Financial Shocks and Natural Selection†

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Abstract

In this paper, we investigate whether financial shocks change the working of the natural selection mechanism in the corporate sector. By using the data on firms after a devastating earthquake, the Great Tohoku Earthquake, we examine the impact of damages to lender banks on firms exit. Toward this end, we focus on firms located outside the earthquake-affected areas but transacting with banks located inside the areas to extract the impact of purely exogenous financial shocks on firm exit. From our analysis, we find that the bank damage in fact reduces firm exit and thereby mitigate the natural selection mechanism in such a direction, which is supported by several possible interpretations.

Keywords: firm exit, natural selection, earthquake, natural disaster, evergreening

JEL classification codes: L10, G21
1. Introduction

Do financial shocks affect the real activities of the corporate sector in an economy? Numerous studies have tried to tackle this question by focusing on adverse shocks transmitted from transacting banks, given that for many firms, especially small- and medium-sized enterprises (SMEs), borrowing from banks is one of the key sources of finance. Such studies investigate whether shocks from banks have real impact on different aspects of corporate activities, e.g., capital investment (Hosono et al. 2012; Amiti and Weinstein 2013), exports (Amiti and Weinstein 2011; Paravisini et al. 2011), and construction activity (Peek and Rosengren 2000). Among the impacts of financial shocks from banks on various real activities of firms, we specifically focus on the impact of financial shocks on an important aspect of firm dynamics: firm exit.

The major challenge in examining the real impact of financial shocks transmitted from banks is how to overcome the endogeneity problem. While the shock to banks could adversely affect real activities of borrowing firms, poor performance of borrowers itself adversely affects the performance of the banks. Thus, it is generally difficult to empirically identify the direction of the causality. There are some approaches to address this problem, and one of them, which we follow in this paper, is to take an advantage of a situation where we can utilize a financial shock that are purely exogenous to firms. To be more precise, we make use of the environment of a natural experiment provided by a natural disaster, using data of firms after a devastating earthquake, the Great Tohoku Earthquake (also known as the Great East-Japan Earthquake) that hit the Tohoku area of Japan on March 11, 2011.¹

¹ There were 27,154 casualties (18,131 dead, 2,829 missing, and 6,194 injured) due to this earthquake (and accompanying tsunami and the accident of the nuclear plant in Fukushima) (Fire and Disaster Management Agency of the Government of Japan: http://www.fdma.go.jp/bn/higaihou/pdf/jishin/146.pdf (in Japanese)).
We use the data of many SMEs that are located outside the earthquake-affected area. We examine the difference in their exit probability in the case of whether or not their main banks suffered damages from the earthquake. For this purpose, the damage of banks is measured based on the location of the banks’ headquarters, or the share of their branch offices inside the affected area. While we can expect that damaged banks have, for example, adverse impact on their borrowers through the deterioration of lending capacity, we encounter identification problem if we simply use a sample of firms located inside the affected area. This is because their poor performance (which is exit in our case) might be due to their own damages from the earthquake. Given this concern, we focus on firms located outside the affected area. Because these firms are less likely to be directly damaged by the earthquake, damages to the bank from the earthquake will work as a purely exogenous shock.

In our investigation of the impact of bank damages on the probability of exit of their borrowers, we are also interested in whether and how the shock changes the natural selection mechanism of firms, i.e., the mechanism through which the market eliminates inefficient firms (e.g., Bertin, et al. 1996, Bresnahan and Raff 1991, Caballero and Hammour 1994, 1996, 2005). Evidence suggests that the natural selection mechanism indeed worked after the Great Tohoku Earthquake both inside and outside the affected area (Uchida et al. 2014). However, several extant studies suggest that the unnatural selection mechanism due to evergreening loans (zombie lending) by banks, especially under-capitalized banks, have contributed to a long stagnation of the Japanese economy during the so-called “lost decades” from 1990s (see e.g., Sekine et al. 2003, Peek and Rosengren 2005, Fukuda, et al. 2006, Caballero et al. 2008). We thus examine whether the mechanism differ depending on the presence and absence of the shock from the lending banks by comparing the effects of firm
efficiency on firm exit between the case where the lending bank suffered damages and in the case it did not.

From our analysis, we consistently find that our proxies for the bank damage have a negative and statistically significant coefficient. This implies that the damage to the main bank decreases the exit probability of its borrowing firms. We also find evidence that supports the natural selection mechanism both for firms transacting with damaged main banks and those with undamaged ones. However, the evidence suggests that the natural selection mechanism is demoted for firms when the main bank is damaged. On balance, our findings suggest that damages to main banks contribute to hinder the exit of their borrowers.

