean	std. dev.
Log Number of Suppliers	Contemporaneous	6014	4.395	1.024
#New Suppliers	One Year Difference	6014	2.083	1.019
	Five Year Difference	3749	3.590	1.021
#Dropped Suppliers	One Year Difference	6014	1.834	0.991
	Five Year Difference	3749	3.325	1.017
ΔNumber Suppliers	One Year Difference	6014	0.030	0.095
	Five Year Difference	3744	0.123	0.234

Log Employees	Contemporaneous	5762	5.905	1.218
	One Year Difference	5034	0.003	0.117
	Five Year Difference	3029	0.022	0.215
Log Sales	Contemporaneous	5762	9.800	1.302
	One Year Difference	5034	-0.001	0.145
	Five Year Difference	3029	0.049	0.260
Log Intermediate (M)	Contemporaneous	5406	18.525	1.475
	One Year Difference	4689	0.000	0.178
	Five Year Difference	2698	0.070	0.303
Log Value Added (VA)	Contemporaneous	5394	16.953	1.474
	One Year Difference	4668	0.003	0.278
	Five Year Difference	2689	0.084	0.411
Log Labor Productivity (LP)	Contemporaneous	5389	11.010	0.555
	One Year Difference	4660	-0.001	0.261
	Five Year Difference	2684	0.060	0.357
Log TFP	Contemporaneous	5389	9.648	1.561
	One Year Difference	4661	-0.001	0.259
	Five Year Difference	2685	0.061	0.363
ΔCEO Death	One Year Difference	4576	0.013	0.115
	Five Year Difference	2798	0.064	0.245

Notes: The number of new suppliers are measured by $ln(1 + \#New\ Suppliers\ between\ t - X\ and\ t)$ *while the number of dropped suppliers refers to* $ln(1 + \#Dropped\ Suppliers\ between\ t - X\ and\ t)$*. Changes in the number of suppliers is reflected by the log growth rates of suppliers* $ln(\#Suppliers_t) - ln(\#Suppliers_{t-X})$*. Descriptives correspond to the matched sample described in section 4.1, applying matching probability weights.*

The basic statistics for variables used in the regression analysis are summarized in Appendix Table B1.

4. Results

4.1 Unexpected CEO Changes and Supply Chain Reorganization

The paper starts by presenting our econometric analysis on the direct effects of a firm's unexpected CEO death or illness on their supplier network highlighted in Equation 1. The results in Table 2 demonstrate that indeed, CEO death is positively linked with changes in the number of new suppliers (see columns 1 and 2). Similarly, we find that sudden changes to CEOs also lead to a positive change in the numbers of dropped suppliers (columns 3 and 4), suggest that management reorganization is linked with the dropping of existing suppliers and the adoption of new ones.[7] This is consistent with the loss of the human relationships that support the existence of supply chains. Interestingly however, while CEO death is linked with experimentation of one's supplier network this does not appear to impact the total sum of suppliers connected to the firm, signified by the insignificant coefficients in columns 5.

Importantly, the main message of our findings is present over both a short time period (one year) but also over the more medium term (five years), indicating that these lost investments are not replaced by the affected parties. However, the strongest effects appear to reveal themselves over longer periods of time signified by the large size of the coefficients and the greater degree of significance as can be seen in columns 2 and 4. In terms of the total numbers of suppliers, again the coefficient is close to zero and is not statistically significant suggesting that even five years after the sudden CEO's death, changes do not impact the quantity of one's suppliers (column 6).

Our results are robust to different matching techniques. One concern with using data on CEO's is that they may be large firm bias and therefore be over-represented in our treatment group. To control for this, we rely on CEM method (Blackwell et al. 2009) to ensure our covariate is balanced between the treatment and control. This method relies on motivation from the literature on what types and how many strata (variables) should be used for the matching. Our most

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[7] We also examined the direct effect of a firm's unexpected CEO death/illness on the firm's customer network, by estimating Equation 1 using the number of new or dropped customers during the period or the total number of customers per firm as dependent variables. However, we did not find that unexpected CEO changes significantly promoted the churning of customers, which contrasted with the estimation results for the supplier network shown in Table 2.

