Inventory as a Liquidity Provision Channel

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Abstract

We find an increase of a customer's inventory investment when its supplier faces a financial constraint. Moreover, several additional tests reveal that such inventory substitution is more pronounced when suppliers are in competitive markets, for small-size customers, and for customers in industries with a high inventory ratio. Lastly, we examine the impact of inventory on a customer's subsequent financial performance. We find no evidence that an increase in inventory to support financially constraint suppliers has a negative impact on customers' performance.

Keywords: Inventory Investment; Liquidity Propagation; Supply Chain Network

JEL classification code: G20; G32

The bankruptcy of a supplier requires its customers to pay switching costs to search for an alternative supplier (Titman, 1984). In order to predict possible bankruptcy, customers collect private information on their suppliers (Smith, 1987; Biais and Gollier 1997; Burkart and Ellingsen, 2004; Ivashina and Iverson, 2018). Such private information is used to monitor the financial quality of their suppliers and to prepare for the supplier's possible bankruptcy by reducing their own risk.[1] Also, when customers detect the risk of bankruptcy with their suppliers, they support these suppliers. Indeed, previous studies argue that trade credit financing is used as a channel for providing liquidity to constraint suppliers.[2] Yet, other possible methods to support suppliers are now well examined.

We hypothesize that firms use inventory as a liquidity provision channel to support suppliers that are facing financial constraints. The idea is that if a firm faces a financial problem and its customers want to save it, the customers can provide liquidity by purchasing more product from its financially-constrained supplier. As customers purchase more, the revenue from suppliers increases. This increases the cash holding of suppliers facing financial constraints.

Examining this hypothesis requires information of major suppliers for each listed firm. In the U.S., the 10-K disclosure is frequently used in trade credit research.[3] Unfortunately, this does not include main supplier information, which makes it difficult to examine our hypothesis using the U.S. dataset especially when the customer is large enough to be a supplier.[4] In light of these limitations, we use a Japanese dataset in which information on major suppliers is available. Our dataset contains both the major customers and suppliers of listed firms from 2001 to 2017, covering about 84% of listed firms.

[1] Previous literature reveals the changes in such as leverage (Titman, 1984; Custódio, Ferreira, and Garcia-Appendini, 2018), cash holding (Itzkowitz, 2013), trade credit (Garcia-Appendini and Montoriol-Garriga, 2013) and investment (Itzkowitz, 2015).
[2] See such as Petersen and Rajan (1997), Nilsen (2002), Mateut et al. (2006), Guariglia and Mateut (2006), Love et al. (2007), and Huang et al. (2011).
[3] In the US, listed firms are required to report major customers those who exceed 10% of the firm's total revenue.
[4] It is difficult to identify main suppliers using only main customer information, especially when the customer is a large as a supplier.

We employ various types of analyses to overcome the endogeneity concern. First, we conduct a regression discontinuity design where the supplier's financial deficit for two consecutive years is the threshold event. The guideline published by the Financial Service Agency (FSA) of Japan prohibits banks from providing a new loan for firms with two consecutive years in deficit. Due to this rule, suppliers with more than two years of financial deficit cannot rely on bank lending. Under our hypothesis, customers increase inventory in order to increase the supplier's liquidity. To examine this, we restrict our sample to firms whose suppliers report negative ordinary income in the previous accounting period. Then, we plot two fitted lines: one for the criteria in which a supplier's ordinary income is negative (i.e., those are under the FSA's prohibition), and one in which the ordinary income is positive. We observe that a discontinuity around zero ordinary income is statistically significant (p = 0.034). While the regression discontinuity design has the advantage of making the causality clear, it requires a specific situation—that one of the suppliers reports two or more years of financial deficit. Hence, based on this model alone, our findings might not be generalizable.

Next, we conduct several multivariate regression analyses with the entire sample. Findings show that the degree of suppliers' financial constraints affects customer's inventory ratio. Consistent with our hypothesis, we find a positive correlation between suppliers' degree of financial constraint and customers' inventory investment. Another concern of the endogeneity problem is that the customers' inventories and suppliers' financial problems are jointly affected by other factors. To eliminate this possibility, we use an instrumental variable approach in which the average revenue growth ratio of the suppliers' industry is used as an instrument. If a macroeconomic shock affects a certain industry, revenues decline for all firms in the same industry. This instrumental approach also reports a positive correlation between the suppliers' financial problems and the customers' inventory level, which supports our hypothesis.

Next, we use an exogenous shock to identify the relationship between a supplier's financial condition and its customer's inventory investment. As an exogenous shock, we use the tsunami caused by a massive

earthquake that happened in northeastern Japan in March 2011. This tsunami caused severe damage for the coastal area of northeastern Japan. Previous literature points out that a natural disaster temporally makes the role of financial intermediates dysfunctional (Hosono et al., 2016). We identify the listed firms that have plants or offices in affected areas. Then, we compare the inventory level of customers of those suppliers that are in earthquake-affected areas and those that are not. We find an increase in customer inventory when suppliers face financial constraints and are located in the tsunami affected area.

We further conduct several subsample analyses. We find that the inventory substitution effect is observed when the supplier is in the competitive market. We also find that customers support financially constrained suppliers through inventory channel only when the size of suppliers is small. Lastly, we observe that inventory substitution is observed for customers in industries with inventory ratios above the median.

Lastly, we examine the impact on subsequent operating performance when customers support suppliers through increased inventory. Previous literature finds a negative correlation between the amount of inventory and subsequent performance. This leads to a concern that an increase in inventory for supporting financially constrained suppliers harms the customers' liquidity, which can decrease the customers' subsequent performance. To address this possibility, we compute the marginal effects of the suppliers' financial problems on customers' subsequent performance measured by both ROA and Tobin's *q*. We do not find any evidence that supporting suppliers through increased inventory harms the customers' subsequent performance in both ROA and Tobin's *q*.

This paper expands our knowledge about one key factor of working capital management. Interestingly, most of the literature on corporate finance that researches working capital is about trade credit (Biais and Gollier, 1997; Petersen and Rajan, 1997); however, limited attention has been paid to the importance of inventory management. Our paper is the first to reveal that inventory investment works similarly to the substitution effects of trade credits. Furthermore, our paper contributes to the literature on inventory

examined in broad areas, such as operation management, asset pricing, and accounting (Buzacott and Zhang, 2004; Gaur et al., 2005; Cannon, 2008; Eroglu and Hofer, 2011; Tunca and Zhu, 2017). However, previous studies focus on the firm itself and do not closely examine whether the supplier–customer relationship affects inventory decisions. Our paper also contributes to the literature on inter-firm liquidity transactions. A large amount of literature points out that firms in some cases have an incentive to support other firms.[5]

2 Literature Review and Hypothesis

2.1 Literature on Inventory

This subsection reviews the literature on inventory. A large body of the literature examines the relationship between inventory management and firm performance. The relationship between inventory management and operating performance has long been debated, especially in operations research literature (Gaur, Fisher, and Raman, 2005; Eroglu and Hofer, 2011). Previous studies find that firms reduce their inventory to achieve high operating performance and high stock return (Thomas and Zhang, 2002; Kesavan, Gaur, and Raman., 2010; Belo and Lin, 2013; Steinker and Hoberg, 2013; Chen, 2016). In other words, a decline in inventory reduces the cost of capital (Jones and Tuzel, 2013). However, some studies find the opposite. Eroglu and Hofer (2011) observe an inverse U-shape between inventory management and performance, which would imply that a reduction in inventory is not always positively associated with firm performance. Bianco and Gamba (2019) argue that firms adjust their inventory by considering the risk of their future risk.

Another stream of the literature examines the determinants of inventory. Gaur, Fisher, and Raman (2005) reveal that three factors (i.e., capital intensity, gross margins, and sales surprise) have a strong

[5] Other studies in this vein point out the financial contagion propagates through the customer-supplier network (Kiyotaki and Moore, 1997; Leitner, 2005; Lian, 2017)

explanatory power for inventory level. In this paper, we examine the possibility that a supplier's financial problems also determine an inventory level.

While recent corporate finance studies point out the importance of the inter-firm relationship, there are no papers examining whether firms strategically use inventory. Our paper is the first to examine the possibility that firms use inventory to support their client firms.

2.2 Trade Credit

Our debate is closely related to studies that view trade credit as having substitution role of the traditional financial intermediates. Trade credit is created when suppliers offer terms that allow customers (buyers) to delay payment for goods delivered (Ng et al. 1999) and enable to reduce the transaction costs of paying bills (Ferris, 1981). This natural nature of trade credit enables it as a financial source when the traditional financial intermediate is dysfunctional (Petersen and Rajan 1997; Ng et al. 1999). The assumption that suppliers have private information about their customers is examined by Ivashina and Iverson (2018). They observe that fire sales of trade credits by suppliers have high predictability of a customer's bankruptcy, a finding that implies the existence of private information of suppliers.

