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KASHIWAGI, Yuzuka
Waseda University

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Enterprise Resilience to Disasters: Who Needs Public Support?[1]

Yuzuka KASHIWAGI
Waseda University

Abstract

This paper examines the effect of capital subsidies after great disasters on the recovery of small- and medium-sized enterprises (SMEs) using propensity score matching estimations. Our estimates show that capital subsidies were effective for the recovery of performance for SMEs in the retail sector. However, in the manufacturing and other service sectors, we find no significant difference between the recovery of SMEs with and without the subsidy. Utilizing firm-level supply chain data, we further explore the mechanism behind the heterogeneity across sectors. Our results suggest that the heterogeneity comes from variations in the degree of private support across sectors rather than variations in supply chain disruption.

Keywords: resilience, disaster, supply chains
JEL classification: H20, L14

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[1] Graduate School of Economics, Waseda University, and Research Fellow of Japan Society for the Promotion of Science (JSPS), 1-6-1 Nishi-Waseda, Shinjuku-ku, Tokyo 1698050, Japan (email: yuzu-26@akane.waseda.jp)

1. Introduction

Natural disasters are often unanticipated costly events for businesses. To repair or reinstall what disasters destroy, firms that survive are often saddled with loans. Because it is difficult for many local firms to either cover the total cost by themselves or prepare for such rare unpredictable events in advance to reduce the cost, the government often intervenes after disasters. For example, the Japanese government provided a capital subsidy known as the *Group Subsidy* to help small-and medium-sized enterprises (SMEs) recover from the damage caused by the Great East Japan Earthquake in 2011. The United States Small Business Administration and Farm Service Agency also provide disaster assistance to businesses affected by declared disasters. Among the developing countries, Thailand, for example, introduced relief aid to local businesses that suffered from the flood.

However, the reconstruction cost is too enormous for the government budgetary resources to absorb, and thus, natural disasters deteriorate the government's financial conditions (Benali, Abdelkafi, and Feki 2018). The cost of disasters for the government is likely to continue growing considering the increasing frequency and severity of disasters (Altay and Ramirez 2010), and the political motivations inherent in subsidies (Garrett and Sobel 2003). Further, some warn that the repeated application of government support may crowd out private coping and private support of individual firms and increase the costs incurred by government (Nakazawa 2018). On the other hand, government support is essential, especially for the most vulnerable firms that cannot expect much private support. Therefore, it is important to discuss the effective targeting of government support to disaster-hit firms.

A small number of quantitative studies examine the process of enterprise recovery (De Mel, McKenzie, and Woodruff 2012, Hsu et al. 2018). Even fewer studies investigate the effect of public or private support, although there is a large body of literature on how households cope with disasters (Skoufias 2003, Sawada and Takasaki 2017). With regard to public support for firms, De Mel, McKenzie, and Woodruff (2012) provide firm-level evidence from a randomized control trial in a developing country that suggests that the capital subsidy is effective in the retail sector but not in other sectors in the short and medium run. They note that disruptions in supply chains may be potential contributors to this difference, but they do not test this hypothesis due to data limitations. Regarding private support, Todo, Nakajima, and Matous (2015) use firm-level data in Japan and find that private support through supply chains is helpful for resuming performance. However, their study does not examine the alternate or supplemental relationship with public support.

In this paper, we examine the impact of the subsidy, or public support, on firms hit by the Great East Japan Earthquake and explore the mechanism behind sectoral heterogeneity. We first estimate the impact of the capital subsidy on the recovery of disaster-hit firms in Japan in the medium run and investigate the heterogeneity of the impact across sectors. Consistent with De Mel, McKenzie, and Woodruff (2012), we find a substantial impact of the subsidy on the retail sector, but we do not observe any difference between the recovery of firms with and without the subsidy in the manufacturing and

other service sectors. Because we have supply chain information of firms in Japan, we further investigate the mechanism that causes the sectoral difference. Our results suggest that the heterogeneity comes from variations in the degree of private support across sectors rather than variations in supply chain disruption.

Our findings contribute to several strands of literature. First, a small number of papers examine the impact of the relief subsidy on firms' recovery, as mentioned above. Our finding that the subsidy differentiates the level of recovery only for the retail sector and reconstruction-related sectors is new to the research on enterprises in developed countries. In addition, coupled with the study in a developing country by De Mel, McKenzie, and Woodruff (2012), this study contributes to the relief aid literature by providing the methodological implication that the impact on retailers may need to be estimated separately.

Second, based on supply chain information, the results identify the potential mechanism explaining why the relief subsidy is effective only for some sectors. Previous research has not examined this issue due to the lack of supply chain data. Our conclusion adds to the discussion on the mechanism and provides important implications for policymakers who consider the provision of relief support for firms.

Finally, this paper also contributes to the literature on private risk management. There are many household-level analyses that investigate how people cope with disasters through private and public mechanisms (Mozumder et al. 2009, Sawada and Takasaki 2017). However, few studies explore this at the firm level, even though qualitative interviews reveal that firms also cope with disasters through both private and public mechanisms in the post-disaster periods. The closest study in this context is Todo, Nakajima, and Matous (2015). They study the effect of supply chain links as a source of private support. However, they did not look at other channels of support such as public support. We build on their study and explore an interplay between public and private support. Further, our investigation of sectoral differences in the impact of private support is also new to the literature.

The paper is organized as follows. Section 2 describes the Great East Japan Earthquake and the related subsidy. Section 3 describes the data. Section 4 describes our estimation strategy. Section 5 presents our estimates. Section 6 offers concluding remarks.