conservative approach, our baseline in Table 2 uses 6 variables to make strata (2315 strata created) and identifies control group firms which are matched to 89 treated firms out of the 116 firms in the treatment group. One possible concern with this approach is that the null effect that we find for the total number of suppliers is driven by a small sample due to our matching approach. To assess this, we relax our CEM approach by using 5 variables (excluding within industry productivity quartiles) and using a higher aggregation of sector classifications, from 2 digit used in our more conservative baseline to a substantially broader classification (229 strata created). The less conservative CEM approach identifies control group firms which are matched to 115 treated firms out of the 116 firms in the treatment group, and thus results in a larger sample size. (see further details in the Appendix). Reassuringly, the results in Table A2 in the Appendix find consistent results to those in our baseline in Table 2. Sudden CEO departures lead to increased changes in new suppliers and dropped suppliers but not on the total number of suppliers. We therefore decide to continue with our most conservative approach throughout the remainder of the paper.

Our baseline dependent variables of supplier networks (See Table 1) are calculated by taking log(x+1) to avoid dropping zeros in our data. To assess the robustness of our finding we also recalculate our dependent using the log-like inverse hyperbolic sine transformation, which has the advantage of avoiding adding one to avoid dropping zero values. The results presented in Table A3 in the Appendix mirror those in the main body providing additional reassurances to our main findings.

Table 2 Effects of CEO death/illness on their supplier networks

	(1)	(2)	(3)	(4)	(5)	(6)
Growth Rate Measure:	#New Suppliers		#Dropped Suppliers		ΔNumber Suppliers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
Δ CEO Death	0.282**		0.287**		0.005	
	(0.134)		(0.144)		(0.013)	
Δ CEO Death		0.417***		0.512***		-0.009
		(0.152)		(0.173)		(0.048)
Observations	5,497	3,485	5,497	3,485	5,479	3,473

Notes: The number of new suppliers are measured by $ln(1 + \#New\ Suppliers\ between\ t - X\ and\ t)$ *while the number of dropped suppliers refers to* $ln(1 + \#Dropped\ Suppliers\ between\ t - X\ and\ t)$*. Changes in the number of suppliers is reflected by the log growth rates of suppliers* $ln(\#Suppliers_t) - ln(\#Suppliers_{t-X})$*. Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

4.2 Unexpected CEO Changes and Firm Performance

An assumption that we make in the paper in order to identify the effects of the loss of business network relationship between firms is that the death/illness of the CEO occurs unexpectedly and was itself not caused by some aspect of underperformance within the firm. That is, we capture solely the loss of the human relationship between the affected businesses and not a decline in some other aspect of the relationship between the two firms. There is no way to directly test this assumption. Instead, by estimating Equation 2 in Section 3.1, we test whether the broader performance of the firm in which the CEO dies, might be plausibly affected by a negative shock to these other forms of investment or because of unobservable management failures. If what we are capturing in our identification strategy is the effect of the loss of the human relationship, we would expect no change in other performance measures for the directly affected firm.

The results presented in Table 3 examine the direct effects of CEO deaths on the firm's subsequent performance including employment, sales, materials, value added, labor productivity and TFP. Importantly, the results suggest no effect of a CEOs unexpected change on one's performance. The coefficients for all performance variables are small and statistically insignificant both in the short run (one-year changes) and the longer run (five-year changes).

Table 3 Effects of CEO death on their performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	0.006		-0.003		-0.004		-0.050		-0.051		-0.054	
	(0.012)		(0.020)		(0.021)		(0.058)		(0.046)		(0.054)	
ΔCEO Death		-0.014		-0.054		-0.058		0.032		0.022		0.008
		(0.029)		(0.034)		(0.045)		(0.049)		(0.038)		(0.036)
Observations	4,576	2,798	4,576	2,798	4,284	2,512	4,267	2,504	4,259	2,499	4,262	2,501

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

4.3 Indirect effect: unexpected effects of top customer's CEO change on firm performance

In this section, we turn our attention to whether there are indirect effects of a CEOs death throughout the supply chain and whether these effects are heterogeneous by firm size. We focus on downward linkages and therefore examine the extent to which unexpected change of the CEO within the top customer affects their suppliers' subsequent performance.