On one hand, our findings of a favorable effect of bank damages on borrowers’ exits are inconsistent with the financial constraint theory. On the other hand, they are consistent with the evergreening (zombie lending) hypothesis introduced above, to the extent that damaged banks suffered from undercapitalization due to deteriorated asset (loan) base and tried to keep zombie firms alive as performing borrowers. There is also a hypothesis that is consistent with our findings, the aid hypothesis. After the earthquake, the Government of Japan and the Bank of Japan implemented various measures to support damaged banks, such as rescue funding or capital injection contributed. These measures might have contributed for damaged banks to rather increase their lending capacity, and enabled the banks to lend to less efficient firms.

Although exact identification between these two hypotheses is difficult, we conduct further analysis, in which we consider the effect of the public capital injection into banks, to obtain some more evidence. In this analysis, in addition to the effect of bank damages, we also take into account the impact of the injection into main banks on the exit of borrowing firms. From the univariate
analysis, we find that the exit rate is smaller when the firms’ main banks obtained injection of
government funds, but no such effect is found from the regression analysis. Judging from the data
restriction, we can conclude that our findings lend at most some weak support for the capital
injection hypothesis.

As indicated at the outset, this paper is related to the literature on the effect of financial shocks
on real activities of firms. Among many studies, the closest to our study is those examining the
impact of financial shock due to exogenous change in the economic conditions on firm exit or loan
default (Khwaja and Mian 2008; Schnabl 2012). Our paper differs from these papers in that we take
advantage of the shock created by a natural disaster, and that we also focus on the selection
mechanism.

This paper is also related to the studies on the impact of natural disasters on economic
activities. There are many studies on the disasters’ impact on economic growth. Some studies focus
on their impact on the productivity of the economy’s corporate sector (Skidmore and Toya 2002,
Crespo-Cuaresma et al. 2008). There are also a few studies focusing on the impact on firm recovery
(Leiter et al. 2009, De Mel et al. 2011, Hosono et al. 2012). In this paper we examine the impact of
a natural disaster on firm exit, but we do not focus on the direct damage of firms because we
exclude damaged firms (those located inside the affected areas) to cope with the endogeneity
problem.

The remaining part of this paper is composed of as follows. The next section explains data and
methodology. Section 3 reports the results. In Section 4 we extend the analysis by taking into
account the effect of the public capital injection into banks. The final section concludes the paper.
2. Data and methodology

2.1. Data and sample selection

We obtain firm-level data, including information on firm exits, firm attributes, and their banks, from Teikoku Databank Ltd. (TDB) which is one of the top business credit information bureaus in Japan. From this dataset, we select firms whose headquarters are located in the six prefectures in Tohoku area of Japan (Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima) when the Great Tohoku Earthquake hit the region. Within the six prefectures, we have information of firm exit during a post-earthquake period from March 2011 to November 2012 for 98,070 firms. Note that we decided not to use firms outside these six prefectures because most of our sample firms are SMEs and are not likely to borrow at a distance from damaged banks in these prefectures.

These six prefectures include the areas that were seriously damaged by the earthquake. However, because the direct damage from the shaking land is not severe, serious damages were mostly concentrated in the coastal area that faces the Pacific where tsunami affected, and in a specific area in Fukushima prefecture where the nuclear plant accident affected. To consider firms that are not affected (or not seriously affected) by the earthquake, we eliminate those firms that are located in these areas. More specifically, we eliminated firms whose headquarters were located in those cities and towns that are included in the Japanese Government’s Act Concerning Special Financial Support to Deal with a Designated Disaster of Extreme Severity.\(^2\) This reduces the number of firms to 62,193.\(^3\)

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\(^2\) Because we have no such information, we cannot exclude firms based on locations of their establishments. However, the majority of our sample firms are SMEs which typically have only one establishment.

\(^3\) Due to this definition, we cannot capture firms’ damages to their establishments that are different from their headquarters. However, the majority of our sample firms are small- and medium-sized enterprises, and are one-establishment firms.
We further eliminate those firms for which any of the variables to indicate firm characteristics that will be used for the regression analysis (see below) or information to identify their main banks is not available. We also eliminate firms that belong to Finance industries and those for which no industry information is available. As a result, we have 53,904 firms in our sample. As for the identification of firms’ main banks, we use a list of the banks with which the firms transact that is included in the TDB database. In this list, banks are listed in the order of importance to the firms based on subjective evaluation by the firms. Following widely used convention, we define the bank listed at the top as the firms’ main banks.

Finally, we augment our data set with data of these main banks. We add variables from the banks’ financial statements that are obtained from the Nikkei NEEDS Financial Quest compiled by Nikkei, Inc. (Nihon Keizai Shimbunsha) and Financial Statements of Shinkin Banks and Credit Cooperatives from the Kin-yu Tosho Consultant Corporation. We further augment our data set with information about the location (address) of the main banks’ branches obtained from Nihon Kin-yu Meikan of Nikkin Publishing. Because the financial statements are not available for certain types of banks, those firms whose main banks are neither a city bank, a regional bank, a Shinkin bank, nor a credit cooperative are not included in the sample of 53,904 firms.