2. Background

2.1 The Great East Japan Earthquake and the Impact on Firms

The Great East Japan Earthquake occurred on March 11, 2011, and several prefectures in Japan directly suffered from it. The magnitude of the earthquake was 9.0, the fourth largest earthquake in the world since 1900. The earthquake also triggered a large tsunami and nuclear accidents in the Fukushima Daiichi Nuclear Power Plant. The economic loss from this disaster was huge, at 16.9 trillion yen or approximately 212 million dollars (Cabinet Office of Japan 2011). A total of 99.9% of firms located in the disaster-hit area were SMEs (The Small and Medium Enterprise Agency of Japan 2012). A survey

of 2,117 firms in the disaster-hit area conducted by the Research Institute of Economy, Trade and Industry suggests that 1,376 plants were destroyed because of the earthquake and 115 plants were partially destroyed by the tsunami (Wakasugi and Tanaka 2013). Approximately 50% of them restarted business within three months, and most of the firms that successfully continued business after the disaster restarted their business within a year (Teikoku Databank 2016).

But how did firms cope with the Great East Japan Earthquake? According to the Cabinet Office of Japan (2016), only around 20% of SMEs in the disaster-hit area were insured. Thus, although Runyan (2006) documented that insurance is the key factor of recovery in the US context, that coping strategy was not available for most of the SMEs suffering from the Great East Japan Earthquake. Instead, many firms utilized public and private support from the government and other firms. The government helped firms with their finances through the provision of subsidies, loans, and guarantees and the system for consultations. In particular, to help firms restore and reconstruct their facilities, the government created the *Group Subsidy*, which is the most popular public support for severely affected SMEs, as we will explain in detail in the next subsection. In contrast, firms outside the disaster-hit area provided a variety of voluntary support, such as sending needed machines and products (Yoshida 2011). The substantial effect of support from supply chain partners is quantitatively confirmed by Todo, Nakajima, and Matous (2015).

2.2 Group Subsidy

The *Group Subsidy*, hereafter the subsidy for simplicity, has been provided by the Japanese government through the SME Agency under the Ministry of Economy, Trade and Industry and prefecture governments to groups of SMEs in the areas damaged by the earthquake, i.e., Hokkaido, Aomori, Iwate, Miyagi, Fukushima, Tochigi, Ibaraki, and Chiba Prefectures. More specifically, this subsidy program targets SMEs that form groups to recover from damages caused by the Great East Japan Earthquake and play an important role in employment and economic activities in the region. The program subsidizes 75% of the costs to repair or restore the capital goods of SMEs destroyed by the earthquake and the subsequent tsunamis (SME Agency of Japan 2011). More than 95% of subsidies are provided to groups in the four most affected prefectures: Aomori, Iwate, Miyagi, and Fukushima.

A notable feature of this policy is that subsidies are provided not to individual firms but to groups of firms. Groups are formed voluntarily among firms linked through supply chains, in the same industrial park, in the same commercial area, and in the same industry, for example. This policy measure was developed because public money could not be used to restore private properties of individual firms even in the case of natural disasters but could be provided to firm groups for regional recovery. Although groups are primarily made of SMEs, non-SMEs can also become members as coordinators. Besides, some reported that many of applicant firms got subsidies; only 5 percent of firms answered that they had applied but failed in the survey by the National Conference of the Association of Small Business Entrepreneurs (Nakazawa 2018, The National Conference of the Association of Small Business

Entrepreneurs 2013). In the group level, Iwate Prefectural Office (2018) reports that firm groups in Iwate faced competition with an acceptance rate of 37 percent to get the subsidy during the first one-year of the implementation, but 83 percent of applicant groups got subsidies during the following year. Thus, once firms successfully formed groups, it was not quite difficult to get subsidies.

The first round of subsidies was announced in June 2011, three months after the earthquake, and granted in August 2011 (SME Agency of Japan 2011). As of December 2018, more than seven years after the earthquake, the program had continued to provide subsidies to SMEs. The amount of subsidies provided by this policy is extremely large; by 2018, a total of 504 billion yen (approximately 4.5 billion US dollars) had been provided to 705 groups of firms damaged by the Great East Japan Earthquake.

3. Data

3.1 Data source

This study utilizes firm-level data collected by Tokyo Shoko Research (TSR). The TSR data contains corporate information, such as each firm's location, sales, and number of employees, and information on suppliers and customers. The TSR data includes the identification number of each supplier and client, and based on the data, we can identify networks of firms through supply chains in Japan. The TSR data is commonly used in the economics literature. Regarding enterprise resilience against natural disasters, Carvalho et al. (2016) and Todo, Nakajima, and Matous (2015) examined the negative and positive effects of supply chains in times of the Great East Japan earthquake.

Specifically, we utilize the TSR data licensed to the Research Institute of Economy, Trade and Industry (RIETI) in 2011, 2012, and 2014. Because most corporate information is collected one year before the year of licensing, our data cover detailed corporate information in the fiscal years 2010, 2011, and 2013. In addition, because the TSR data includes information about sales in the previous year, data on sales for the fiscal years 2009 and 2012 is available. Our TSR data for 2010 contains 1,161,096 firms and 4,971,671 supply-chain links.

3.2 Identification of the disaster areas and subsidized firms

We assume that firms in the disaster-hit areas were directly damaged by the disasters, following previous literature such as Barrot and Sauvagnat (2016). We identify the disaster areas using three government documents on the severely affected areas: the Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, Article 41-2, issued on April 28, 2011 by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT); Tsunami flooded areas identified originally by MLIT and provided by the Center for Spatial Information Science, the University of Tokyo; and the conceptual diagram of restricted areas around the Fukushima Daiichi Nuclear Power Plant provided by the Ministry of Economy, Trade and Industry. The disaster areas we identified include four prefectures, Aomori, Iwate, Miyagi, and Fukushima, and are plotted in Figure 1.

Further, we identify firms that received the subsidies using lists of recipient firms provided by the four prefecture governments in the disaster areas. Because only the prefecture of each recipient firm, rather than its address, is available in the lists,[1] we identify recipient firms in each prefecture in the TSR data using their names, prefecture, and corporate classifications and where the corporate classification is placed in the corporate name. In TSR data, the ratio of disaster-hit firms that can be exactly identified by this set of variables to the entire TSR sample of disaster-hit firms is approximately 98%. In our matching process of subsidized firms, for firms in Fukushima prefecture, we find a small percentage of firms, each of which is matched with more than one firm in the TSR data using the set of variables above. In these cases, we choose firms in the TSR data that can be classified as SMEs according to the definition of the SME Agency of Japan (2018) because the subsidies were primarily provided to SMEs. Despite these efforts, we still cannot exactly identify 27 subsidized firms in Fukushima in the TSR data, or 0.7% of all subsidized firms that are exactly identified. We have dropped these firms from our sample.