We find that this supply chain shock leads to significant performance changes (see Table 4 which shows the estimation results of Equation 3 in Section 3.2). Notably, we find an unexpected change in the leader of a firm's top customer results in a reduction in employment and material purchases. At the same time, this shock causes an increase in productivity measured by value added per worker and TFP. These performance effects reveal themselves in the short run (over one year) then but dissipate over longer periods of time. One plausible explanation for these results is that firms who experience a shock in the relationship with their top customer, try and reduce costs in the short-run by reducing employment and material purchases which results in a short-term increase in productivity. We find similar results when measuring the importance of the dead CEO within a firm's customer ranking i.e. they are amongst the top 75% or the top 50% of customers (see Table A6 and A8 in the Appendix). Using these different measures of customer importance provides consistent results to our baseline, particularly that this indirect shock leads to positive productivity effects.

Exploring the results in more detail, we next assess the extent to which these indirect effects are heterogeneous across different types of firms i.e. a priori firm employment (measured log(employment) at time t). The results in Table 5 find that small firms experience a positive change in employment due to the indirect shock, whereas for initially larger firms the effect is negative. These effects are apparent both one and 5 years after the death of the top customers CEO. The turning point between these positive and negative effects is close to 60 employees at one-year and 175 employees for the longer term effect. This pattern of positive effects on employment for initially small firms and negative effects for initially larger firms reverses for labor productivity. Here the longer run effects are negative for initially smaller firms and positive for larger firms.

The turning point in this regression is close to 160 employees. Outside of this we find little evidence of heterogeneity, including on sales, material purchases, value added and TFP.

Table 4. The effects of top customers' CEO deaths on firm performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO	-0.015*		-0.022		-0.055***		0.055**		0.069***		0.070***	
Death	(0.009)		(0.016)		(0.021)		(0.027)		(0.026)		(0.026)	
ΔCustomer CEO		0.002		-0.027		-0.051*		0.003		0.005		0.008
Death		(0.018)		(0.022)		(0.026)		(0.029)		(0.022)		(0.023)
Observations	5,964	3,923	5,964	3,923	5,548	3,527	5,542	3,521	5,541	3,521	5,494	3,502

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table 5 Heterogeneity effects of a major customers' CEO death on firm performance by firm size

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	0.057*		-0.022		0.094		0.01		-0.068		0.016	
	(0.033)		(0.115)		(0.120)		(0.165)		(0.162)		(0.159)	
ΔCustomer CEO Death												
*Log(Emp)	-0.014**		0.000		-0.029		0.009		0.027		0.011	
	(0.007)		(0.023)		(0.024)		(0.033)		(0.033)		(0.032)	
ΔCustomer CEO Death		0.238**		0.129		0.154		-0.057		-0.298**		-0.201
		(0.095)		(0.124)		(0.143)		(0.199)		(0.152)		(0.167)
ΔCustomer CEO Death												
*Log(Emp)		-0.046**		-0.03		-0.04		0.012		0.059*		0.041
		(0.019)		(0.025)		(0.028)		(0.040)		(0.030)		(0.034)
Observations	5,964	3,923	5,964	3,923	5,548	3,527	5,542	3,521	5,541	3,521	5,494	3,502

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. Log(Emp) refers to log employment at the start of the sample period. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

4.4 Indirect effect: unexpected effects of top customers'? CEO death/illness on changes in supplier? Networks

Having found evidence that the downstream death of the CEO that constitutes the majority of its sales leads to performance effects in the indirectly affected firm, we next explore if this also leads to reorganization of their supplier-chains (see Tables A11 and A12 in the Appendix). The results show that the death within a firm's top customer leads to an increase in the numbers of new suppliers they gain and an increase in the numbers of dropped suppliers in the longer run (five-year period), suggesting that this shock leads to a reorganization of supplier network.

5. Conclusions and Policy implications

The ability of firms to effectively harness supply chains can enable enhanced productivity at the micro-level which can result in greater efficiency at the macro-level. Policy makers and economists are therefore particularly interested in understanding the resilience of supply chains and the implications for firms and their performance in the event of a shock. Unexpected adjustments may adversely affect firms as they incur additional costs and bear great uncertainty in both the search for new customers and suppliers and any adjusting to these new relationships. Conversely, when put under stress, firms may find new and possibly better suppliers of the intermediate inputs which may lead to positive externalities that get passed down to customers and suppliers throughout these intricate networks.

While the economics literature has studied this from the perspective of large and often catastrophic shocks to the economy, such as earthquakes, supply chains are modified all the time by firms – they add and drop suppliers and customers as part of normal business. To date, these types of shocks are less understood and such questions cannot be extrapolated from the existing literature given the large and specific nature of the shocks being studied. Large catastrophic shocks are characterized by changes in supply chains but also other supply side determinants such as loss of infrastructure and human capital and to changes on the demand side. From an econometrics perspective, the question is made difficult by the fact that adjustments within supply chain changes are not random. Firms decide who their suppliers based on their relationship with the business and is typically unobservable to the econometrician.