2.2. Regression and variables

2.2.1. Regression and main variables

We examine the effect of the damages on firms’ main bank by running a probit regression that takes the following form:

\[
Pr[Exit_i = 1] = Pr[y_i > 0],
\]
where

\[ y_i^* = X_i b + e_i, \]

and \( i = 1, \ldots, N \) is an indicator for each of the \( N \) sample firms.

Our main variable is Exit dummy variable, an indicator of firm exit, that takes the value of one when the firm is recorded as exited during the post-earthquake period from March 2011 to November 2012.\(^4\) We assume that the exit probability \( \Pr[\text{Exit}_i = 1] \) is determined by the value of a latent variable \( y_i^* \), which is determined by a vector \( X_i \) of independent variables and the ordinary error term \( e_i \).\(^5\)

The main independent variable (that is included in the vector \( X_i \)), is a proxy for bank damage, which we label B_DAMAGED. We use two alternative variables as proxies for bank damage. As explained above, we define main banks of our sample firms as those listed at the top of the banks they transact with. Our first proxy, B_HQDAMAGED, is a dummy variable that takes a value of one if the banks’ headquarters are located inside the affected area defined by the Japanese Government’s Act Concerning Special Financial Support to Deal with a Designated Disaster of Extreme Severity. Our second proxy is created based on information of the location of the banks’ branch offices. The variable B_BRDAMAGED is the ratio of the number of branches inside the affected areas to the total number of the branch offices that the main bank has. By their nature, these two alternative proxies will capture different aspects of damages main banks suffered from. B_HQDAMAGED are likely to capture the decline in bank’s managerial capacity to process loan

\(^4\) Those firms that voluntarily closed down their businesses are not included in exit firms.

\(^5\) To circumvent any endogeneity, we use the pre-earthquake value of the independent variables, except for the proxies for earthquake damages. More precisely, the variables from the bank financial statements are as of the end of the fiscal year 2010 (i.e., March 31, 2011), and the other variables are in year 2010 (January to December 2010). For some firms, TDB’s collected information at multiple data points within 2010, but we only use the most recent data.
applications at the back office, while B_BRDAMAGED is likely to capture the decline in a bank’s financial health and risk-taking capacity.

The descriptive statistics for our main variables, Exit and the two bank damage variables, are shown in the first three column of Table 1. In this table, column (1) report the statistics for our whole sample (for regressions), but the table also shows them when we divide the sample depending on the value of B_HQDAMAGED (columns (2) and (3)), together with the results for the test of equal mean for each variable in column (4).

As explained above, we have 53,904 firms in our sample which are located in the six prefectures but outside the affected area. From the first row of this table, we find that the exit rate for these firms (column (1)) is 0.516%. If we focus on those firms whose main banks are located outside the affected area (column (2)), the rate is slightly higher and is 0.555%. However, when the main banks are located inside the area (column (3)), the rate is smaller and is 0.349%. From column (4), we find that the difference is statistically significant. This suggests that damages to main banks demote, not promote, exit of their borrowers. However, we cannot conclude so before controlling for many other factors that affect firm exit.

The second and the third rows of this table show summary statistics for our two proxies for bank damages. We find that the firms whose main banks are located inside the affected area (i.e., B_HQDAMAGED = 1) account for 19% of the whole sample. If we measure bank damage by the fraction of branch offices inside the affected area (B_BRDAMAGED), we find that on average our sample firms transact with the main banks 21% of whose branch offices are located inside the

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6 These results are qualitatively unchanged if we use the sample of a larger number of firms for which information to define the variables Exit and B_HQDAMAGED is available.
affected area. Columns (2) and (3) show the breakdown of this fraction depending on the value of B_HQDAMAGED. Naturally, the fraction is higher when B_HQDAMAGED = 1, but we also find from column (2) that even for firms transacting with main banks whose headquarters are located outside the affected area, 11% of the main banks’ branches are inside the affected area.

2.2.2. Proxy for firm efficiency

We are not only interested in the direct impact of bank damage on the exit probability but also in its impact on the selection mechanism. To examine whether the mechanism is natural or unnatural, we need a proxy for firm efficiency. A most widely used proxy for firm efficiency is total factor productivity (TFP) (define in various forms), but we need firms’ financial statement to create even a crude measure of TFP. Because most of our sample firms are SMEs, financial statement information is available for only a small subset of them.

As an alternative but informative measure for firm efficiency, we use firms’ score, F_SCORE that TDB calculates, as our measure of firm efficiency. Based on financial figures, past performances, operating history, and qualitative evaluation of firms and their CEOs, TDB scores firms in terms of the soundness of their management, their repayment ability, and whether they can be safe trade counterparts, from a third-party viewpoint. The score takes an integer value on a 1–100 scale. Although the evaluation is partly based on TDB researchers’ subjective evaluation, the score is calculated on an unsolicited basis (i.e., the firms do not pay for being rated), so it is widely used in practice, e.g., when a firm wants to evaluate possible trade partners.