Following this matching process, we match 50.3% of subsidy recipients on the lists with firms in the TSR data. One reason for the relatively low match ratio is that many subsidy recipients on the lists are presented as persons' names rather than companies' names. We presume that these enterprises represented by persons' names are most likely microenterprises that are operated by a single person or a family. The omission of these firms from the sample thus may not result in substantial biases in estimates. Another reason for the relatively low match ratio is that the TSR data cover approximately 53% of all firms in Japan, as the coverage of microenterprise is not complete (Carvalho et al. 2014).

Although the subsidies were provided to SMEs in eight prefectures, as presented in Section 2, the disaster areas officially defined above are in only four of the eight prefectures, i.e., Aomori, Iwate, Miyagi, and Fukushima. Therefore, when we estimate the direct effect of the subsidies on recipient firms in the disaster areas, we ignore recipients in the four prefectures outside the disaster areas, i.e., Hokkaido, Tochigi, Ibaraki, and Chiba.

3.3 Construction of variables and samples

We mainly use data from two time periods, 2010 and 2013. Accordingly, as primary outcome variables, we use sales and the number of workers in 2013. As we will explain later in detail, we will employ propensity score matching (PSM) estimations. Our covariates in the pre-earthquake period for matching include sales, the number of workers, firm age, and the number of transaction partners in 2010. These variables are taken directly from the TSR data and we take the log of them. In addition, our covariates contain dummy variables for firms that were hit by the tsunami and forced to evacuate due to the accident in the Fukushima Daiichi Nuclear Power Plant after the tsunami, and a variable which indicates

[1] For firms in Iwate prefecture, cities can be identified. We use city names for firms in Iwate, when multiple firms are matched using only firm names, prefectures, or corporate classifications and when the classification is placed in the corporate name.

the geographical proximity of the disaster-hit SMEs. These variables are constructed from geographic information on the officially identified tsunami-hit areas and evacuation areas as well as the number of disaster-hit SMEs located within one kilometer of each firm.

We focus on SMEs in disaster-hit areas. We follow the SME Agency of Japan (2018)'s definition of SMEs. For the wholesale sector, firms with 100 million yen or less in paid-in capital or 100 or fewer employees are categorized as SMEs. For retailers, the criteria of either 50 million yen or less in paid-in capital or 50 or fewer employees must be satisfied. For other service industries, firms with 50 million yen or less in paid-in capital or 100 or fewer employees are categorized as SMEs. For other sectors, firms that have paid-in capital of less than 300 million yen or fewer than 300 employees are defined as SMEs. Because the subsidies were primarily provided to the secondary and tertiary industries, we have dropped entities in agriculture, forestry, and fishery as well as public entities such as governments, academic institutions, schools, and political and religious institutions.

4. Estimation Strategy

We estimate the direct effect of the subsidies on the recovery of firms from earthquake damages by sector. In these estimations, we focus on SMEs in the officially defined disaster-hit areas (see Section 3.2) and examine possible differences in changes in sales and employment from the pre- to the post-earthquake periods between firms with and without the subsidies.

There are two potential issues that may bias the estimates. First, the subsidies were not provided randomly to SMEs in the disaster-hit areas but were provided to groups of SMEs. Second, unobservable firm attributes, such as managers' ability and preferences, may be important factors of both firm growth and receipt of the subsidies. These two econometric issues generate biases due to endogeneity.

To correct for such endogeneity biases, we employ a PSM procedure with a difference-in-differences (DID) estimation developed by Blundell and Costa Dias (2000). This method can correct for biases due to an endogenous selection of recipients by the PSM approach and biases due to unobservable firm attributes by the DID estimation. It is often used in policy evaluation using non-experimental data, such as Görg, Henry, and Strobl (2008), who estimate the effect of grant support to firms on their exporting activity. We further incorporate an analysis of variance (ANCOVA), which is found by McKenzie (2012) to be more efficient than fixed-effects and DID estimations.

More specifically, we first run a logit model[2] to examine factors that determine the subsidy program participation of SMEs in the disaster areas. We do so using pre-earthquake firm attributes and disaster types, such as sales, the number of workers, firm age, the number of transaction partners, the number of disaster-hit SMEs located within one kilometer (all of the above are in logs), an evacuation-area dummy, a tsunami-affected area dummy, and prefecture dummies.

[2] To consider the spatial auto-correlation, we also consider a spatial lag logit model instead of simple logit. However, the results of the subsidy's effect on firm performance are similar.

In this first process, we divide SMEs in the disaster areas into strata at the sector level. Although our data include industry classification codes of TSR at the three-digit level, the number of subsidized firms in the sample for direct effects, approximately 1,100, is too small for us to divide them into detailed industry classifications, even at the two-digit level. Therefore, we classify firms into four sectors: the manufacturing industry, other secondary industries (construction industry, electric industry, gas industry, mining industry), the wholesale and retail industry, and the other industries.

Next, using the estimates from the logit model for each sector, we calculate the propensity score, or the predicted probability of participating in the subsidy program given the pre-earthquake attributes. Then, we match each participant firm in the program in each stratum with a non-participant with a propensity score closest to that of the participant. One notable issue in this matching process is that firms' fiscal-year-end months vary substantially. If the fiscal-year-end month is different between two particular firms, their sales and sales growth in the pre-earthquake period are defined as occurring in different time periods and thus may capture different economic shocks. To avoid matching two firms with similar sales or sales growth because of different economic shocks, we match firms within the same sector and with the same fiscal-year-end month. We impose common support: i.e., we drop firms whose propensity score is outside the overlap of the two distributions of participants and non-participants. In addition, we set the caliper of the difference in the propensity score at 0.05, matching two firms only when the difference between their propensity scores is less than 5%.