In this paper we solve this endogeneity problem by focusing on changes to the supply chains that do occur randomly, because relationships between firms are disrupted by the unexpected death of the CEO of one of the businesses. These shocks are used for identification as human relationships are important in maintaining long term business relationships and often involve senior managers such as the CEO the greater is the importance of the customer/supplier to the firms operations or sales. Unexpected deaths therefore cause a disruption to human relationships and therefore make it more likely there will be changes in the ongoing business relationship. We find that for firms that suffer such deaths this promotes the churning of suppliers but not for customers and therefore these shocks propagate through the supply chain. Of interest we find that it does not affect the performance of the affected company, either in the short or longer term.

These unexpected CEO deaths also lead to changes further away from this immediate shock, by affecting the suppliers and customers of firms that supplied or were customers of the firm where the CEO death occurred. We find that within indirectly affected firms, in our case firms where the CEO death occurred in their main customer, these have negative short-run effects on employment and material purchases and consequently improvements in productivity. It would appear from this that firms respond to supply chain shocks by pushing the effects of the shock onto workers and backwards along the supply chain. These short run effects do not persist into the longer run, although there is some evidence of permanent effects on firms with the largest employment. Consistent with this we find that downstream shocks tend promote churning of suppliers. Following more investigation, we will contribute an understanding of the propagation of shocks through supply chains and therefore on questions relevant to macroeconomic stabilization as well as to more micro-focused policies on whether and how to smooth adjustment to smaller supply chain shocks

There are many directions that this paper could be extended and the precise mechanisms through which the effect occur explored. One obvious extension would be to examine more completely heterogeneity in the effects of CEO deaths. This could include heterogeneity arising from the characteristics of the CEO, for example the age of the CEO. This could provide evidence whether death that are more surprising given the age of the individual matters. A second type of heterogeneity to be explored could include the characteristics of the products. One idea here could be to use whether products are more differentiated using the well-known metric constructed by Rauch. A final type of heterogeneity to be explored would be to focus on the characteristics of the firms involved. This could include financial heterogeneity (using measures such as the debt-asset ratio of the firm), the productivity, ownership and position in the supply chain and whether firms are directly involved in international markets or not (importers/exporters).

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APPENDIX

Table A1 Industry distribution of treatment group firms

Industry classification	Freq.	Percent
Manufacturing industries	64	55.15
Food products, beverages and tobacco [CA]	7	6.03
Textiles, wearing apparel, leather and related products [CB]	2	1.72
Wood and paper products, and printing [CC]	2	1.72
Coke and refined petroleum products [CD]	1	0.86
Chemicals and chemical products [CE]	12	10.34
Basic pharmaceutical products and pharmaceutical preparations [CF]	5	4.31
Rubber and plastics products, and other non-metallic mineral products [CG]	3	2.59
Basic metals and fabricated metal products, except machinery and equipment [CH]	6	5.17
Computer, electronic and optical products [CI]	10	8.62
Electrical equipment [CJ]	1	0.86
Machinery and equipment n.e.c. [CK]	9	7.76
Transport equipment [CL]	4	3.45
Furniture; other manufacturing; repair and installation of machinery and equipment [CM]	2	1.72
Wholesale and retail trade, repair of motor vehicles and motorcycles [G]	35	30.17
Other services	17	14.65
Accommodation and food service activities [I]	2	1.72
Publishing, audiovisual and broadcasting activities [JA]	4	3.45
IT and other information services [JC]	6	5.17
Legal and accounting activities, etc [MA]	2	1.72
Administrative and support service activities [N]	3	2.59
Total	116	100

Table A2 Effects of CEO death on their supplier networks with CEM 2 Sample

	(1)	(2)	(3)	(4)	(5)	(6)
Growth Rate Measure:	#New Suppliers		#Dropped Suppliers		ΔNumber Suppliers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	0.419***		0.389***		0.011	
	(0.115)		(0.126)		(0.012)	
ΔCEO Death		0.573***		0.574***		0.032
		(0.130)		(0.155)		(0.042)
Observations	34,752	21,644	34,752	21,644	34,554	21,516