Working capital, frequently defined as accounts receivable minus accounts payable plus inventory, is a key concept in corporate finance.[6] Many studies on working capital management find that trade credit acts as a substitute for bank financing (Meltzer, 1960; Petersen and Rajan, 1997; Love et al., 2007; Shenoy and Williams, 2017). These studies argue that by controlling the accounts payable, customers can provide liquidity for financially constrained suppliers. Indeed, both inventory and accounts payable have several similarities. For one, both are classified as current assets and key components of working capital. For another, both are generated from business transactions with suppliers. These similarities suggest that firms

[6] See, for example, Kieschnick, Laplante, and Moussawi (2013); Aktas, Croci, and Petmezas (2015); Brandenburg (2016); Zeidan and Shapir (2017).

can use inventory to provide liquidity to financially constrained suppliers just as they do by managing trade credit.

Several studies in trade credit literature find an increase of accounts payable when business partners are in financial trouble (both suppliers and customers) (Wilner, 2000; Casey and O'Toole, 2014; Carbó-Valverde, Rodríguez-Fernández, and Udell, 2016). This is possibly due to private information about suppliers their customers have, which enables customers to act as a substitution for banks (Smith, 1987; Ng, Smith, and Smith, 1999) In other word, customers, rather than conventional financial investors (e.g., banks), can provide liquidity for their suppliers.

Such informational advantage over financial intermediates can be also adopted by conventional financial intermediates (Biais and Gollier 1997; Burkart and Ellingsen, 2004). For example, Biais and Gollier (1997) argue that uninformed banks can use the trade credit condition to acquire the private information for lending business. Burkart and Ellingsen (2004) theoretically rationalize supplier's incentive to collect private information, and that leads to the alternative financing channel of bank lending. A firm's bankruptcy negatively affects its customers in several ways. Customers of the bankrupt firms must search for alternative suppliers (Titman, 1984; Cuñat, 2007; Kale and Shahrur, 2007; Garcia-Appendini and Montoriol-Garriga, 2019). Empirically, Hertzel, Li, Officer, and Rodgers (2008) also observe a decline in the customer's stock prices following the news of a bankrupt supplier. This information advantage of the trade credit works well especially when a friction in financial intermediates exists in a financial market, which leads to financial constraints. In such case, firms prefer to borrow from non-institutional sources (Petersen and Rajan 1997; McMillan and Woodruff 1999; Nilsen 2002). Petersen and Rajan (1997) find that firms prefer to rely on trade credit when credit from financial institutions is constricted. In the similar vein, McMillan and Woodruff (1999) find that firms located in a country with underdeveloped legal and financial systems rely on trade credit financing. Nilsen (2002) finds that small firms substitute trade credit for bank credit when they are faced with bank lending shocks.

By applying the arguments associated with trade credit, we can hypothesize that customers can provide liquidity for their suppliers in financial constraint. Indeed, both items have several similarities, because inventory and accounts payable are classified as current assets. Also, both items are generated from transactions with the suppliers. Then, a change of these items changes the liquidity position of suppliers. By making payments more quickly or earlier, we will likely find an identical effect that customers can provide liquidity for their financially constraint suppliers.

To the best of our knowledge, no paper has examined the possibility that inventory is used to support financially constrained suppliers in the same ways that customers do through trade credit channels. Supporting suppliers is possible not only through the trade credit channel, but also by purchasing products earlier than they need, which leads to the increase of inventory.

Hypothesis: Customers increase inventory when their suppliers are in financial trouble.

3 Dataset

We use the Main Suppliers/Customers Data Set provided by Nikkei Media Marketing. This contains the top suppliers and customers of listed firms in Japan for each year between January 2001 and March 2017. It contains 424,752 records of a total of 4,631 listed firms. This information is collected by a data vender company; hence firms are not mandated to report by corporate law. Yet, this data set covers about 83.8% of Japanese listed firms except for those in financial industries. This data set reports the names of main customers/suppliers, and identifiers, such as ticker symbol or firm ID of main customers/suppliers, are not assigned. We then check all firm names manually and put the firm specific codes so that we can connect with financial data.[7]

[7] This dataset does not contain the amount of trade with suppliers or customers.

The accounting information is from the Nikkei Quick FactSet, which covers all listed firms in Japan. We exclude observations with missing values for the main variables used in our analysis. Because our analysis requires the financial reports of customers, we remove the observations for those reported customers that are non-listed firms.[8] We also exclude observations on customers who report that inventory is zero because our interest is the level of inventory. After exclusions, we use 55,873 customer–supplier–year observations in our analyses.

4 Regression Discontinuity Design Approach

We start our analyses with a regression discontinuity design approach, using a specific situation: when banks are discouraged to lend to firms. In Japan, the FSA, a government agency that monitors the operation of financial intermediates, has guidelines for the commercial lending services of banks. The guidelines discourage banks from providing new loans for firms with two consecutive years of deficits. We use the guidelines that restrict loans to suppliers with two consecutive years of deficits as an exogenous shock, and we examine the validity of our hypothesis. A regression discontinuity design requires a threshold for which an exogenous event is either above or below. In this case, we examine the relationship between a supplier's profit and a customer's inventory ratio.

Figure 1 plots the relationship between the ordinary income of suppliers who recorded financial deficits in previous years and customers' inventory ratio. The sample is consistent with the firm–year observations about suppliers who report negative ordinary income in previous accounting periods. We also plot two fitted lines for the criteria in which a supplier's ordinary income in the previous year is negative or positive. Discontinuity exists around the threshold where ordinary income is a zero value. Furthermore, when the

[8] A large portion of the sample is excluded because they are not listed firms so that we cannot connect the financial data. Such omitted sample includes observations report unlisted firms, individuals or government agencies as main customer.

ordinary income near zero is still slightly negative, the inventory ratio is higher than when the ordinary income near zero is still slightly positive.

Unreported OLS analysis shows that the discontinuity is statistically significant (*t* statistics = 2.12 and *p*-value = 0.034).[9] The estimated coefficient of the discontinuity dummy variable is 1.70, indicating that the inventory ratio increases 1.70%, a 0.18 standard deviation of inventory ratio, when a supplier is in deficit for two consecutive years.

The weakness of this analysis is that we rely on a specific situation: suppliers who report a financial deficit for two or more consecutive years. Indeed, the number of observations in the analysis is only 2,232. This, of course, diminishes the external validity of our findings. To overcome this problem, we use a comprehensive dataset to investigate our hypothesis in the next section.

5 Multivariate Analysis Approach

5.1 Empirical model

The main empirical specification is as follows:

$$Inventory_{it} = \beta FC\ of\ Supplier_{jt} + \boldsymbol{\gamma X_{it-1}} + \alpha_{ij} + \mathrm{y_t} + \epsilon_{it}, \quad (1)$$

where subscript *i* represents a customer, and *j* is its supplier at year *t*. *Inventory* is the customer's inventory ratio, defined as the total amount of inventory divided by sales. $\boldsymbol{X}$ is a vector of control variables. The customer–supplier level dummy variable, α_{ij}, captures unobserved (time-invariant) heterogeneity at the customer–supplier level.

To eliminate customer-supplier level unobservable factors, we use a standard fixed-effect model with within-transformation (Wooldridge, 2010, Roberts, and Whited, 2013). The within-transformation

[9] We restrict the sample to customers whose ordinary income in the previous year is negative, and we run a regression where the dependent variable is the customers' inventory. The main explanatory variable is a dummy variable that takes a value of one for a firm whose supplier records a deficit for two consecutive years. Other independent variables are a customer's ordinary income divided by its total assets, its squared term, cubic terms, and their interaction term with the dummy variable.

removes the time-invariant unobserved heterogeneity, α_{ij}, from the model by substituting the mean value of each variable for each customer-supplier pair.[10] Hence, the model for our estimation is as follows:

$$Inventory_{it} - \overline{Inventory_{ijt}} = \beta(FC\ of\ Supplier_{jt} - \overline{FC\ of\ Supplier_{ijt}}) + \boldsymbol{\gamma}(\boldsymbol{X_{it-1}} - \overline{\boldsymbol{X_{ijt-1}}}) + y_t + (\epsilon_{it} - \overline{\epsilon_{it}}). \quad (2)$$

The variable of interest is the *FC of Supplier*, which represents the supplier's financial constraints. Financial constraints are situations in which the firm's cost of external capital is much higher than that of internal capital (Farre-mensa and Ljungqvist, 2016). Under financial constraints, firms face difficulties to raise enough money to invest in new projects with positive NPV. In these situations, firms find it harder to borrow capital from banks. Hence, there is room for customers to substitute as liquidity providers for suppliers in financial trouble.