After matching, we check whether treatment firms (recipients of the subsidies) and matched controls (non-recipients in disaster-hit area) are balanced in terms of pre-earthquake attributes and disaster type using *t*-tests. The results for the entire sample are reported in Table 1. The results for subsamples by sector used in the benchmark estimation suggest similarly well-balanced results, which are available from the author upon request.

Finally, using the matched sample, we run the following ordinary least squares (OLS) estimations:

$$\ln Y_{it_2} = \beta_0 + \beta_1 \ln Y_{it_0} + \beta_2 Subsidy_{it_1} + D_i\delta + \varepsilon_i, \quad (1)$$

where Y_{it}, $Subsidy_{it}$, and D_i denote an outcome variable, the dummy variable for receipt of the subsidy, and dummy variables of firm i in time t, respectively. We experiment with several sets of dummy variables, such as sector dummies, prefecture dummies, and fiscal-year-end dummies. The time t_0 represents the pre-earthquake year, 2010; t_1 represents the year of receipt of the subsidy, either 2011 or 2012; and t_2 represents the post-earthquake year, 2013. The outcome variables are the log of sales and the number of workers. Because we take a log of the outcome variables and incorporate the lagged outcome variables as independent variables, following the ANCOVA analysis of McKenzie (2012), we can rewrite equation (1) as

$$\ln Y_{it_2} - \ln Y_{it_0} = \beta_0 + (\beta_1 - 1)\ln Y_{it_0} + \beta_2 Subsidy_{it_1} + X_{it_0}\delta + \varepsilon_i. \quad (2)$$

Therefore, we are essentially estimating the effect of the subsidies on the growth rate of sales, and

employment taking into account fixed effects included in and convergence represented by $\ln Y_{it_0}$. When we estimate equation (2) assuming $\beta_1 = 1$ or conduct DID estimations, we obtain similar results. Therefore, we rely on the ANCOVA analysis.

In the benchmark estimations, we separate our sampled firms into four different sectors to examine whether industry affects the effect of the subsidies. The four sectors are the retail sector, the manufacturing sector, other secondary industries (construction industry, electric industry, gas industry, mining industry), and other service industries, similar to the approach in De Mel, McKenzie, and Woodruff (2012). The difference between our approach and theirs is the category "other secondary industries." Because our sample includes many firms in this sector, we add this category in our study.

5. Results

5.1 Baseline Results

We begin the analysis by first reporting the estimates of equation (1) by sector, which are presented in Table 2. Columns (1) and (2) of panel (I) report the impact of the subsidy on sales of disaster-hit firms in the retail sector. The estimates of the impact are close to zero and statistically insignificant, suggesting no difference between the sales recovery of firms with and without the subsidy. In contrast, the impact of subsidies on the employment of disaster-hit firms in the retail sector is substantial, 14% higher for receivers, and statistically significant, as shown in columns (3) and (4) of panel (I). This implies that the subsidy is effective for the recovery of employment in the retail sector.

Panels (II), (III), and (IV) of Table 2 report the impact of the subsidy on the manufacturing industry, other secondary industries, and other service industries, respectively. They suggest that the subsidy also had positive and significant impacts on sales and employment of other secondary industries (construction industry, electric industry, gas industry, mining industry), while it did not differentiate the recovery of the manufacturing and other service industries with and without the subsidy. The sectoral difference between retail and manufacturing/services is similar to the findings by De Mel, McKenzie, and Woodruff (2012), who assess the effect of access to capital on microenterprises in a developing country. We will explore the source of this variation in subsection 5.3.

5.2 Robustness

Table 3 presents a series of robustness checks. First, we add pre-disaster sales growth rate into equation (1) and repeat the estimation by sector. The results are shown in columns (1) and (2) of Table 3. We find a positive and significant effect of the subsidy only for the retail and other secondary industries, consistent with the baseline estimation results in Table 2.

Secondly, some may be concerned about bias due to the nuclear power plant accident in Fukushima. Although the sample becomes a bit too small for some panels, we still find a similar result by restricting our sample to firms that are not located in Fukushima and do not have multiple plants as shown in

columns (3) and (4) of Table 3. One exception is the effect on the employment of other secondary industries. Little impact for firms outside Fukushima may possibly come from the different amount of private support between firms in Fukushima and others due to the nuclear power plant accident in Fukushima.

Thirdly, we check if firms with different fiscal year end captures different economic shocks which bias the results. To minimize bias, we carefully match firms that received the subsidy to those that did not but have the same fiscal year end, and we include fiscal-year-end dummies; however, some may still be concerned about the bias caused by the difference. Because the sample of 316 firms is too small to separate into several subsamples, we test the difference between the early group and the late group. We make a dummy variable that is zero if the fiscal year end is from March 2013 to October 2013 and one if it is later than October 2013. Then, we create an interaction term with the subsidies dummy and estimate the effect of the difference in the fiscal year end. Although the evidence for the other secondary industries is not strong, at least for the retail and manufacturing/other service sectors, the results in columns (1) and (2) of Table 4 suggest that the difference by the fiscal year end is not significant and that the baseline result is robust: only for retailers can we find a positive and significant effect for both the single-term coefficient of the subsidy and the joint effect, while there is no effect on the manufacturing sector and other service industries at any period. Thus, the main findings hold.

Finally, columns (3) and (4) of Table 4 investigate whether there is a diminishing effect by the timing of receipt because most of the firms that successfully continued business after the disaster restarted their business within a year and thus the provision of the subsidy in 2012, more than one year after the disaster, may be too late. Because the sample of firms that received the subsidy in 2011 is small, we can separately test the impact of the subsidy only based on the sample of firms that received the subsidy in 2012 and the matched firms. Even applying this restriction, we still observe a substantial positive effect, implying that the possibility of underestimation due to differences in the timing of receipt is considerably low.