Notes: All dependent variables are calculated by inverse hyperbolic sine transformation. The number of new suppliers are measured by IHS $(\#New\ Suppliers\ between\ t-X\ and\ t)$ *while the number of dropped suppliers refers to* $IHS(\#Dropped\ Suppliers\ between\ t-X\ and\ t)$*. Changes in the number of suppliers is reflected by the log growth rates of suppliers IHS* $(\#Suppliers_t)-(\#Suppliers_{t-X})$*. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A3 Effects of CEO death on their supplier networks using IHS

	(1)	(2)	(3)	(4)	(5)	(6)
Growth Rate Measure:	#New Suppliers		#Dropped Suppliers		ΔNumber Suppliers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	0.275**		0.276*		0.008	
	(0.132)		(0.144)		(0.012)	
ΔCEO Death		0.399***		0.490***		-0.054
		(0.146)		(0.167)		(0.054)
Observations	5,497	3,485	5,497	3,485	5,497	3,485

Notes: All dependent variables are calculated by inverse hyperbolic sine transformation. The number of new suppliers are measured by IHS $(\#New\ Suppliers\ between\ t-X\ and\ t)$ *while the number of dropped suppliers refers to* $IHS(\#Dropped\ Suppliers\ between\ t-X\ and\ t)$*. Changes in the number of suppliers is reflected by the log growth rates of suppliers IHS* $(\#Suppliers_t)-(\#Suppliers_{t-X})$*. Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

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Table A4 Effects of CEO death on firm performance, CEM 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	0.007		0.018		0.022		-0.016		-0.021		-0.021	
	(0.009)		(0.019)		(0.021)		(0.047)		(0.037)		(0.044)	
ΔCEO Death		0.017		-0.004		0.011		0.052		0.031		0.021
		(0.033)		(0.043)		(0.046)		(0.049)		(0.030)		(0.034)
Observations	25,310	14,615	25,310	14,615	23,511	13,007	23,413	12,963	23,376	12,941	23,195	12,899

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A5 The effects of top customers' CEO deaths on firm performance, CEM 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	-0.016**		-0.021		-0.049**		0.044*		0.060**		0.062**	
	(0.008)		(0.015)		(0.020)		(0.025)		(0.025)		(0.025)	
ΔCEO Death		-0.008		-0.021		-0.037		-0.008		-0.001		0.005
		(0.017)		(0.020)		(0.024)		(0.028)		(0.020)		(0.021)
Observations	10,717	6,811	10,717	6,811	9,910	6,047	9,893	6,036	9,879	6,028	9,815	6,002

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A6: The effects of top 75% customers' CEO deaths on firm performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCEO Death	-0.017**		-0.026*		-0.052***		0.037		0.053**		0.051**	
	(0.008)		(0.014)		(0.018)		(0.024)		(0.023)		(0.023)	
ΔCEO Death		0.01		0.001		-0.005		0.02		0.015		0.018
		(0.016)		(0.019)		(0.023)		(0.026)		(0.021)		(0.022)
Observations	7,973	5,271	7,973	5,271	7,407	4,721	7,398	4,713	7,395	4,712	7,338	4,685

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A7 The effects of top 75% customers' CEO deaths on firm performance, CEM 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	-0.016**		-0.023*		-0.045***		0.027		0.044**		0.043**	
	(0.007)		(0.013)		(0.017)		(0.022)		(0.022)		(0.022)	
Δ Customer CEO Death		0.007		0.003		-0.004		0.019		0.011		0.016
		(0.015)		(0.017)		(0.021)		(0.024)		(0.020)		(0.020)
Observations	13,595	8,731	13,595	8,731	12,572	7,731	12,551	7,718	12,537	7,710	12,458	7,672

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A8 The effects of top 50% customers' CEO deaths on firm performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
Δ Customer CEO	-0.003		-0.014		-0.031**		0.027*		0.027*		0.031**	
Death	(0.006)		(0.009)		(0.012)		(0.016)		(0.016)		(0.016)	
Δ Customer CEO		0.013		-0.014		-0.028*		0.014		0.002		0.010
Death		(0.011)		(0.013)		(0.016)		(0.017)		(0.014)		(0.014)
Observations	15,635	10,369	15,635	10,369	14,530	9,296	14,495	9,274	14,480	9,268	14,375	9,223