The three measurements of financial conditions (*FC*) are as follows. The first of these constraints is the KZ index based on Lamont, Polk, and Saa-Requejo (2001), derived from the estimation in Kaplan and Zingales (1997). The second is the KZ index without Tobin's *q*, created by Baker, Stein, and Wurgler (2003), conceding to the critique that Tobin's *q* has potential measurement errors. The third is the WW index, defined following Whited and Wu (2006) and Hennessy and Whited (2007). All of them have high values as the firm's financial condition worsens. Hence, we predict a positive coefficient for the *FC of Supplier*: formally, $H_0\ \beta = 0$, and $H_1\ \beta > 0$.

The vector of control variables $\boldsymbol{X}$ contains the following control variables. Following on Gaur, Fisher, and Raman (2005), we use gross margin and capital intensity. The gross margin is measured by the ratio

[10] One may concern that when a firm has multiple suppliers, there are two or more observations with same value as the dependent variable. Because the inventory is the firm level variable and the sample is customer-supplier level, there are more than one observation with identical value of dependent variable if a firm has multiple supplier. However, due to the within transformation in customer–supplier level fixed-effect model, the dependent variable takes a different value when a firm has multiple suppliers and transaction years. To check robustness, we conduct several experiments to overcome the characteristics of the issue of having only one dependent variable.

of the gross profit net of markdowns to net sales. Capital intensity is calculated by the ratio of fixed assets to total assets. We control for firm size measured by the natural logarithm of total assets because it is known that large firms can provide abundant liquidity to business partners by managing current assets, including inventory (e.g., Meltzer, 1960; Petersen and Rajan, 1997; Nilsen, 2002; Love, Preve, and Sarria-Allende, 2007; Carbó-Valverde, Rodríguez-Fernández, and Udell, 2016; Shenoy and Williams, 2017). We also control financial leverage defined as long-term and short-term loans divided by total assets. Finally, we control the effect of relative size, likely to influence inventory management, by adding the variable measured as total sales of the business partner scaled by the firm's total sales.

We also add the financial condition of the customer *i* itself (FC_{it}) as a control variable for two reasons. First, only financially healthy firms can support financially constrained suppliers. Second, previous studies point out the negative relationship between inventory and operating performance. All of our control variables are lagged values to avoid the concern of reverse causality.

Also, variables in ratio are expressed in percentage points. Control variables are winsorized at the 1st and 99th percentiles. Standard errors are computed by the clustering at the customer level. Table 1 reports the summary statistics of variables used in our analysis.

5.2 Main results of the fixed-effects model

Table 2 reports the estimated parameters of equation (2) with a customer-supplier level fixed-effects model. All financial constraint variables have positive coefficients. This supports our hypothesis that customers have incentive to support financially constrained suppliers by increasing inventory.

The economic impact is not so huge. Holding other variables constant, one-standard-deviation increase in the KZ-index of supplier is associated with an increase in (customers') inventory over sales by about 0.365 percentage points (= 0.41% × 0.89) of inventory over sales; that is 0.186 standard-deviation of the inventory of supplier. A one-standard-deviation increase in *FC(WW)* of supplier increases (customers')

inventory over sales by about 0.45 percentage points (= 5.07% × 0.09) of inventory over sales; that is 0.013 standard-deviation of the supplier's inventory ratio. This trivial impact is reasonable. The increase of inventory increases its own risk because as previous studies have shown, high inventory leads to low performance. Hence, while the inventory liquidity channel exists, it is not optimal to pronouncedly rely on this.

We evaluate the coefficients of control variables. We find a positive relationship between financial problem of the customer itself (*FC*) and inventory investment in four of five estimations. This is consistent with previous literature that argues that there is a negative relationship between performance and inventory investments.[11] Inconsistent with findings of Gaur, Fisher, and Raman (2005), our results show that gross margin and capital intensity have negative coefficients. Coefficients of *Capital Intensity* are negative, and this is inconsistent with Gaur, Fisher, and Raman (2005).[12] In subsequent IV analysis, the coefficient will be positive—consistent with the findings in the existing literature. *Relative Size* has positive coefficients implying that inventory ratio increases as the supplier size is larger than its customer. *Firm size* is positively correlated with the inventory whereas leverage is negatively correlated with inventory.

5.3 Alternative fixed effects

In the equation (1), most of the explanatory variables, especially the control variables, are customer characteristics, whereas we control for customer-supplier unobservable factors. The usage of the customer-supplier fixed-effects model may cause concern to some readers. To consider this, we conduct a customer-level fixed-effects model. Because each customer-year observation appears multiple times in

[11] However, in model (4) we do not find significant coefficient for both *FC(Inv. Cov. Ratio)* of supplier and customer. Nevertheless, we do not exclude inverse coverage ratio from our baseline analysis since we find inverse coverage ratio has significant explanatory power in the next section of further analysis.

[12] One caveat is that our dependent variable is inventory over sales, not inventory turnover.

our sample, we cannot use the within-transformation. Hence, we use regressions with a set of dummy variables for running equation (1). Adding multiple dummy variables increases fit of the model, as measured by the R-Squared.

Panel B of Table 2 reports the results with (customer) firm-level fixed-effects. While the coefficients are smaller than those in Panel A with customer-supplier fixed-effects, we find the results consistently support our hypothesis. All estimated coefficients on the FC of suppliers are positive, consistent with our hypothesis.

5.4 Instrumental variable approach

Next, we conduct an instrumental variable approach. There is a concern that both the inventory of customer and the financial condition of supplier are jointly affected by endogenous factor. The instrumental variable we use is the industry growth of the supplier's industry. The industry growth would directly affect the financial condition of the supplier. The negative shock in the industry leads to the decline of the profitability and increase the probability of financial problem of the firms belonging to the industry. However, if a specific shock happens in an industry, it should affect the financial healthiness of the firms in the industry but would not affect the inventory level of firms in other industries.

Table 3 reports the results of first- and second-stage IV estimations. Overall, we find a positive relation between the financial constraint of suppliers and inventory level of customers. Two KZ indices of suppliers are positively associated with customer's inventory investment. Due to this assumption, the sample in the instrumental variable analysis are the customer-supplier pairs that are in different industries, because if both are in the same industry, it is natural to assume that the shock affects both supplier's financial condition and the customer's inventory ratio. Now, gross margin is positively related to inventory management, which is consistent with the existing studies such as Gaur, Fisher, and Raman (2005).

We must evaluate the validity of the instrumental variables. First, we find that The *Average FC of Supplier's industry growth* has strong explanatory power in the first stage. Consistent with the prediction, it has positive coefficients and is statistically significant. Also, it satisfies the weak instrumental problem. Hence, columns in odd numbers of Table 3 report the *F*-statistics of the instrumental variable. In all estimations, *F*-statistics are more than the criteria value that is 16.38 for 10% IV size with one endogenous variable, evidence to support rejecting the concern of the weak instrument problem.

5.5 Regression analysis with exogenous shock

We use a situation with an exogenous shock for firm production: the earthquake and tsunami that happened in East Japan in March 2011. This brought severe damage in the sea coast of East Japan with the death of 18,430 people. Also, a huge tsunami made severe damage to the equipment of the firms located near the sea coast. If our hypothesis is valid, customers may support the business of suppliers affected by the tsunami disaster. The tsunami is a clear exogenous shock for the customer and supplier. More specifically, the collapse of equipment is not caused by the profitability of the supplier. Hence if the customers are healthy enough, customers will financially support suppliers affected by the tsunami. Hence, we identify the firms whose plants are in tsunami-damaged area. And then we compare the inventory level of their customers and the other firms.

We use Nikkei's Plant data information that contains the location information of the plants and branches of listed firms in Japan. Furthermore, we access several government disclosures to identify the cities affected by the tsunami.[13] Combining two data sets enables us to identify the firms with plants or branches in tsunami-affected areas.

[13] Three prefectures, Iwate, Miyagi, and Fukushima, affected by the tsunami report the number of deaths in each city. We obtain this unique data from websites of the prefectural governments. We identify the cities with more than 100 deaths and label them as tsunami-affected areas.