There is an evidence for the selection mechanism after the Great Tohoku Earthquake using this score. Using a similar data set, Uchida et al. (2014) find that the probability of firm exit after the
Great Tohoku Earthquake is lower for firms with higher score, both inside and outside the affected area. In this paper, we examine whether such an impact of firms’ score changes if their main banks are damaged. In this vein, we use an interaction term of firms score and a proxy for bank damage (B_DAMAGED). We also add F_SCORE in its isolation in the vector of independent variable $X_i$. As shown in the fourth row of Table 1, an average score for our sample firms is 45.6. We also find that the score is higher in the case where B_HQDAMAGED = 0 than in the case where B_HQDAMAGED = 1, although the exit probability is higher when B_HQDAMAGED (first row).

2.2.3. Control variables

To single out the effects of bank damage and firm efficiency on firm exit, we use a number of control variables. The definition and the descriptive statistics of these variables are shown in the lower half of Table 1. We first use three controls for firm characteristics: F_EMP is the number of employees (firm size); F_AGE is the age of the firm; and F_NBANK is the number of banks that the firm transacts with. We also include industry dummies in our regression. From Table 1, we find that our sample firms on average hire 13 employees, are 30 years old, and transact with 2 banks.

We also use variables to represent bank characteristics. Three variables are from main banks’ financial statements: B_ROA is the return on asset (defined as ordinary profit over total asset); B_CAP is the book-based capital asset ratio; and B_InASSET is the total asset (in natural logarithm). To differentiate the effect of different bank types, we also use three bank type dummies:

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7 The industry decomposition of our 53,904 sample firms are: Agriculture, Forestry, or Hunting (1.04%), Services (0.25%), Construction (36.59%), Manufacturing (11.64%), Wholesale (9.76%), Retail or Restaurants (18.86%), Transportation, IT, or Utilities (3.20%), and Real estate (3.21%).
B_REGIONAL, B_REGIONAL2, and B_SHINKIN respectively indicate that the main bank is a regional bank, a second-tier regional bank, and a Shinkin bank. Typically, regional banks are medium-sized banks whose banking operations are regionally focused, second-tier regional banks also operate regionally but they tend to be smaller in size, and Shinkin banks are cooperative banks specializing in providing commercial banking services to member SMEs and individuals.\(^8\) The coefficient of these dummies measure the difference in the exit probability for each bank type as with the case when the main bank is a city bank, a type of banks that is largest in size and operates nationwide, or a trust banks, a type of banks that can also offer trust services.

3. **Results**

3.1. **Main results**

Table 2 shows our baseline regression results. Columns (1) and (2) of this table reports the result when we use B_DAMAGED only, and columns (3) and (4) report the results when the interaction term of B_DAMAGED and F_SCORE is added. The bank damage variable B_DAMAGED is either B_HQDAMAGED (headquarter damage) in columns (1) and (3), or B_BRDAMAGED (branch damage) in columns (2) and (4). The figures in the dF/dx columns are the marginal effects of the respective variables, those in the “p-value” columns are p-values of the estimates, and ***, **, or * respectively indicates that the null hypothesis of the coefficient being zero is rejected at 1%, 5% or 10% significance level. P values are based on the heteroskedasticity-robust standard errors.  

We first find that most of the control variables are statistically significant. The estimates of the

\(^8\) See Uchida and Udell (2010) for more information on the types of banks in Japan.
marginal effects mean that the probability of firm exit is higher for larger (F_EMP) and older (F_AGE) firms and for those transacting with a larger number of banks (F_NBANK). Compared with borrowers of city or trust banks, the exit probability is higher for borrower of regional banks (B_REGIONAL), and further higher for borrowers of second-tier regional banks and Shinkin banks. We also find that borrowers of less profitable (B_ROA) and less capitalized (B_CAP) banks have a higher probability of exit. The finding for B_CAP is consistent with a capital crunch theory (e.g., Peek and Rosengren 1995).

The main independent variable in this study is B_DAMAGED, a proxy for bank damage. We consistently find that its coefficient is negative and statistically significant. This means that if the headquarters of the main bank is located inside the earthquake-affected area (B_HQDAMAGED), or if a larger number of branch offices of the main bank are located inside the area (B_BRDAMAGED), the probability of firm exit is lower. The coefficient in column (1) indicates that the exit probability for firms transacting with banks whose main banks were damaged is lower by 0.174% point than that for those transacting with non-damaged main banks. Also, the coefficient in column (2) indicates that one point increase in B_BRDAMAGED decreases the exit probability by 0.414% point, which is comparable to 0.190% point increase for a two-standard deviation (0.23*2: see column (1) of Table 1) increase in B_BRDAMAGE. Because the average exit rate is 0.516% (column (1) in Table 1), these effects are economically significant.