5.3 Mechanism

Thus far, our analysis has focused on evaluating the impact of the subsidy on the recovery of firms in disaster-hit areas, and it has found robust heterogeneity across sectors. We next explore the potential mechanisms underlying these results.

5.3.1 Constraints from Supply Chain Disruption

Enterprise recovery, especially sales, reflects both firms' own recovery and supply chain recovery. Even if a particular company in a disaster-hit area restores what it needs for normal operation, its performance will be limited without normal supply and demand. Tables 5 and 6 investigate this possibility by looking at network structures and the negative impact coming from supply chain disruption, respectively, using the same sample as Table 1, i.e. the matched sample that is not divided by sector.

In Table 5, we observe how differently firms are linked with other firms by sector. The baseline

category in this table is the manufacturing sector. Estimates in column (1) of Table 5 indicate a negative effect of non-manufacturing sector dummies with statistical and economic significance, suggesting that firms in the manufacturing sector are approximately 20 to 25% more connected to firms outside the disaster area than others. In column (2) of Table 5, we find that retailers have the weakest connection with firms in the disaster-hit area, which may imply that the lower potential of exposure to supply chain disruption enables retailers to fully enjoy the effect of subsidy.

In the remaining columns, we check which types of disruption are more likely to occur in the manufacturing and service sectors. Here, we focus on the links with firms in tsunami-hit areas, which most likely take a longer time to recover. However, we confirm that the tendency does not change even if we also consider other disaster areas. The results of columns (3) to (6) of Table 5 suggest that the possibility of having suppliers in tsunami-hit areas does not differ or is even smaller for manufacturing, but the manufacturing and other service industries tend to have more potential to be exposed to demand shocks by customers in tsunami-hit areas.

To investigate whether demand shocks explain the sectoral heterogeneity of the impact of the subsidy, in Table 6, we examine the impact of supply chain disruption in the short and medium run. For the short-run impact, we use the log of sales and employment in 2011, while medium-run variables are the same as our main outcome variables, that is, performance in 2013. As in columns (1) and (3) of Table 6, we find a negative propagation of disaster shocks from customers in tsunami-hit areas to firms in disaster-hit areas, while no negative propagation from suppliers can be observed.

In columns (2) and (5) of Table 6, we test whether the negative propagation effect persists. The results suggest that there is no persistent impact in the medium run, consistent with the finding of Barrot and Sauvagnat (2016) and Kashiwagi, Todo, and Matous (2018) that the negative propagation effect of natural disasters diminishes within a year using natural disasters in the United States as an exogenous shock. Even if we limit the sample to the manufacturing sector, we do not observe any negative impact of supply chain disruption on firms' performance in 2013. Therefore, supply chain disruption is not likely to be the source of the small impact of the subsidy in some sectors.

5.3.2 Private Support

A possible alternative explanation is that the different degrees of private support across sectors differentiate the impact of the subsidy. For example, the manufacturing sector may be more sensitive to physical damage to their facilities than the retail sector. Speaking in extremes, many retailers can run their business in front of their disaster-destroyed store, while manufacturing sectors often need to restore their facilities to reopen their business. Considering that private support from other firms partly aims to mitigate negative propagation effects from damaged firms through supply chains, private support may provide only what is necessary to run business, and thus, retailers may receive much less support in terms of restoring physical capital. Then, retailers must restore a large part of their facilities using other sources, such as loans and public aid, while manufacturers want to obtain public support to repair much

smaller problems, such as cracked wall surfaces. Repairing cracked wall surfaces is important but may not be critical to firms' performance in the short and medium run or their expectations of their own future growth prospects.

We explore this alternative explanation by re-estimating equation (1) but with proxy variables of private support. The proxy variables include the log of the number of inter-firm links within disaster areas and outside these areas plus one[3], following Todo, Nakajima, and Matous (2015). Columns (3) and (6) of Table 7 contain the main estimation results of this table. As reported in column (3) of Table 7, for sales, the number of links within disaster areas indicates a substantial positive effect throughout all sectors, implying that partner firms within disaster areas helped the sales recovery of disaster-hit firms. This result is consistent with the finding of Todo, Nakajima, and Matous (2015). We interpret this result as partner firms providing information and lending some machinery or tools that are needed to recover sales. However, the subsidy shows a significant positive effect only for other secondary industries, which are the ones that benefitted from the reconstruction demand. These results imply that firms had already received enough support to recover sales before the subsidy was provided.

In contrast, column (6) of Table 7 suggests that either the subsidy or the links with firms outside the disaster area has a substantial positive impact on the employment level in 2013. This implies that support from outsiders, including government and firms located far away, helps restore facilities that are expensive or face excessive demand after the disaster and reduce damaged firms' monetary burden for restoring them. If firms worry about the repayment of loans received to restore facilities and they already have the minimum number of employees to operate, they may hesitate to hire extra employees. Thus, to recover the employment level, firms must have positive prospects of their own business. As described at the beginning of subsection 5.3.2, because retailers are less likely to receive enough support for restoring physical capital, they benefit only from the subsidy. The impact on other secondary industries can be interpreted similarly. In contrast, because the manufacturing sector and other service industries received enough support from other firms, additional support by the government had a limited impact. The positive sign of the coefficient of private support from firms within the disaster areas on the employment level in the other secondary industries and services may imply that for sectors that need some basic repairing but do not need massive restoring, not only support from outsiders but also relatively small support within disaster areas can contribute to their complete recovery.

For reference, we again show the estimation results of equation (1) in columns (1) and (4) of Table 7, which are the same as those in columns (2) and (4) of Table 2. They show the effect of the subsidy on sales and employment by sector and suggest that the significant positive effect of the subsidy appears only for the retail and other secondary industries. Similarly, columns (2) and (5) of Table 7 show that

[3] We checked our identification strategy with a placebo test; i.e., we estimate the coefficient of the proxies on sales growth in 2010 by controlling sales growth in 2009 and adding the same set of dummies. However, the results suggest no significant effects of these proxies at the 5% significance level, indicating the validity of the parallel trend assumption.

the size of the coefficients of private support is similar between with- and without-subsidy variables in the estimation equations. To summarize all the findings in Table 7, the subsidy has a significant impact only when private support is not enough, and retailers and firms in other secondary industries tend to lack private support.