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A9 The effects of top 50% customers' CEO deaths on firm performance, CEM 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
Δ Customer CEO	-0.001		-0.013		-0.027**		0.024		0.023		0.026*	
Death	(0.005)		(0.008)		(0.012)		(0.015)		(0.015)		(0.014)	
Δ Customer CEO		0.015		-0.005		-0.017		0.019		0.002		0.011
Death		(0.010)		(0.012)		(0.015)		(0.016)		(0.013)		(0.013)
Observations	28,442	18,193	28,442	18,193	26,279	16,115	26,208	16,072	26,172	16,053	25,994	15,984

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A10 Heterogeneity effects of a major customers' CEO death on firm performance by firm size, CEM2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome:	*Δln(Employees)*		*Δln(Sales)*		*Δln(M)*		*Δln(VA)*		*Δln(LP)*		*Δln(TFP)*	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*	*One*	*Five*
Δ Customer CEO Death	0.052*		0.007		0.123		0.061		-0.005		0.061	
	(0.030)		(0.105)		(0.112)		(0.149)		(0.146)		(0.144)	
Δ Customer CEO Death *ln_emp	-0.013**		-0.006		-0.034		-0.003		0.013		0.000	
	(0.006)		(0.021)		(0.022)		(0.030)		(0.029)		(0.029)	
Δ Customer CEO Death		0.242***		0.095		0.139		-0.093		-0.295**		-0.159
		(0.085)		(0.116)		(0.134)		(0.179)		(0.134)		(0.148)
Δ Customer CEO Death *ln_emp		-0.048***		-0.022		-0.034		0.016		0.057**		0.032
		(0.016)		(0.023)		(0.026)		(0.036)		(0.027)		(0.030)
Observations	10,717	6,811	10,717	6,811	9,910	6,047	9,893	6,036	9,879	6,028	9,815	6,002

*Notes: Differences outcomes are measured over one- and five-year periods. Labor productivity refers to value added per worker and TFP is calculated via Wooldridge (2009). All dependent variables are in logs. Log(Emp) refers to log employment at the start of the sample period. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. All regressions include year fixed effects. Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A11 The effects of top customers' CEO death/illness on firms' supplier networks

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome:	#New_Suppliers		#Dropped_Suppliers		ΔNumber_Suppliers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	-0.042		0.003		-0.010	
	(0.056)		(0.053)		(0.009)	
ΔCustomer CEO Death		0.038		0.129*		-0.038**
		(0.074)		(0.074)		(0.018)
Observations	5,842	3,829	5,842	3,829	5,811	3,813

Notes: The number of new suppliers are measured by $ln(1 + \#New\ Suppliers\ \ between\ t - X\ and\ t)$ *while the number of dropped suppliers refers to* $ln(1 + \#Dropped\ Suppliers\ between\ t - X\ and\ t)$. *Changes in the number of suppliers is reflected by the log growth rates of suppliers* $ln(\#Suppliers_t) - ln(\#Suppliers_{t-X})$. *Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A12 The effects of top customers' CEO death/illness on firms' supplier networks, CEM2

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome:	#New_Suppliers		#Dropped_Suppliers		ΔNumber_Suppliers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	0.011		0.048		0.001	
	(0.055)		(0.052)		(0.009)	
ΔCustomer CEO Death		0.120*		0.203***		0.002
		(0.073)		(0.072)		(0.017)
Observations	10,449	6,613	10,449	6,613	11,955	7,458

Notes: The number of new suppliers are measured by $ln(1 + \#New\ Suppliers\ \ between\ t - X\ and\ t)$ *while the number of dropped suppliers refers to* $ln(1 + \#Dropped\ Suppliers\ between\ t - X\ and\ t)$. *Changes in the number of suppliers is reflected by the log growth rates of suppliers* $ln(\#Suppliers_t) - ln(\#Suppliers_{t-X})$. *CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A13 The effects of top customers' CEO death/illness on firms' customer networks

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome:	#New_Customers		#Dropped_Customers		ΔNumber_Customers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	-0.185***		-0.158***		-0.007	
	(0.060)		(0.053)		(0.010)	
ΔCustomer CEO Death		-0.08		-0.115		0.019
		(0.088)		(0.090)		(0.020)
Observations	5,836	3,822	5,836	3,822	5,806	3,807