On one hand, our finding of the positive impact of B_DAMAGED is inconsistent with the prediction that damaged banks are likely to have smaller lending capacity due to malfunctioning of the back-office operations or due to destroyed physical and/or human capital at branches. On the other hand, our finding is consistent with the evergreening loans by damaged banks with
deteriorated capital and/or with a larger lending capacity of damaged banks that obtained various kinds of public and private aids.

Turning to the results regarding the selection mechanism, we consistently find that the firms’ score (F_SCORE) has a negative and statistically significant coefficient. This means that higher-scored firms are less likely to exit. This finding is consistent with a natural selection mechanism, and is consistent with a finding in Uchida et al. (2014). However, from column (3) or (4), we find that the interaction term of B_DAMAGED and the firms’ score (F_SCORE) has a positive and statistically significant coefficient. This means that irrespective of whether it is measured by headquarter damage or branch damage, bank damage demotes the natural selection mechanism. Note that this positive impact is not large enough to turn the selection mechanism unnatural because the absolute value of the estimated coefficient for the interaction term is smaller than that for F_SCORE.

3.2. Illustrative representation of the results

To comprehend the whole picture of the effect of bank damage on the exit probability, we also provide an illustrative representation of the findings in Table 2. Figure 1 show the relation between the exit probabilities and the firms’ score for firms borrowing from damaged main banks (B_HQDAMAGED = 1: gray line with markers) and those borrowing from non-damaged ones (B_HQDAMAGED = 0: black line). The height of each line (Y-axis) indicates the predicted probabilities, which are measured for different values of F_SCORE (X-axis) from its mean (45.61: see Table 1) plus two sigmas (i.e., two standard deviations: 5.62 * 2) to the mean minus two sigmas. To calculate the predicted probabilities, we first calculate the predicted values of the latent variable
\( y_i^* \) for the specification in column (3) of Table 2, and then obtain the corresponding probabilities that follows the standard normal distribution.\(^9\)

From the figure, we first find that the two lines are downward-sloping. This confirms our interpretation above that the natural selection mechanism is working (irrespective of the presence/absence of bank damages). We also find that the gray line is located below the black one, and that the slope of the gray line is flatter than that of the black one. These differences stem not only from the negative coefficient for \( B_{\text{HQDAMAGED}} \) but also from the positive coefficient for \( B_{\text{HQDAMAGED}} \times F_{\text{SCORE}} \).\(^10\) Again, these findings confirm our interpretation that bank damages demote the natural selection mechanism. By drawing this figure, we can additionally find that the difference in the exit probability for firms transacting damaged and non-damaged banks almost disappears as firms’ score increases. This is because as \( F_{\text{SCORE}} \) increases, its effect dominates and the marginal impact of \( B_{\text{HQDAMAGED}} \) (either in its isolation or through the interaction with \( F_{\text{SCORE}} \)) becomes smaller.

### 3.3. Discussion

On balance, we find that damages to the main banks contribute to the decrease in the frequency of exits of their borrowers, in a manner that demotes their natural selection mechanisms (i.e., more decrease for borrowers that are less efficient). Although this finding is consistent with a prediction that bank damages deteriorate the lending capacity of the banks and do harm on their

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\(^9\) Specifically, we first sum the products of the mean of each independent variable and its estimated coefficient (for those variables other than the first three). We then add the product of the value of \( F_{\text{SCORE}} \) (shown on the X-axis) and its estimated coefficient (which is different when \( B_{\text{HQDAMAGED}} = 0 \) and \( = 1 \)). For the gray line, we further add the estimated coefficients for \( B_{\text{HQDAMAGED}} \).

\(^10\) Note that even if the coefficient for the cross term were zero, the slope of the gray line would be flatter as long as the coefficient for \( B_{\text{HQDAMAGED}} \) is negative. Due to the non-linearity of the probit model, the impact of \( B_{\text{HQDAMAGED}} \) (times its coefficient) is not uniform and depends on the value of \( F_{\text{SCORE}} \).
borrowers. As mentioned above, however, we can have at least two possible hypotheses that can account for these findings.

First, damaged banks might extend evergreening loans, especially to less efficient firms. This interpretation is consistent with existing evidence for evergreening loans by weakly capitalized banks during the banking crisis period in the 1990s in Japan (see e.g., Sekine et al. 2003, Peek and Rosengren 2005, Fukuda, et al. 2006, Caballero et al. 2008). Although we already control for the effects of small capital, because we include B_CAP as a control variable, we should note that this variable based on book value may not be able to capture an evergreening effect due to actual deterioration in bank health or lending capacity caused by the earthquake damages.

Second, various measures have taken after the Great Tohoku Earthquake to rescue financial institutions in the affected area. Banks in the Tohoku area obtained many financial aids, including rescue funding from the Bank of Japan, and capital injection using public funds.11 These measures might have contributed to increase the lending capacity of banks in the affected areas, enabled them to provide more funds to less efficient firms, and thereby allowed them to survive.