Using the difference-in-differences approach, we estimate the equation below.

$$Inventory_{it} = \beta_1 FC\ of\ Supplier_{jt} + \beta_2 After\ Earthquake \times Suppliers\ in\ Affected\ Areas_{ijt} + \beta_3 After\ Earthquake \times Suppliers\ in\ Affected\ Areas \times FC\ of\ Suppliers_{ijt} + \boldsymbol{\gamma X_{it-1}} + \alpha_{ij} + y_t + \epsilon_{it}, \quad (3)$$

Table 4 reports the results. *After Earthquake* × *Suppliers in Affected Areas* is a dummy variable that takes a value of one for the observations corresponding to suppliers located in tsunami-affected areas. *After Earthquake* × *Suppliers in Affected Areas* × *FC of Suppliers* is the three-way interaction term between *After Earthquake* × *Suppliers in Affected Areas* and *FC of Supplier*. Changes of inventory when a supplier is in financial constraints and located in tsunami-damaged area is captured by this interaction term.

We find positive coefficients for two of three financial constraints measurements. This implies that customers purchase more inventory from suppliers who suffered the earthquake and face financial problems. Interestingly, being located in the earthquake area itself does not have an impact on inventory. The coefficients of the double interaction term, *After Earthquake* × *Suppliers in Affected Areas*, are not statistically significant in all models. Overall, suppliers in financial constraints and impacted by the tsunami disaster are supported by their customers by increasing inventory.

As same with previous regressions, estimated coefficients of FC of Suppliers are positive and significant in three financial constraint measurements. Also, the FC, which is the financial constraint of customer itself, has positive coefficients.

6 Robustness Check

In previous section, we test various estimations that show customers support their suppliers by purchasing more products and increasing inventory when suppliers are in financial constraints. Now we

identify the specific situation, such as market competitiveness or power balance between customer and supplier, that incentivize customers to support suppliers. We expect additional results may provide robustness and alternative explanations of our findings.

6.1 Competitiveness of Supplier's Industry

First, we examine the heterogeneity of suppliers. Especially we test the impact of market competitiveness of the suppliers. If the financially constrained supplier is in a less-competitive market, it is much easier to recover due to less competition. However, if a supplier is in a competitive market, it requires that more support from customers. In addition, the customer is likely to find a chance to broaden its business influence in a competitive market. To do so, we divide the sample by the HHI (Herfindahl Hirschman Index) into two groups: the firms belonging to the product market with bottom and top quartile of HHI.

We find the strong positive relationship between the financial problem of suppliers and increase of inventory in the low HHI subsample (Panel A of Table 5). On the other hand, no significant coefficients are observed in high HHI subsample where the financially constriant suppliers are in oligopolistic markets (Panel B of Table 5). These results indicate that customers have stronger incentives to support suppliers in competitive markets (low HHI).

6.2 Alternative Explanation: Possibility of Exploitation

We assume that customers support suppliers. However, there are different interpretations of our findings. There is the concern related to the exploitation story, *i.e.* if a supplier has a strong bargaining power against a customer, the supplier chooses weak customers to buy more products. In this case, if a supplier has multiple customers, it chooses the weakest customer to buy more products. Furthermore, it could be also possible if the supplier's size is larger than its customer.

We consider the possibility that financially constraint suppliers choose weak customers to increase more inventory. To tackle this possibility, we identify the strong and weak customers for each supplier. Concretely, we restrict the suppliers with three or more suppliers. For each supplier, we identify the strongest and weakest customer by the degree of power that is measured by firm size or cash holding. Then, we divide the sample by the relative size of the supplier on the customer. The idea is that if the size of the supplier is sufficiently larger than its customer, the large supplier can require a customer to purchase more inventory. We further divide the sample by the relative size which is defined as the size of the supplier divided by that of the customer. Panel A of consists of the sample whose relative size is more than the median, *i.e.* the suppliers are larger than their customers, whereas Panel B of Table 6 consists of the sample whose relative size is equal to or less than median. Only in the Panel B, we find a positive coefficient on the *FC of Suppliers*, which implies the customers increase inventory when a weak supplier is in financial trouble. Overall, our findings reject the possibility that our main results are caused by exploitation by strong suppliers.

6.3 Weighted Value Approach

We also conduct the regression model with different ways to minimize a concern of using observations paired at the customer-supplier level. As mentioned in the methodology section, if a firm has multiple suppliers with exactly the same business relationship, the dependent variable takes the similar value for all customer-supplier pairs. To eliminate this possibility, we conduct a different set of analyses. We compress our dataset from supplier-customer-year level to customer-year level. While we estimate equation (2), the original model, equation (1) has same value for the dependent variable and control variables if a customer has multiple suppliers. Instead of using the supplier-customer-year level data, we estimate a model where the financial condition variable (*FC of Suppliers*) is the weighted average of

multiple suppliers. The FC of Supplier is computed by weighting the average value with the supplier's firm size measured by sales.

Table 7 shows positive coefficients on the FC of Suppliers measured by KZ indices. However, WW index reveals statistically insignificant coefficient. The sample size reduces from 57,625 in Table 2 into 18,943. Interestingly, the results are weaker than those we have above. Two of three coefficients of *FC of Suppliers* (weighted average value) have positive coefficients but now they are statistically significant at the 5% level. This may seem to be a counterargument with our findings; however, we conclude this is in line with the results. We found the sensitivity of the supplier's financial constraints on customer's inventory is high as the customer's size is larger than the supplier. Weighted averages make the level of financial constraints of larger size suppliers. Then it seems to weaken the support to small suppliers by customers.

6.4 Industry Characteristics

Some may argue that there are some industry-level trends. For example, it would be possible that the level of inventory asset is affected by the industry. If firms have little or no inventory due to their own business model, it is impossible to support others by increasing inventory. Furthermore, some industries like fresh foods avoid having more inventory due to the short shelf-life of their products. Hence, we can predict that such support by increasing inventory is possible for firms in industries with higher inventories.

However, this relationship is not well observed. Figure 2 shows the results. The x-axis is the average inventory inevstment at industry level. There are 53 industries. Y-axis is the estimated coefficient of suppliers' financial constraints, measured by the KZ index. While the plot line has positive coefficients, it is statistically insignificant (*t*-statistics =1.01). Moreover, we find that some of the industries have negative coefficients, most of them are statistically insignificant even at the 10% level, which is against our hypothesis.

We further conduct a subsample analysis. We divide the sample by the industry-median inventory ratio. Table 8 reports the results with high industry inventory-ratios in columns 1 to 3 and with low ratios in columns 4 to 6. The sensitivity of the financial constraints of supplier on customer's inventory is pronounced in the high industry inventory-ratio groups. This indicates the customers can support suppliers by increasing inventory when their business models rely on holding more inventory.

7 Subsequent Performance

Lastly, we examine whether such financial support by purchasing the inventory affects the financial healthiness of the customer. Some studies find a negative relationship between the amount of inventory and subsequent performance. This makes us a concern that the increase of inventory to support the financially constrained suppliers harms the liquidity of customers, which subsequently leads to the decline of the customer's performance. To tackle this possibility, we conduct the following interaction term approach.

$$Performance_{i,t+n} = \beta_1 Inventory_{i,t} + \beta_2 FC(KZ) of\ Supplier_{j\,t}$$

$$+\beta_3 Inventory \times FC(KZ) of\ Supplier + \boldsymbol{\gamma X_{it-1}} + \mathrm{a_i} + \mathrm{y_t} + \epsilon_{it} \qquad (4)$$

We compute the marginal effects of financial condition of the KZ-index on the subsequent performance in various values of financial the constraint variable. If the inventory is due to supporting a financially constraint supplier, the marginal effects should be negative. As a performance measure, we adopt ROA and Tobin's q. To eliminate unobservable firm characteristics that potentially affect firm performance, we use firm-level fixed-effects model. To ease the interpretation of the interaction terms' results, we use a standardized value of financial condition. The financial constraint variables used in this table is KZ-index.

Table 9 reports the estimated coefficients from equation (4) where we use ROA as the dependent variable in columns 1 to 3, and Tobin's q in columns 4 to 6. None of the six interaction terms have negative

coefficients, implying that there is no negative impact on customers' performance arising from the increased inventory to support suppliers.

8 Conclusion

We examine the possibility that inventory is used to rescue financially constraint suppliers. We find that the degree of supplier's financial problems positively relates to subsequent investments of its customers. This is observed in several types of fixed-effects models and instrumental variable estimations. Furthermore, we divide the sample by competitiveness of suppliers. We find a strong relationship between the financial condition of suppliers and a customer's inventory when the supplier is in competitive markets. This implies that a customer's incentive to support a financially constraint supplier is stronger when the suppliers face competitive conditions. Lastly, we examine the possibility that reliance on this inventory mechanism to support suppliers negatively impacts customer performance. However, we find no evidence that the increase of inventory to support constraint suppliers has a negative impact on the customer's performance.