Notes: The number of new customers are measured by $ln(1 + \#New\ Customers\ \ between\ t - X\ and\ t)$ *while the number of dropped customers refers to* $ln(1 + \#Dropped\ Customers\ between\ t - X\ and\ t)$*. Changes in the number of customers is reflected by the log growth rates of customers* $ln(\#Customers_t) - ln(\#Customers_{t-X})$*. Year fixed effects are included in all the equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

Table A14 The effects of top customers' CEO death/illness on firms' customer networks, CEM2

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome:	#New_Customers		#Dropped_Customers		ΔNumber_Customers	
Difference (Years):	*One*	*Five*	*One*	*Five*	*One*	*Five*
ΔCustomer CEO Death	-0.177***		-0.155***		-0.006	
	(0.057)		(0.051)		(0.010)	
ΔCustomer CEO Death		-0.048		-0.048		-0.004
		(0.082)		(0.084)		(0.018)
Observations	10,454	6,617	10,454	6,617	10,393	6,580

Notes: The number of new customers are measured by $ln(1 + \#New\ Customers\ \ between\ t - X\ and\ t)$ *while the number of dropped customers refers to* $ln(1 + \#Dropped\ Customers\ between\ t - X\ and\ t)$*. Changes in the number of customers is reflected by the log growth rates of customers* $ln(\#Customers_t) - ln(\#Customers_{t-X})$*. CEM2 refer to a more relaxed matching method that relies on 5 variables and broader industry classifications. Year fixed effects are included in all the* *equations Standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5%, and 10% level, respectively.*

CEM Matching

1) CEM Type 1: most conservative case, control group firms identified for 89 treated firms out of 116 firms in the treatment group.

Variables (strata) used for matching

- Firm age: 1-10 years old, 11-25 years old, 26-50 years old, older than 50 years
- Employment size: 50-300 employees, 301-500 employees, 501-1000 employees, more than 1000 employees
- Industry classification: ind_a38 (2 digit industry level, see Appendix Table 1).
- Quartile of TFP level within industry (Q1, Q2, Q3, Q4), The TFP measure is estimated at the firm-level using the Wooldridge (2009) control function approach with value added as a measure of output. Firms are assumed to have a Cobb-Douglas production function, but not necessarily constant returns to scale.
- Number of customers: 1-5 firms, 6-15 firms, 16-25 firms, more than 25 firms
- Number of suppliers: 1-5 firms, 6-15 firms, 16-25 firms, more than 25 firms

2) CEM Type 2: most relaxed case, control group firms identified for 115 treated firms out of 116 firms in the treatment group.

Variables (strata) used for matching

- Firm age: 1-25 years old, 26-50 years old, older than 50 years
- Employment size: 50-300 employees, 301-500 employees, 501-1000 employees, more than 1000 employees
- Industry classification: broad industry classification (1=manufacturing, 2=wholesale & retail trade, 3=other services (mainly IT and business services))
- Number of customers: 1-15 firms, more than 15 firms
- Number of suppliers: 1-15 firms, more than 15 firms

Appendix Table B1 Basic Statistics

Panel (a) Basic statistics for variables used for the direct effect estimations (Table 3, CEM1)

Variable	Obs	Mean	Std. dev.	Min	Max
d1_ln(Employees)	5,034	0.003	0.117	-3.433	1.913
d1_ln(Sales)	5,034	-0.001	0.145	-1.480	1.311
d1_ln(M)	4,689	0.000	0.178	-2.887	2.383
d1_ln(VA)	4,668	0.003	0.278	-3.767	3.320
d1_ln(LP)	4,660	-0.001	0.261	-1.981	2.103
d1_ln(TFP)	4,661	-0.001	0.259	-2.341	1.998
d1_CEO Death	4,576	0.013	0.115	0	1
d5_ln(Employees)	3,029	0.022	0.215	-3.366	2.380
d5_ln(Sales)	3,029	0.049	0.260	-2.043	2.459
d5_ln(M)	2,698	0.070	0.303	-2.622	2.598
d5_ln(VA)	2,689	0.084	0.411	-4.024	2.651
d5_ln(LP)	2,684	0.060	0.357	-2.187	2.040
d5_ln(TFP)	2,685	0.061	0.363	-2.287	2.594
d5_CEO Death	2,798	0.064	0.245	0	1

Panel (b) Basic statistics for variables used for the direct effect estimations (Table A4, CEM2)