It is difficult to exactly identify which (or both) of these hypothesis, the evergreening hypothesis and the aid hypothesis, is the mechanism working behind our findings. In particular, to test the evergreening hypothesis, we need detailed information on the change in the capital ratio of each of the main banks, but it is hard to obtain detailed information of banks’ capital ratio other than in the form of book-level ones from banks’ financial statements that is available only in an annual basis. Related to this point, we also need to take into account the effect of the public capital

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11 From May 2011, the Bank of Japan started to supply funds to financial institutions in disaster areas as the special funds-supplying operation, which aims to support such financial institutions to meet demand for funds for restoration and rebuilding. Also, the Government of Japan injected capital to regional financial institutions in the disaster areas from September 2011 to December 2012.
injection, but it is hard to evaluate whether sufficient amounts of capital were injected in each banks.

Nonetheless, we can still conduct some additional tests for the aid hypothesis. Although it is generally difficult to discern which banks obtained what kinds of public or private aids, it is relatively easy to specify the banks that obtained capital injection of public funds. Using this information, we can extend our analysis in the previous section to test the capital injection hypothesis, in other words, a capital-injection-version of the aid hypothesis.12

4. Public capital injection to main banks

In this section, we extend our analysis in the previous section to test the capital injection hypothesis by considering the effect of the public capital injection into banks in the Tohoku area that were implemented after the earthquake. During our sample period from March 2011 to November 2012, the Government of Japan injected capital into 11 financial institutions based on special earthquake-related provisions of the Act on Special Measures for Strengthening Financial Functions After the Earthquake.13 Below, we examine whether the negative effect of bank damages on the probability of firm exit changes when we differentiate those firms whose main banks obtained the capital injection and those not.

12 We do not focus on rescue funding from the Bank of Japan, because information (especially bank-level information) to consider its effect is not available. Also, the funding was mostly a temporary measure to help short-term financing soon after the earthquake. 13 The 11 institutions are 4 banks (Sendai (Sep. 2011), Tsukuba (Sep. 2011), 77 (Dec. 2011), and Tohoku (Sep. 2012)), 4 Shinkin Banks (Miyako (Feb. 2012), Kesennuma (Feb. 2012), Ishinomaki (Feb. 2012), and Abukuma (Feb. 2012)), and 3 credit cooperatives (Soso (Jan. 2012), Iwaki (Jan. 2012), and Nasu (Mar. 2012)). Note that after our sample period, Kirayaka Bank (Dec. 2012) and Gumma-Mirai Shinkumi Bank (Dec. 2012) also obtained the capital injection.
We first create a new dummy variable B_INJECTION that takes the value of one if the firm’s main bank is one of the above financial institutions that obtained public capital injection. Table 3 shows the decomposition of our sample firms depending on whether their main bank obtained the public capital injection (i.e., whether B_INJECTION = 0 or 1). We find that 5,232 firms (9.7%) out of our 53,904 sample firms have main banks that obtained the capital injection.

Table 3 also shows further decompositions depending on the values of Exit and B_HQDAMAGED. It is worthwhile to note that there are some banks that are located inside the affected area (i.e., B_HQDAMAGED = 1) but do not obtain the capital infusion (i.e., B_INJECTION = 0), and some banks that are located outside the affected area (i.e., B_HQDAMAGED = 0) but obtain the capital infusion (i.e., B_INJECTION = 1). The presence of these banks implies that the effect of our bank damage variables (especially B_HQDAMAGED) that we found in the previous section might not capture the effect of capital injection into damaged banks. However, it is difficult to judge whether the effect of these banks economically matter in our sample. Table 3 shows that the number of our sample firms when B_HQDAMAGED = 1 and B_INJECTION = 0 is 6,927 (12.9% of 53,904 firms), and that when B_HQDAMAGED = 0 and B_INJECTION = 1 is 3,392 (6.3% of 53,904 firms). These firms are not majority but still these numbers are are non-negligible.\textsuperscript{14}

From Table 3, we have some evidence that is consistent with the capital injection hypothesis. In the table, we can see that the exit rate in the absence of the capital injection (i.e., B_INJECTION

\textsuperscript{14} From the table, we can compare the effect of bank damage when B_INJECTION = 0 and when B_INJECTION = 1. In the former case, the exit rate in the case of damaged main banks is higher than that in the case of non-damaged ones. We also find that this difference is statistically significant as well (not reported in the table). In the case of B_INJECTION = 1, the rates are similar, irrespective of whether B_HQDAMAGED = 0 or 1. Also, the difference is statistically insignificant as well (not reported in the table).
= 0) is on average higher (0.57% when B_HQDAMAGED = 0 or 0.38% when = 1) than that in its presence (B_INJECTION = 1: either 0.27% or 0.29%). However, we must take into account the small number of firms that exited (278 firms), which becomes even smaller when decomposed depending on B_HQDAMAGED and B_INJECTION.