APPENDIX Definition of variables

Variable	Definition
Inventory	Net stated inventories scaled by sales × 100
Raw Material	Raw material storage scaled by sales × 100
Semi	Semi-finished goods and Work in process scaled by sales × 100
Finished Goods	Finished goods and Merchandise scaled by sales × 100
Gross Margin	Sales minus cost of goods sold divided by sales × 100
Capital Intensity	Property, plant and equipment divided by total assets × 100
Firm Size	Natural logarithm of total assets
Leverage	Long-term and short-term loans divided by total assets × 100
Relative Size	Natural logarithm of supplier's sales divided by customer's sales
FC	Customer's financial constraints proxies below
FC of Supplier	Supplier's financial constraints proxies below
Financial constraints proxies	
FC(KZ)	KZ-index; see Lamont, Polk, and Saa-Requejo (2001) for the computation of the KZ-index
FC(KZ w/o Q ratio)	KZ-index without Tobin's *q* ratio; see Baker, Stein, and Wurgler (2003) for the computation of the KZ-index without *q* ratio.
FC(WW)	WW-index; see Whited and Wu (2006) and Hennessy and Whited (2007) for the computation of the WW-index

References

Aktas, Nihat, Ettore Croci, and Dimitris Petmezas. 2015. “Is Working Capital Management Value-Enhancing? Evidence from Firm Performance and Investments.” *Journal of Corporate Finance* 30(1): 98–113.

Baker, M., Stein, J.C., and Wurgler, J., 2003. “When does the market matter? Stock prices and the investment of equity-dependent firms.” *Quarterly Journal of Economics* 118: 969–1006.

Belo, Frederico, and Ziaoji Lin. 2013. “The Inventory Growth Spread.” *SSRN Electronic Journal*.

Biais, Bruno, and Chiristian Gollier, 1997, Trade credit and credit rationing, *Review of Financial Studies* 10, 903–937.

Bianco, Marco, and Andrea Gamba, 2019, Inventory and corporate risk management, *The Review of Corporate Finance Studies* 8, 97–145.

Brandenburg, Marcus. 2016. “Supply Chain Efficiency, Value Creation and the Economic Crisis - An Empirical Assessment of the European Automotive Industry 2002-2010.” *International Journal of Production Economics* 171: 321–35.

Burkart, Mike, and Tore Ellingsen, 2004, In-kind finance: a theory of trade credit, *American Economic Review* 94, 569–590.

Buzacott, John A., and Rachel Q. Zhang. 2004. “Inventory Management with Asset-Based Financing.” *Management Science* 50(9): 1274–92.

Cannon, Alan R. 2008. “Inventory Improvement and Financial Performance.” *International Journal of Production Economics* 115(2): 581–93.

Carbó-valverde, Santiago, Francisco Rodríguez-Fernández, and Gregory F. Udell. 2016. “Trade Credit, the Financial Crisis, and SME Access to Finance.” *Journal of Money, Credit and Banking* 48(1): 113–43.

Casey, Eddie, and Conor M. O'Toole. 2014. "Bank Lending Constraints, Trade Credit and Alternative Financing during the Financial Crisis: Evidence from European SMEs." *Journal of Corporate Finance* 27: 173–93..

Chen, Zhanhui. 2016. "Time-to-Produce, Inventory, and Asset Prices." *Journal of Financial Economics* 120(2): 330–45.

Cuñat, Vicente, 2007, Trade Credit: Suppliers as Debt Collectors and Insurance Providers, *Review of Financial Studies* 20, 491–527.

Custódio, C., Ferreira, M. A., & Garcia-Appendini, E. (2018). The Economic Costs of Financial Distress. *Mimeo*.

Eroglu, Cuneyt, and Christian Hofer. 2011. "Lean, Leaner, Too Lean? The inventory-performance link revisited." *Journal of Operations Management* 29(4): 356–69.

Farre-mensa, Joan, and Alexander Ljungqvist, 2016, Do Measures of Financial Constraints Measure Financial Constraints, *Review of Financial Studies* 29, 271–308.

Ferris, J Stephen, 1981, A transactions theory of trade credit use, *Quarterly Journal of Economics* 96, 243–270.

Garcia-Appendini, Emilia, and Judit Montoriol-Garriga, 2013, Firms as liquidity providers: Evidence from the 2007–2008 financial crisis, *Journal of Financial Economics* 109, 272–291.

Garcia-Appendini, Emilia, and Judit Montoriol-Garriga, 2019, Trade credit use as firms approach default, *Journal of Money Credit and Banking* forthcoming.

Gaur, Vishal, Marshall L. Fisher, and Ananth Raman. 2005. "An Econometric Analysis of Inventory Turnover Performance in Retail Services." *Management Science* 51(2): 181–94.

Guariglia, Alessandra, and Simona Mateut, 2006, Credit channel, trade credit channel, and inventory investment: evidence from a panel of uk firms, *Journal of Banking and Finance* 30, 2835–2856.

Hennessy, C.A., and Whited, T.M., 2007. "How costly is external financing? Evidence from a structural estimation." *Journal of Finance* 62: 1705–1745.

Hertzel, Michael G., Zhi Li, Micah S. Officer, and Kimberly J. Rodgers, 2008, Inter-firm Linkages and the Wealth Effects of Financial Distress along the Supply Chain, *Journal of Financial Economics* 87, 374–387.

Hosono, Kaoru, Daisuke Miyakawa, Taisuke Uchino, Makoto Hazama, Arito Ono, Hirofumi Uchida, and Iichiro Uesugi, 2016, Natural disasters, damage to banks, and firm investment, *International Economic Review* 57, 1335–1370.

Huang, Henry He, Gerald Lobo, Chong Whang, and Hong Xie, 2016, Customer concentration and corporate tax avoidance, *Journal of Banking & Finance* 72, 184–200.

Itzkowitz, Jennifer, 2013, Customers and cash: How relationships affect suppliers' cash holdings, *Journal of Corporate Finance* 19, 159–180.

Itzkowitz, Jennifer, 2015, Buyers as stakeholders: how relationships affect suppliers' financial constraints, *Journal of Corporate Finance* 31, 54–66.

Ivashina, Victoria, and Benjamin Iverson, 2018, Trade creditors' information advantage, *NBER Working Paper*.

Jones, Christopher S. and Selale Tuzel. 2013. "Inventory Investment and the Cost of Capital." *Journal of Financial Economics* 107(3): 557–79.

Kale, Jayant R., and Husayn Shahrur, 2007, Corporate capital structure and the characteristics of suppliers and customers, *Journal of Financial Economics* 83(2), 321–365.

Kaplan, S.N., and Zingales, L., 1997. "Do investment-cash flow sensitivities provide useful measures of financing constraints?" *Quarterly Journal of Economics* 112: 169–215

Kesavan, S., V. Gaur, and A. Raman. 2010. "Do Inventory and Gross Margin Data Improve Sales Forecasts for U.S. Public Retailers?" *Management Science* 56(July 2015): 1519–33.

Kieschnick, R., M. Laplante, and R. Moussawi. 2013. “Working Capital Management and Shareholders’ Wealth.” *Review of Finance* 17(5): 1827–52.

Kiyotaki, Nobuhiro, and John Moore, 1997, Credit chains, *Mimeo*.

Lamont, O., Polk, C., and Saa-Requejo, J., 2001. “Financial constraints and stock returns.” *Review of Financial Studies* 14: 529–554.

Leitner, Yaron, 2005, Financial networks: contagion, commitment, and private sector bailouts, *Journal of Finance* 60, 2925–2953.

Lian, Yili, 2017, Financial distress and customer-supplier relationships, *Journal of Corporate Finance* 43, 397–406.

Love, Inessa, Lorenzo A. Preve, and Virginia Sarria-Allende. 2007. “Trade Credit and Bank Credit: Evidence from Recent Financial Crises.” *Journal of Financial Economics* 83(2): 453–69.

Mateut, Simona, Spiros Bougheas, and Paul Mizen, 2006, Trade credit, bank lending and monetary policy transmission, *European Economic Review* 50, 603–629.

McMillan, John, and Christopher Woodruff, 1999, Interfirm relationships and informal credit, *Quarterly Journal of Economics* 114, 1285–1320.

Meltzer, Allan H. 1960. “Mercantile Credit , Monetary Policy and Size of Firms.” *Review of Economics and Statistics* 42(4): 429–37.

Nilsen, Jeffrey H. 2002. “Trade Credit and the Bank Lending Channel.” *Journal of Money, Credit and Banking* 34(1): 226–53.

Ng, Chee K., Janet K. Smith, and Richard L. Smith, 1999, Evidence on the Determinants of Credit Terms Used in Interfirm Trade, *Journal of Finance* 54, 1109–1129.