6. Conclusion

This paper investigates the heterogeneity in the impact of government support for SMEs on recovery from disasters and explores the mechanism behind it. To this end, we use a rich firm-level dataset on Japanese firms that contains information on their supply chain and basic attributes. We employ an estimation strategy that combines a PSM matching procedure with an ANCOVA estimator to address the potential selection problem inherent in an analysis of government support's effect on firm performance. Our results suggest that government support is effective only in the retail and other secondary industries. This is consistent with previous findings from a developing country. Unlike the study of developing countries, we have well-covered supply chain data, and thus, we can further explore possible mechanisms behind sectoral heterogeneity

We discuss two possible mechanisms. First, disruptions in supply chains may limit the recovery of firms even if the firms themselves successfully restore their facilities. Second, private support from other firms, which was provided prior to the subsidy, was enough for some sectors; thus, for them, the impact of the subsidy was limited. We find evidence for the latter.

Today the frequency and the severity of disasters is increasing. In addition, the scope of the public support for recovering also tends to be expanded in many countries. Therefore, we believe that the knowledge on how the public support might be more effectively provided is valuable in the era of increasing disasters.

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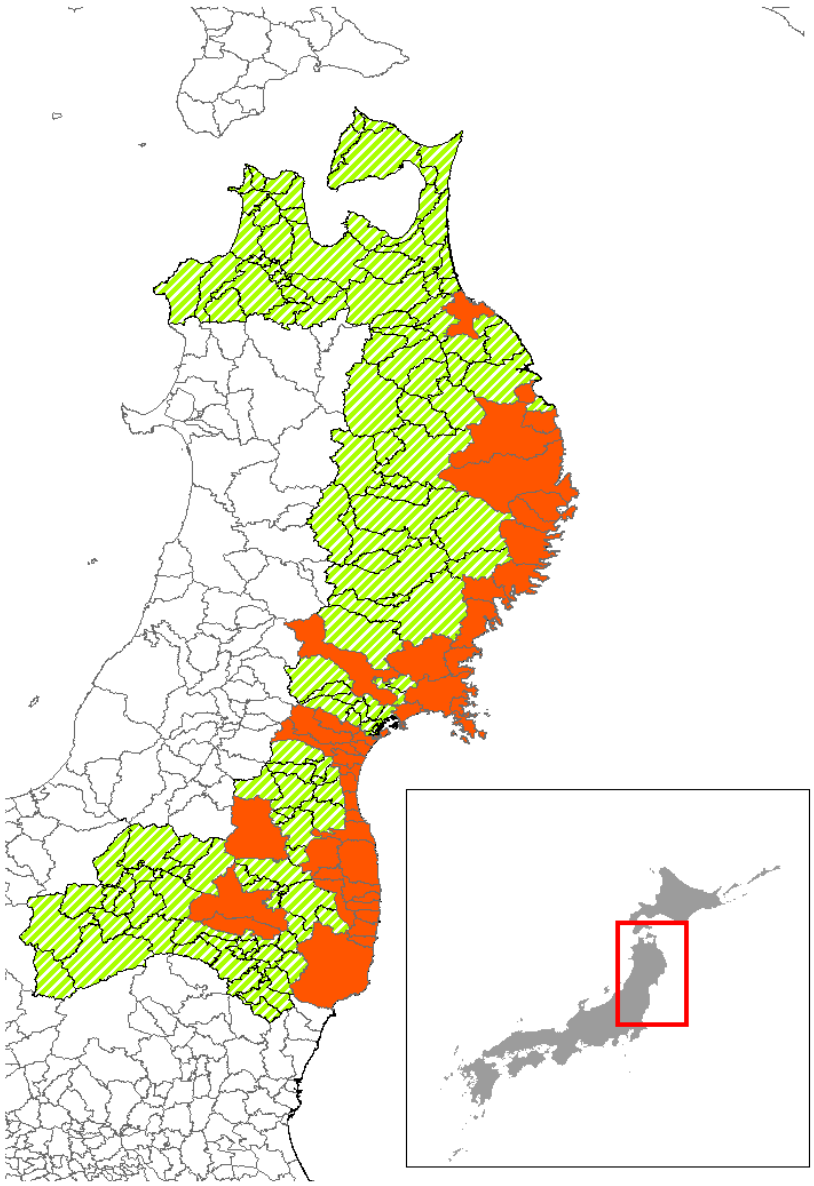
Figure 1. Disaster Areas and Disaster-Hit Prefectures



Notes: The officially defined disaster areas are painted in red, whereas the four disaster-hit prefectures, Aomori, Iwate, Miyagi, and Fukushima, are highlighted in green and red.

Table 1: Balancing Test for Whole Sample

Variable		Mean			
		Treated	Control	Difference	
Sales (1000 yen, in logs, 2010)	Unmatched	12.352	11.561	0.791	***
	Matched	12.232	12.28	-0.048	
Number of workers (in logs, 2010)	Unmatched	2.5649	1.9211	0.6438	***
	Matched	2.4729	2.5324	-0.0595	
Firm age (in logs)	Unmatched	3.4231	3.1688	0.2543	***
	Matched	3.3875	3.4053	-0.0178	
Dummy for tsunami-hit areas	Unmatched	0.43253	0.06538	0.36715	***
	Matched	0.33835	0.32241	0.01594	
Dummy for evacuation areas	Unmatched	0.03647	0.00396	0.03251	***
	Matched	0.02657	0.02746	-0.00089	
Number of supply chain partners (in logs)	Unmatched	2.1914	1.8769	0.3145	***
	Matched	2.1400	2.1344	0.0056	
Number of damaged SMEs located within 1 km (in logs)	Unmatched	3.9558	4.2893	-0.3335	***
	Matched	3.9631	3.9038	0.0593	

Note: The statistical significance of the difference is indicated by *** p<0.01, ** p<0.05, and * p<0.1.