To examine whether the negative impact of the capital injection on the probability of firm exit, we extend the analysis in Section 3 and run the probit regression by using the dummy variable B_INJECTION, a dummy that indicates the presence of the capital injection into firms’ main banks. We use this variable not only in its isolation but also by interacting it with our main variables. The results using these additional variables are reported in Table 4. Columns (1) and (2) report the specifications when we add B_INJECTION (in its isolation) and its interaction with F_SCORE. In specifications reported in columns (3) and (4), we further add B_DAMAGED * B_INJECTION and a triple interaction term (F_SCORE * B_DAMAGED * B_INJECTION). The bank damage variable (B_DAMAGE) used in columns (1) and (3) is B_HQDAMAGED, and that used in columns (2) and (4) is B_BRDAMAGED.

Our findings from the regression analysis are not necessarily supporting the finding in Table 3 and the prediction that the public injection increased the main banks’ lending capacity and contributed to the survival of their inefficient borrowers. In none of the four columns of Table 4, B_INJECTION has no significant coefficient in its isolation. Also, none of its interaction terms is significant as well. These findings imply that the public capital injection neither increased nor decreased the exit probability of the borrowers of the injected banks. Also, the injection neither promoted nor demoted the natural selection mechanism of firm exit.

On balance, our findings from the univariate analysis (based on Table 3) and those from the
regression analysis (Table 4) are not necessarily consistent. In Table 3, we find some evidence that the public capital injection reduced the probability of firm exit, but we find no such effect in Table 4. Note that this inconsistency could stem from the data restriction, i.e., a small number of observations for exit firms as we mentioned above. Due to the small number, the cross terms we used in Table 4 take the value of zero for majority of sample firms. Also, it is likely that a high correlation between B_DAMAGED and B_INJECTION produces multicollinearity, which might reduce the significance of these variables (although B_DAMAGED was consistently significant in Table 4). Thus, it is safe to conclude that we have some weak evidence for the hypothesis that the public capital injection contributed to reduce the probability of firm exit.

5. Conclusion

In this paper, we investigated the impact of financial shocks caused by damages to firms’ main banks on firm exit, using data of firms located outside the affected areas of the Great Tohoku Earthquake. We find no evidence for the negative impact of financial shocks on firms’ survivability suggested by credit crunch hypothesis, but rather find that the exit probability is smaller and the natural selection mechanism is demoted when firms’ main banks were damaged. On one hand, these findings are not necessarily consistent with the prediction that damages to banks have a real impact on their borrowers. On the other hand, our findings are consistent with the hypothesis that public and private aids contributed to increase damaged banks’ lending capacity. From an additional analysis, we find weak evidence for the capital injection version of the aid hypothesis, i.e., the hypothesis that the injection contributed to increase the lending capacity of damaged banks, allow these banks to extend more loans to less efficient firms, and enable such firms to survive. Note that
these findings do not mean that the analysis in this paper is perfect. Due to data limitation, the evidence for the capital injection hypothesis is only weak. Also, our findings of the negative impact of bank damages on the probability of firm exit are also consistent with another hypothesis, the evergreening hypothesis where damaged banks that have deteriorated capital base extended zombie lending. In this paper we have no evidence for or against this zombie hypothesis. Identifying a more detailed mechanism behind our findings is left as an important task for future studies.
References


Natural disasters, damage to banks, and firm investment. RIETI Discussion Paper 12-E-062.


Oxford Handbook of Banking, Ch. 35, Oxford University Press.
### Tables and Figure