Petersen, Mitchaell, and Raghuram G. Rajan. 1997. “Trade Credit: Theories and Evidence.” *Review of Financial Studies* 10(3): 661–91.

Roberts, Michael R, and Toni M Whited, 2013, Endogeneity in empirical corporate finance, in George Constantinides, in Milton Harris, and in Rene M Stulz ed.: *Handbook of the Economics of Finance* (Elsevier).

Shenoy, Jaideep, and Ryan Williams. 2017. "Trade Credit and the Joint Effects of Supplier and Customer Financial Characteristics." *Journal of Financial Intermediation* 29: 68–80.

Smith, Janet Kiholm, 1987, Trade Credit and Informational Asymmetry, *Journal of Finance* 42, 863–872.

Steinker, Sebastian, and Kai Hoberg. 2013. "The Impact of Inventory Dynamics on Long-Term Stock Returns - An Empirical Investigation of U.S. Manufacturing Companies." *Journal of Operations Management* 31(5): 250–61.

Thomas, Jacob K., and Huai Zhang, 2002, Inventory Changes and Future Returns, *Review of Accounting Studies* 7, 163–187.

Titman, Sheridan, 1984, The Effect of Capital Structure on a Firm's Liquidation Decision, *Journal of Financial Economics* 13(1), 137–151.

Tunca, Tunay I., and Weiming Zhu, 2017, Buyer intermediation in supplier finance, *Management Science* 64, 5631–5650.

Whited, T.M., and Wu, G., 2006. "Financial constraints risk." *Review of Financial Studies* 19: 531–559.

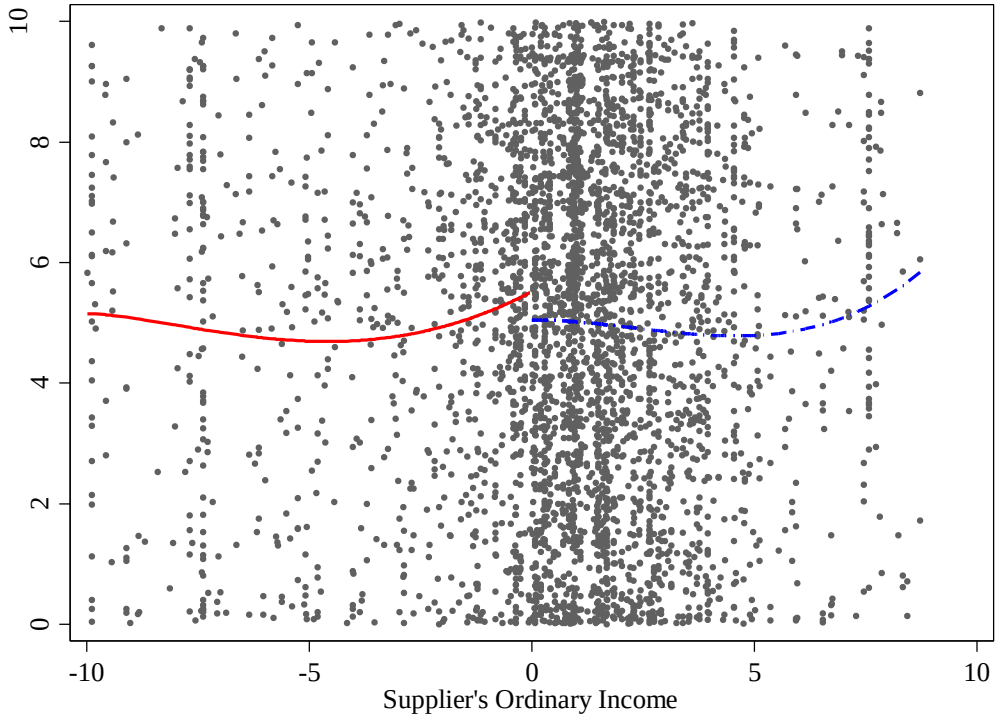
Wilner, Benjamin S. 2000. "The Exploitation of Relationships in Financial Distress: The Case of Trade Credit." *Journal of Finance* 55(1): 153–78.

Wooldridge, Jeffrey M., 2010, *Econometric Analysis of Cross Section and Panel Data* (MIT Press).

Zeidan, Rodrigo, and Offer Moshe Shapir. 2017. "Cash Conversion Cycle and Value-Enhancing Operations: Theory and Evidence for a Free Lunch." *Journal of Corporate Finance* 45: 203–19.

Figure 1 Regression Discontinuity Design Approach for Two-year Deficit Firms

This figure plots the customer's inventory ratio for the sample those suppliers record negative ordinary income in previous accounting year. X-axis is the supplier's latest ordinary income. Two lines are fitted curves for negative (positive) suppliers' ordinary income in present financial reports.



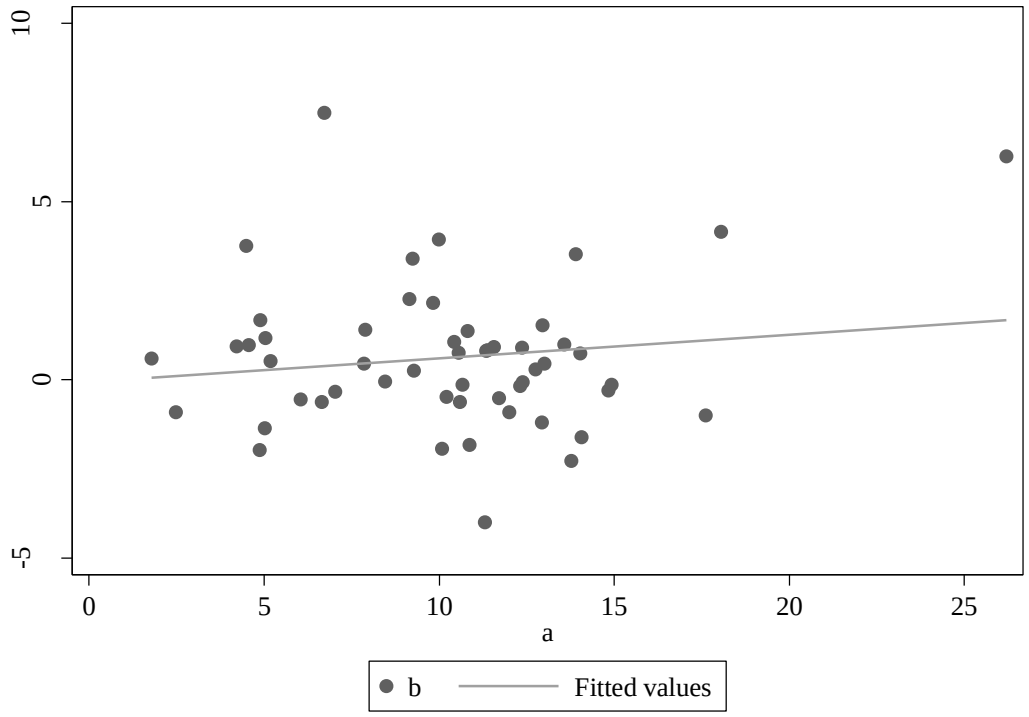


Figure 2 Relationship between the Inventory Investment (%, x-axis) and Estimated Coefficients (y-axis) at Industry Level.

Table 1 Summary Statistics

This table reports the summary statistics of the variables used in this study

	N.	Mean	St. Dev.	Minimum	25 Pctil	Median	75 Pctile	Max
Inventory (Customers)	55,873	11.58	11.94	0.00	3.67	8.48	15.64	79.30
FC of Suppliers								
KZ	55,873	1.67	0.89	-2.45	1.09	1.82	2.34	4.53
KZ w/o Q	55,873	1.36	0.93	-3.13	0.79	1.53	2.05	3.24
WW	55,873	-0.63	0.09	-0.85	-0.70	-0.63	-0.57	-0.19
Inv. Cov. Ratio	55,873	0.15	0.32	-1.28	0.02	0.08	0.20	2.22
Deficit_2yrs	55,873	0.02	0.13	0	0	0	0	1
FC of Customers								
KZ	55,873	1.34	0.96	-2.48	0.69	1.41	2.05	5.08
KZ w/o Q	55,873	1.03	0.98	-3.47	0.38	1.11	1.76	3.30
WW	55,873	-0.52	0.08	-0.83	-0.57	-0.52	-0.47	-0.02
Inv. Cov. Ratio	55,844	0.11	0.35	-1.28	0.01	0.04	0.14	2.22
Deficit_2yrs	55,873	0.04	0.21	0	0	0	0	1
Control variables (Customers)								
HHI	55,873	1.73	4.89	0.00	0.01	0.13	1.62	79.19
Gross Margin	55,873	79.22	14.50	3.58	74.03	82.89	89.37	96.66
Capital Intensity	55,873	17.19	12.05	0.14	7.60	15.33	24.50	56.76
Firm Size	55,873	10.59	1.54	5.12	9.57	10.48	11.49	17.39
Leverage	55,873	53.04	21.04	7.98	37.31	53.98	69.15	99.17
Reletive Size	55,873	2.54	2.24	-5.97	0.99	2.53	4.07	10.01