Variable	Obs	Mean	Std. dev.	Min	Max
d1_ln(Employees)	25,890	0.005	0.119	-3.433	3.291
d1_ln(Sales)	25,890	0.000	0.159	-2.191	1.986
d1_ln(M)	24,018	-0.003	0.198	-3.303	3.118
d1_ln(VA)	23,916	0.009	0.300	-4.739	3.320
d1_ln(LP)	23,877	0.004	0.281	-3.070	2.447
d1_ln(TFP)	23,696	0.005	0.282	-4.002	3.003
d1_CEO Death	25,310	0.003	0.056	0	1
d5_ln(Employees)	14,896	0.030	0.230	-3.366	3.203
d5_ln(Sales)	14,896	0.051	0.284	-2.385	2.594
d5_ln(M)	13,232	0.054	0.341	-5.078	2.598
d5_ln(VA)	13,187	0.086	0.433	-4.024	3.749
d5_ln(LP)	13,165	0.054	0.372	-2.447	3.030
d5_ln(TFP)	13,122	0.063	0.382	-3.368	3.065
d5_CEO Death	14,615	0.016	0.126	0	1

Panel (c) Basic statistics for variables used for the indirect effect estimations (Tables 4, A6, A8, CEM1)

Variable	Obs	Mean	Std. dev.	Min	Max
d1_ln(Employees)	16,327	0.005	0.121	-2.194	2.839
d1_ln(Sales)	16,327	-0.004	0.183	-1.932	2.513
d1_ln(M)	15,163	-0.009	0.218	-3.552	3.405
d1_ln(VA)	15,128	0.006	0.328	-4.147	3.945
d1_ln(LP)	15,113	0.001	0.299	-3.100	2.658
d1_ln(TFP)	15,008	0.002	0.294	-3.073	2.574
d1_TOP1_Customer_CEO Death	5,964	0.036	0.185	0	1
d1_TOP50%_Customer_CEO Death	15,635	0.034	0.181	0	1
d1_TOP75%_Customer_CEO Death	7,973	0.031	0.173	0	1
d5_ln(Employees)	10,787	0.032	0.245	-3.035	2.761
d5_ln(Sales)	10,787	0.053	0.322	-3.789	2.430
d5_ln(M)	9,661	0.046	0.375	-4.309	2.955
d5_ln(VA)	9,639	0.084	0.457	-4.024	3.745
d5_LogLP_VA	9,633	0.049	0.401	-3.084	2.943
d5_ln(TFP)	9,588	0.059	0.397	-3.064	2.758
d5_TOP1_Customer_CEO Death	3,923	0.183	0.387	0	1
d5_TOP50%_Customer_CEO Death	10,369	0.172	0.378	0	1
d5_TOP75%_Customer_CEO Death	5,271	0.163	0.369	0	1

Panel (d) Basic statistics for variables used for the indirect effect estimations (Tables A5, A7, A9, CEM2)

Variable	Obs	Mean	Std. dev.	Min	Max
d1_ln(Employees)	29,894	0.004	0.121	-2.194	2.851
d1_ln(Sales)	29,894	-0.004	0.177	-1.932	2.513
d1_ln(M)	27,609	-0.008	0.215	-3.552	3.405
d1_ln(VA)	27,535	0.007	0.320	-4.147	3.945
d1_ln(LP)	27,499	0.003	0.291	-3.100	2.658
d1_ln(TFP)	27,320	0.003	0.287	-3.073	3.184
d1_TOP1_Customer_CEO Death	10,717	0.021	0.143	0	1
d1_TOP50%_Customer_CEO Death	28,442	0.020	0.141	0	1
d1_TOP75%_Customer_CEO Death	13,595	0.020	0.139	0	1
Variable	Obs	Mean	Std. dev.	Min	Max
d5_ln(Employees)	19,062	0.027	0.238	-3.035	3.104
d5_ln(Sales)	19,062	0.048	0.315	-3.789	2.985
d5_ln(M)	16,877	0.041	0.367	-4.309	3.316

d5_ln(VA)	16,832	0.081	0.458	-4.024	5.327
d5_LogLP_VA	16,813	0.054	0.394	-3.084	2.943
d5_ln(TFP)	16,744	0.059	0.394	-3.064	2.758
d5_TOP1_Customer_CEO Death	6,811	0.112	0.316	0	1
d5_TOP50%_Customer_CEO Death	18,193	0.106	0.308	0	1
d5_TOP75%_Customer_CEO Death	8,731	0.106	0.308	0	1