Table 2: Effect of *Group Subsidy* on Recovery of Disaster-Hit Firms by Sector

	(1)	(2)	(3)	(4)
	Sales in 2013	Sales in 2013	Employment in 2013	Employment in 2013
(I) Retail Sample				
Subsidies	0.00345	7.29e-05	0.137***	0.135***
	(0.0538)	(0.0539)	(0.0460)	(0.0457)
Observations	316	316	316	316
Adj R2	0.906	0.906	0.877	0.879
(II) Manufacturing Sample				
Subsidies	-0.0271	-0.0282	0.00762	0.00234
	(0.0540)	(0.0543)	(0.0454)	(0.0455)
Observations	428	428	428	428
Adj R2	0.862	0.862	0.853	0.855
(III) Other Secondary Industries Sample				
Subsidies	0.192***	0.189***	0.0667**	0.0649**
	(0.0472)	(0.0468)	(0.0270)	(0.0264)
Observations	706	706	706	706
Adj R2	0.773	0.776	0.857	0.861
(IV) Other Service Industries Sample				
Subsidies	-0.0239	-0.0225	-0.0128	-0.0112
	(0.0420)	(0.0419)	(0.0283)	(0.0283)
Observations	764	764	764	764
Adj R2	0.869	0.868	0.903	0.903
Lagged outcome	YES	YES	YES	YES
Prefecture FE	NO	YES	NO	YES
Industry FE	NO	YES	NO	YES
Fiscal year end FE	NO	YES	NO	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables and lagged outcome variables are taken in logs. The variable Subsidies is a dummy that is one if the firm received the subsidy.

Table 3: Robustness Check 1 – Different Covariates or Sample

	(1)	(2)	(3)	(4)
	Extra control	Extra control	Single-plant firms outside Fukushima	Single-plant firms outside Fukushima
	Sales in 2013	Employment in 2013	Sales in 2013	Employment in 2013
(I) Retail Sample				
Subsidy	-0.0346	0.119**	-0.0642	0.171**
	(0.0554)	(0.0482)	(0.0643)	(0.0729)
Sales growth 2009-2010	-0.127	0.0690		
	(0.116)	(0.0745)		
Observations	276	276	190	190
Adj R2	0.919	0.885	0.898	0.786
(II) Manufacturing Sample				
Subsidy	-0.0198	0.0205	-0.133	-0.0596
	(0.0574)	(0.0449)	(0.0994)	(0.0797)
Sales growth 2009-2010	-0.00217	0.170		
	(0.159)	(0.126)		
Observations	377	377	140	140
Adj R2	0.852	0.865	0.769	0.781
(IV) Other Secondary Industries Sample				
Subsidy	0.168***	0.0659**	0.125**	0.0202
	(0.0491)	(0.0279)	(0.0603)	(0.0320)
Sales growth 2009-2010	-0.241***	0.0590		
	(0.0848)	(0.0387)		
Observations	610	610	462	462
Adj R2	0.785	0.869	0.758	0.876
(V) Other Service Industries Sample				
Subsidy	-0.0289	-0.0207	-0.0760	-0.0175
	(0.0487)	(0.0289)	(0.0586)	(0.0435)
Sales growth 2009-2010	-0.0927	0.161**		
	(0.195)	(0.0666)		
Observations	658	658	394	394
Adj R2	0.864	0.910	0.866	0.885
Lagged outcome	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Fiscal year end FE	YES	YES	YES	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables and lagged outcome variables are taken in logs. In each panel, we run the same set of estimation equations for different samples.

Table 4: Robustness Check 2 – Effect of Timing of Aid Receipt and Fiscal Year End

	(1)	(2)	(3)	(4)
	Sales in 2013	Employment in 2013	Sales in 2013	Employment in 2013
(I) Retail Sample				
Subsidies	-0.00987	0.113**		
	(0.0659)	(0.0535)		
Subsidies*Fiscal end from Sep to Feb	0.0322	0.0718		
	(0.118)	(0.105)		
Subsidies received in 2012			0.0450	0.196***
			(0.0709)	(0.0612)
Observations	316	316	192	192
Adj R2	0.906	0.879	0.915	0.882
P-value (joint effect)	0.818	0.0394		
(II) Manufacturing Sample				
Subsidies	-0.0185	-0.0292		
	(0.0732)	(0.0596)		
Subsidies*fiscal end from Sep to Feb	-0.0252	0.0817		
	(0.105)	(0.0888)		
Subsidies received in 2012			0.0612	0.0952
			(0.0897)	(0.0740)
Observations	428	428	152	152
Adj R2	0.861	0.855	0.882	0.880
P-value (joint effect)	0.568	0.436		
(III) Other Secondary Industries Sample				
Subsidies	0.177***	0.0323		
	(0.0623)	(0.0330)		
Subsidies*fiscal end from Sep to Feb	-0.0264	0.0804		
	(0.109)	(0.0675)		
Subsidies received in 2012			0.237***	0.0864***
			(0.0516)	(0.0275)
Observations	612	612	572	572
Adj R2	0.768	0.857	0.773	0.868
P-value (joint effect)	0.0951	0.0531		
(IV) Other Service Industries Sample				
Subsidies	-0.0382	0.0263		
	(0.0538)	(0.0398)		
Subsidies*fiscal end from Sep to Feb	-0.00428	-0.129*		
	(0.0926)	(0.0681)		
Subsidies received in 2012			0.00686	-0.0362
			(0.0583)	(0.0356)
Observations	482	482	408	408
Adj R2	0.906	0.915	0.867	0.913
P-value (joint effect)	0.571	0.0673		
Lagged outcome	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Fiscal year end FE	YES	YES	YES	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables and lagged outcome variables are taken in logs. The variable Subsidies is a dummy that is one if the subsidy is received in Japanese fiscal year 2011 or 2012 (i.e., by mid-March 2013). The variable Fiscal end from Sep to Feb is a dummy that is one if the firm's fiscal end is sometime between September 2013 and February 2014 and zero if the firm's fiscal end is sometime between March 2013 and August 2013. In each panel, we run the same set of estimation equations for different samples.