Table 2 Fixed-Effect Estimation: Customer-Supplier Level Observation

This table reports the results of fixed effect at customer-supplier relationship level in Panel A and firm level in Panel B. Sample is all customer-supplier pairs appearing in the Nikkei's Main Suppliers/Customers Data Set. We report the estimated coefficients from equation 3. The dependent variable is the inventory ratio of the customer. Main explanatory variable is *FC of Suppliers* for measuring the financial condition of the supplier: three measurements for financial constraints and two for financial deficits. *FC* is the financial condition of the customer. The *t*-statistics are reported with the standard errors clustered at the customer-supplier relationship level (Panel A) and firm level (Panel B). Control variables are the control variables. ***, **, and * report statistical significance at the 1, 5, and 10% levels, respectively.

Panel A Customer-Supplier Fixed-Effects

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	0.41***	0.41***	5.07***
	(3.25)	(3.17)	(3.88)
FC	2.32***	2.51***	1.90
	(13.40)	(15.04)	(1.39)
Gross Margin	-0.02	-0.01	-0.04**
	(-1.19)	(-0.66)	(-2.55)
Capital Intensity	-0.05***	-0.05***	-0.04***
	(-4.40)	(-4.65)	(-3.52)
Firm Size	2.86***	2.20***	2.74***
	(8.34)	(7.12)	(8.28)
Leverage	-0.08***	-0.08***	-0.01
	(-8.96)	(-9.98)	(-1.21)
Reletive Size	1.07***	0.91***	1.17***
	(4.88)	(4.30)	(5.34)
Constant	-18.25***	-10.97***	-11.19***
	(-4.29)	(-2.81)	(-2.91)
Observations	55,873	57,625	57,625
Number of Firms	11,434	11,777	11,777
R-squared	0.045	0.048	0.023
Year dummies	YES	YES	YES
Clustering (Customer)	YES	YES	YES

Panel B Firm Fixed-Effects

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	0.08**	0.08**	5.78***
	(2.03)	(1.98)	(5.21)
FC	2.45***	2.60***	2.13
	(8.60)	(9.87)	(1.01)
Gross Margin	-0.04*	-0.03	-0.06***
	(-1.66)	(-1.48)	(-2.68)
Capital Intensity	-0.06***	-0.06***	-0.05***
	(-4.07)	(-4.36)	(-3.65)
Firm Size	2.24***	1.67***	2.23***
	(5.23)	(4.69)	(5.55)
Leverage	-0.08***	-0.08***	-0.00
	(-5.70)	(-6.37)	(-0.02)
Reletive Size	-0.00	-0.00	0.26***
	(-0.04)	(-0.18)	(4.80)
Constant	-6.43	-0.46	-1.32
	(-1.27)	(-0.11)	(-0.30)
Observations	55,873	57,625	57,625
R Squared	0.881	0.879	0.876

Table 3 Instrumental Variable Estimation

This table reports the results of IV estimations. Columns in odd numbers report the first stage and those in even numbers report second stage results. For each in the first stage, F-statistics of instruments are also reported. The last row, *F*-stats, reports the *F*-statistics of first-stage regression based on Kleibergrn and Paap Wald rank *F*-statistic for weak instruments. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Dependent variable	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ	KZ w/o Q	KZ w/o Q	WW	WW
	1st Stage	*2nd Stage*	*1st Stage*	*2nd Stage*	*1st Stage*	*2nd Stage*
	[1]	[2]	[3]	[4]	[5]	[6]
FC of Suppliers		4.81***		4.49***		51.86
		(6.75)		(6.96)		(1.06)
FC	0.04*	3.28***	0.06***	3.37***	0.11***	18.16**
	(1.87)	(7.23)	(2.87)	(8.61)	(9.42)	(2.53)
Gross Margin	0.00***	-0.02	0.00***	-0.02*	-0.00***	0.02
	(4.97)	(-1.27)	(4.48)	(-1.78)	(-7.66)	(1.08)
Capital Intensity	0.00	-0.14***	0.00	-0.14***	0.00***	-0.13***
	(1.00)	(-5.98)	(1.16)	(-6.33)	(11.68)	(-3.66)
Firm Size	0.08***	0.19	0.07***	0.19	-0.03***	3.91**
	(9.18)	(0.94)	(8.77)	(0.97)	(-45.58)	(2.27)
Leverage	0.00	-0.13***	0.00	-0.13***	-0.00***	0.03
	(1.00)	(-5.56)	(0.17)	(-6.25)	(-10.43)	(1.32)
Reletive Size	0.08***	-0.39**	0.07***	-0.34**	-0.04***	2.48
	(13.17)	(-2.51)	(12.55)	(-2.33)	(-128.10)	(1.26)
Average FC of Supplier's industr	0.71***		0.75***		0.06***	
	(32.30)		(33.77)		(6.65)	
Constant	-0.69***	7.29***	-0.75***	10.74***	-0.05***	4.86
	(-7.41)	(3.55)	(-7.55)	(5.17)	(-8.71)	(1.34)
Observations	47,784	47,784	49,215	49,215	49,215	49,215
R-squared (within)	0.357	-0.021	0.362	-0.011	0.824	0.082
Clustered at Customer	YES	YES	YES	YES	YES	YES
F-stats	44.62		47.34		1.050	

Table 4 Impact of the earthquake

Suppliers in Affected Area is a dummy variable that takes the value of one for the firms located in earthquake area. After Earthquake is a dummy variable that takes the value of one for the financial reports after March 2011 when the earthquake happened. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers (Weighted value)	0.60***	0.61***	6.41***
	(4.02)	(4.06)	(3.97)
Ater Earthquake x Supplier in Affected Area x FC of Supplier	0.69**	0.71**	-0.23
	(2.38)	(2.41)	(-0.05)
Ater Earthquake x Supplier in Affected Area	-0.49	-0.34	0.50
	(-1.05)	(-0.82)	(0.17)
FC	2.13***	2.47***	4.61*
	(6.48)	(7.96)	(1.91)
Gross Margin	-0.06**	-0.04	-0.08***
	(-2.14)	(-1.56)	(-2.75)
Capital Intensity	-0.05***	-0.05***	-0.04**
	(-3.01)	(-3.25)	(-2.50)
Firm Size	2.50***	2.04***	2.42***
	(5.49)	(4.94)	(5.45)
Leverage	-0.08***	-0.09***	-0.02*
	(-5.01)	(-6.00)	(-1.87)
Reletive Size	1.30***	1.17***	1.35***
	(3.86)	(3.63)	(4.02)
Constant	-11.52**	-7.20	-2.69
	(-2.16)	(-1.44)	(-0.54)
Observations	31,305	32,152	32,152
Number of Firms	6,061	6,210	6,210
Firm FE	YES	YES	YES
Year dummies	YES	YES	YES
Clustered at Customer	YES	YES	YES
R-squared (within)	0.0531	0.0593	0.0334
R-squared (between)	0.0138	0.0167	0.0143
R-squared (overall)	0.0145	0.0169	0.0145

Table 5 Divided by Competitiveness of Supplier's Industry

This table reports the subsample analysis where the sample is divided by the competitiveness measured by HHI. Panel A consists of the firms belongs to the industries where HHI is in the bottom 25th percentile, and Panel B consists of those for which HHI is more than the 75th percentile. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Panel A High Competitiveness (HHI is bottom 25 percentile)

FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	1.19***	1.22***	12.08***
	(4.82)	(4.56)	(3.81)
FC	3.51***	3.87***	5.30
	(6.49)	(7.37)	(1.10)
Gross Margin	-0.04	-0.03	-0.08**
	(-1.09)	(-0.78)	(-2.26)
Capital Intensity	-0.05*	-0.05**	-0.04
	(-1.94)	(-2.13)	(-1.62)
Firm Size	4.10***	3.38***	4.30***
	(4.77)	(4.31)	(4.94)
Leverage	-0.12***	-0.12***	-0.02
	(-4.78)	(-5.38)	(-0.97)
Reletive Size	1.21**	1.23**	1.42***
	(2.41)	(2.48)	(2.77)
Constant	-24.67***	-16.94**	-13.01
	(-2.82)	(-2.13)	(-1.60)
N. of observations	13,923	14,410	14,410
R-squared	0.074	0.082	0.040

Panel B Low Competitiveness (HHI is top 25 percentile)

FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	-0.23	-0.19	-0.53
	(-0.68)	(-0.58)	(-0.23)
FC	1.90***	2.15***	2.37
	(5.81)	(6.36)	(0.87)
Gross Margin	-0.03	-0.01	-0.04
	(-0.73)	(-0.33)	(-1.12)
Capital Intensity	-0.03	-0.03	-0.02
	(-1.31)	(-1.58)	(-1.02)
Firm Size	2.59***	1.87**	2.41***
	(3.11)	(2.43)	(3.01)
Leverage	-0.08***	-0.08***	-0.02
	(-4.06)	(-4.48)	(-1.15)
Reletive Size	1.75***	1.19**	1.47***
	(3.34)	(2.23)	(2.63)
Constant	-19.90**	-10.53	-15.90
	(-1.97)	(-1.09)	(-1.60)
N. of observations	14,002	14,382	14,382
R-squared	0.048	0.051	0.030

Table 6 Within Customer Analysis

This table reports the results of subsample analyses in which the sample is divided by the relative size. Relative size is defined as the sales of supplier divided by that of customer. Panel A consists of the sample where relative size is more than the median, and Panel B consists of those less than the median. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Panel A Relative size is more than median (Large suppliers)

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	0.18	0.13	2.11
	(0.66)	(0.49)	(1.07)
Other variables	Included	Included	Included
N. of observations	27,716	28,812	28,812
R-squared	0.039	0.041	0.021

Panel B Relative size is more than median (Large suppliers)

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers	0.42***	0.50***	5.09***
	(3.05)	(3.39)	(3.23)
Other variables	Included	Included	Included
N. of observations	28,157	28,813	28,813
R-squared	0.061	0.066	0.031

Table 7 Weighted Value Approach

This table report the results of subsample analysis in which the dependent variable is the fraction of inventory. Panel A uses raw material, Panel B uses semi-finished products, and Panel C uses the finished goods, all are divided by sales, as the dependent variables. Explanatory variables are the same as in Table 2. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Dependent variable	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW
	[1]	[2]	[3]
FC of Suppliers (Weighted value)	0.25**	0.28**	0.06
	(2.15)	(2.23)	(0.14)
FC	2.20***	2.60***	5.64**
	(7.26)	(8.84)	(2.16)
Gross Margin	-0.10***	-0.09**	-0.13***
	(-2.85)	(-2.50)	(-3.58)
Capital Intensity	-0.06***	-0.06***	-0.05***
	(-3.27)	(-3.46)	(-2.70)
Firm Size	1.66***	1.38***	1.73***
	(4.70)	(3.82)	(4.66)
Leverage	-0.08***	-0.08***	-0.01
	(-5.08)	(-5.64)	(-0.81)
Reletive Size	0.02	0.02	0.03
	(0.40)	(0.44)	(0.74)
Constant	4.35	6.92*	7.91*
	(1.04)	(1.65)	(1.91)
Observations	18,943	18,943	18,943
Number of Firms	2,491	2,491	2,491
Firm FE	YES	YES	YES
Year dummies	YES	YES	YES
Clustered at Customer	YES	YES	YES
R-squared (within)	0.0501	0.0570	0.0327
R-squared (between)	0.0219	0.0297	0.0120
R-squared (overall)	0.0196	0.0252	0.0113

Table 8 Subsample Analysis: Industry Inventory Ratio

This table reports the results of subsample analyses—those divided by industry median inventory ratio. Columns 1 to 3 consist of the firms in industries with high inventory ratios, and columns 4 to 6 to those with low inventory ratios. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

	High Inventory Ratio			Low Inventory Ratio		
Dependent Variables:	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory
FC is measured by ..	KZ	KZ w/o Q	WW	KZ	KZ w/o Q	WW
	[1]	[2]	[3]	[4]	[5]	[6]
FC of Suppliers	0.58**	0.66***	8.97***	0.30**	0.24*	1.39
	(2.45)	(2.71)	(3.33)	(2.28)	(1.87)	(1.08)
FC	3.46***	3.85***	2.35	1.40***	1.49***	2.40
	(11.99)	(13.84)	(1.05)	(7.74)	(8.75)	(1.43)
Gross Margin	-0.04	-0.02	-0.06**	-0.02	-0.01	-0.03
	(-1.08)	(-0.54)	(-2.13)	(-0.80)	(-0.39)	(-1.38)
Capital Intensity	-0.09***	-0.09***	-0.07***	-0.01*	-0.01*	-0.01
	(-4.32)	(-4.55)	(-3.26)	(-1.68)	(-1.86)	(-1.27)
Firm Size	4.12***	3.53***	4.26***	1.43***	0.93***	1.35***
	(7.66)	(6.85)	(7.69)	(3.45)	(2.65)	(3.54)
Leverage	-0.11***	-0.12***	-0.01	-0.05***	-0.05***	-0.01
	(-8.41)	(-9.50)	(-1.11)	(-4.63)	(-5.21)	(-1.03)
Reletive Size	1.32***	1.11***	1.56***	0.76***	0.65***	0.78***
	(3.69)	(3.15)	(4.29)	(2.95)	(2.69)	(3.13)
Constant	-28.31***	-22.21***	-21.05***	-6.53	-0.97	-2.48
	(-4.42)	(-3.62)	(-3.41)	(-1.24)	(-0.21)	(-0.55)
Observations	29,864	30,608	30,608	26,009	27,017	27,017
Number of Firms	7,186	7,350	7,350	6,360	6,607	6,607
R-squared	0.059	0.066	0.029	0.031	0.033	0.015
Year dummies	YES	YES	YES	YES	YES	YES
Clustering (Customer)	YES	YES	YES	YES	YES	YES

Table 9 Subsequent Performance

This table reports the relationship between subsequent performance, inventory, and the financial condition of supplier. Dependent variables are ROA in columns 1 to 3, and Tobin's q in columns 4 to 6. ***, **, and* indicate statistical significance at the 1, 5, and 10% levels, respectively.

Dependent variable is	ROA (t+1)	ROA (t+2)	ROA (t+3)	TBq (t+1)	TBq (t+2)	TBq (t+3)
	[1]	[2]	[3]	[4]	[5]	[6]
Inventory	-0.0782***	-0.0239***	-0.0119**	-0.00373***	-0.00181***	-0.000729***
	(0.00440)	(0.00461)	(0.00480)	(0.000252)	(0.000254)	(0.000259)
FC(Supplier) (Standardized)	0.0162	0.0886	0.0482	-0.00209	0.00895**	0.0103**
	(0.0748)	(0.0793)	(0.0834)	(0.00412)	(0.00424)	(0.00438)
… x *Inventory*	0.00881***	0.00578*	0.00521	0.000977***	0.000631***	0.000116
	(0.00329)	(0.00349)	(0.00362)	(0.000192)	(0.000196)	(0.000200)
FC (Customer)	-0.812***	0.936***	1.715***	0.150***	0.103***	0.0438***
	(0.0709)	(0.0745)	(0.0775)	(0.00405)	(0.00411)	(0.00419)
Gross Margins	0.0448***	-0.00924	-0.00873	0.00487***	0.00319***	4.10e-05
	(0.00557)	(0.00578)	(0.00601)	(0.000317)	(0.000320)	(0.000328)
Capital Intensity	0.00432	0.00529	0.0257***	-0.000910***	-0.000607**	0.000657**
	(0.00497)	(0.00522)	(0.00544)	(0.000291)	(0.000295)	(0.000301)
ln(Total Assets)	-3.207***	-3.323***	-3.101***	-0.313***	-0.252***	-0.222***
	(0.110)	(0.117)	(0.122)	(0.00622)	(0.00638)	(0.00655)
Leverage	0.0740***	0.0475***	0.0158***	0.00106***	0.00119***	0.00216***
	(0.00351)	(0.00366)	(0.00380)	(0.000196)	(0.000198)	(0.000201)
ln(Relative Size)	0.418***	0.450***	0.489***	0.0151***	0.0377***	0.0376***
	(0.0938)	(0.0988)	(0.104)	(0.00522)	(0.00533)	(0.00546)
Constant	31.20***	35.32***	33.74***	3.573***	3.193***	3.194***
	(1.416)	(1.495)	(1.568)	(0.0809)	(0.0829)	(0.0850)
N. of observations	53,187	49,900	46,326	114,672	106,999	99,098
R-squared	0.104	0.101	0.108	0.214	0.192	0.195