Table 5: Possible Mechanism 1 – Impact of Supply Chain Disruption (1)
Network Structural Difference across Sectors (Whole Matched Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	Logit	Logit	OLS	OLS
	# of links outside disaster area	# of links within disaster area	Existence of suppliers in tsunami-hit areas	Existence of customers in tsunami-hit areas	# of suppliers in tsunami-hit area	# of customers in tsunami-hit area
Retail dummy	-0.265***	-0.329***	-0.0379	-1.170***	0.121***	-0.163***
	(0.0539)	(0.0546)	(0.239)	(0.236)	(0.0348)	(0.0289)
Other service industries dummy	-0.181***	0.00467	0.173	-0.574***	0.111***	-0.0584**
	(0.0432)	(0.0459)	(0.168)	(0.173)	(0.0275)	(0.0234)
Other secondary industries dummy	-0.269***	0.598***	0.368**	0.770***	0.0767***	0.194***
	(0.0428)	(0.0441)	(0.168)	(0.171)	(0.0280)	(0.0272)
Observations	2,258	2,258	2,258	2,258	2,258	2,258
Adj R2	0.369	0.378			0.327	0.354
Chi2			762	813.3		
Controls (number of suppliers / customers)	NO	NO	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables in columns (1), (2), (5), and (6) are taken in logs after adding one.

Table 6: Possible Mechanism 1 – Impact of Supply Chain Disruption (2)
Propagation of Negative Shocks from Firms in Tsunami-Hit Areas to their Suppliers/Customers within Disaster-Hit Areas (Whole Matched Sample / Manufacturing Sector Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	All Firms	All Firms	Manufacturing	All Firms	All Firms	Manufacturing
	Sales in 2011	Sales in 2013	Sales in 2013	Employment in 2011	Employment in 2013	Employment in 2013
# of customers in tsunami-hit areas	-0.0490**	0.0138	-0.0334	-0.0462**	0.0181	-0.0418
	(0.0215)	(0.0307)	(0.0660)	(0.0185)	(0.0211)	(0.0479)
# of suppliers in tsunami-hit areas	0.0236	0.155***	0.180**	0.0115	0.00667	0.00234
	(0.0196)	(0.0301)	(0.0764)	(0.0143)	(0.0201)	(0.0589)
Controls (number of suppliers / customers)	YES	YES	YES	YES	YES	YES
Lagged outcome	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	NO	YES	YES	NO
Fiscal year end FE	YES	YES	YES	YES	YES	YES
Observations	2,198	2,258	428	2,248	2,258	428
Adj R2	0.937	0.859	0.866	0.946	0.886	0.856

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables, explanatory variables, and lagged outcome variables are taken in logs.

Table 7: Possible Mechanism 2 – Impact of Private Support vs Impact of Public Support

	(1)	(2)	(3)	(4)	(5)	(6)
	Sales in 2013	Sales in 2013	Sales in 2013	Employment in 2013	Employment in 2013	Employment in 2013
(I) Retail Sample						
Subsidies	7.29e-05		0.00933	0.135***		0.138***
	(0.0539)		(0.0550)	(0.0457)		(0.0471)
# of links within disaster areas (log)		0.0808**	0.0813**		0.0152	0.0205
		(0.0390)	(0.0402)		(0.0351)	(0.0353)
# of links outside disaster areas (log)		0.00161	0.00183		0.0188	0.0211
		(0.0395)	(0.0393)		(0.0320)	(0.0314)
Observations	316	316	316	316	316	316
Adj R2	0.906	0.907	0.907	0.879	0.875	0.878
(II) Manufacturing Sample						
Subsidies	-0.0282		-0.0510	0.00234		0.00555
	(0.0543)		(0.0545)	(0.0455)		(0.0466)
# of links within disaster areas (log)		0.140***	0.144***		0.0125	0.0120
		(0.0373)	(0.0373)		(0.0272)	(0.0283)
# of links outside disaster areas (log)		0.0202	0.0181		0.102**	0.102**
		(0.0461)	(0.0470)		(0.0474)	(0.0477)
Observations	428	428	428	428	428	428
Adj R2	0.862	0.866	0.866	0.855	0.858	0.858
(III) Other Secondary Industries Sample						
Subsidies	0.189***		0.161***	0.0649**		0.0585**
	(0.0468)		(0.0463)	(0.0264)		(0.0264)
# of links within disaster areas (log)		0.276***	0.265***		0.0592**	0.0546**
		(0.0362)	(0.0364)		(0.0233)	(0.0234)
# of links outside disaster areas (log)		-0.0491	-0.0366		-0.00780	-0.00391
		(0.0330)	(0.0333)		(0.0197)	(0.0197)
Observations	706	706	706	706	706	706
Adj R2	0.776	0.785	0.789	0.861	0.861	0.862
(IV) Other Service Industries Sample						
Subsidies	-0.0225		-0.0251	-0.0112		-0.00947
	(0.0419)		(0.0413)	(0.0283)		(0.0280)
# of links within disaster areas (log)		0.125***	0.125***		0.0439**	0.0441**
		(0.0310)	(0.0311)		(0.0199)	(0.0200)
# of links outside disaster areas (log)		0.0449	0.0442		0.0486**	0.0483**
		(0.0317)	(0.0317)		(0.0190)	(0.0189)
Observations	764	764	764	764	764	764
Adj R2	0.868	0.873	0.873	0.903	0.905	0.904
Lagged outcome	YES	YES	YES	YES	YES	YES
Prefecture FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Fiscal year end FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Outcome variables and lagged outcome variables are taken in logs. The variable Subsidies is a dummy that is one if the subsidy is received. In each panel, we run the same set of estimation equations for different samples.