#### Table 1 Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Whole sample</th>
<th>(2) B_HQDAMAGED=0</th>
<th>(3) B_HQDAMAGED=1</th>
<th>(4) t-test for H₀: mean (B_HQDAMAGED=1) = mean (B_HQDAMAGED=0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit</td>
<td>Obs.</td>
<td>Mean</td>
<td>Std. dev.</td>
<td>Obs.</td>
</tr>
<tr>
<td></td>
<td>53,904</td>
<td>0.00516</td>
<td>(NA)</td>
<td>43,585</td>
</tr>
<tr>
<td>B_HQDAMAGED</td>
<td>Dummy taking a value of one if the firm's headquarters of the firm's main bank is located in the earthquake-affected area.</td>
<td>53,904</td>
<td>0.19</td>
<td>(NA)</td>
</tr>
<tr>
<td>B_BRDAMAGED</td>
<td>The ratio of the number of branches of a firm's main bank located in the earthquake-affected area to the total number of branches of that bank.</td>
<td>53,904</td>
<td>0.21</td>
<td>0.23</td>
</tr>
<tr>
<td>F_SCORE</td>
<td>TDB's score of the firm.</td>
<td>53,904</td>
<td>45.61</td>
<td>5.62</td>
</tr>
<tr>
<td>F_EMP</td>
<td>The number of employees of the firm.</td>
<td>53,904</td>
<td>12.70</td>
<td>56.46</td>
</tr>
<tr>
<td>F_AGE</td>
<td>The age of the firm.</td>
<td>53,904</td>
<td>30.41</td>
<td>17.85</td>
</tr>
<tr>
<td>F_NBANK</td>
<td>The number of banks that the firm transacts with.</td>
<td>53,904</td>
<td>2.05</td>
<td>1.17</td>
</tr>
<tr>
<td>B_ROA</td>
<td>The ratio of operating profit to total assets of a firm's main bank.</td>
<td>53,904</td>
<td>0.00193</td>
<td>0.00131</td>
</tr>
<tr>
<td>B_CAP</td>
<td>The equity to assets ratio of a firm's main bank.</td>
<td>53,904</td>
<td>0.04551</td>
<td>0.01098</td>
</tr>
<tr>
<td>B_LNASSETS</td>
<td>The natural logarithm of the total assets owned by a firm's main bank.</td>
<td>53,904</td>
<td>20.95950</td>
<td>1.12796</td>
</tr>
<tr>
<td>B_REGIONAL</td>
<td>Dummy taking a value of one if the firm's main bank is a regional bank.</td>
<td>53,904</td>
<td>0.66644</td>
<td>(NA)</td>
</tr>
<tr>
<td>B_REGIONAL2</td>
<td>Dummy taking a value of one if the firm's main bank is a second-tier regional bank.</td>
<td>53,904</td>
<td>0.14184</td>
<td>(NA)</td>
</tr>
<tr>
<td>B_SHINKIN</td>
<td>Dummy taking a value of one if the firm's main bank is a Shinkin bank.</td>
<td>53,904</td>
<td>0.18023</td>
<td>(NA)</td>
</tr>
</tbody>
</table>
**Table 2 Probit Estimation for Exit Probability**

Dependent variable: Exit (dummy for exits during the 1.8 year period after the earthquake)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B_DAMAGED</td>
<td>(-0.00174, 0.00)</td>
<td></td>
<td>(-0.00414, 0.00)</td>
<td></td>
</tr>
<tr>
<td>F_SCORE</td>
<td>(-0.00039, 0.00)</td>
<td></td>
<td>(-0.00039, 0.00)</td>
<td></td>
</tr>
<tr>
<td>F_SCORE×B_DAMAGED</td>
<td>0.00014, 0.09</td>
<td></td>
<td>0.00014, 0.09</td>
<td></td>
</tr>
<tr>
<td>F_EMP</td>
<td>0.00001, 0.02</td>
<td></td>
<td>0.00001, 0.02</td>
<td></td>
</tr>
<tr>
<td>F_AGE</td>
<td>0.00002, 0.05</td>
<td></td>
<td>0.00002, 0.05</td>
<td></td>
</tr>
<tr>
<td>F_NBANK</td>
<td>0.00103, 0.00</td>
<td></td>
<td>0.00103, 0.00</td>
<td></td>
</tr>
<tr>
<td>B_REGIONAL</td>
<td>0.29248, 0.00</td>
<td></td>
<td>0.29737, 0.00</td>
<td></td>
</tr>
<tr>
<td>B_REGIONAL2</td>
<td>0.99835, 0.00</td>
<td></td>
<td>0.99856, 0.00</td>
<td></td>
</tr>
<tr>
<td>B_SHINKIN</td>
<td>0.99761, 0.00</td>
<td></td>
<td>0.99734, 0.00</td>
<td></td>
</tr>
<tr>
<td>B_ROA</td>
<td>(-0.27664, 0.03)</td>
<td></td>
<td>(-0.23841, 0.08)</td>
<td></td>
</tr>
<tr>
<td>B_CAP</td>
<td>(-0.06201, 0.00)</td>
<td></td>
<td>(-0.05548, 0.01)</td>
<td></td>
</tr>
<tr>
<td>B_LNASSETS</td>
<td>0.00053, 0.25</td>
<td></td>
<td>0.00044, 0.29</td>
<td></td>
</tr>
</tbody>
</table>

Industry dummies: yes  yes  yes  yes
Pseudo R-squared: 0.0703  0.0715  0.071  0.0728
Log likelihood: \(-1619.1351\)  \(-1617.1225\)  \(-1617.9168\)  \(-1614.786\)

Notes: ***, **, and * indicate significance at the 1, 5, and 10% level, respectively.
† The B_DAMAGED variable is either B_HQDAMAGED or B_BRDAMAGED as indicated in the column heading.
Table 3 Exit Rate, Bank Damage and Capital Injection to Banks

<table>
<thead>
<tr>
<th>B_HQDAMAGED = 0</th>
<th>B_HQDAMAGED = 1</th>
<th>Total</th>
<th>B_HQDAMAGED = 0</th>
<th>B_HQDAMAGED = 1</th>
<th>Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit = 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs</td>
<td>%</td>
<td>Obs</td>
<td>%</td>
<td>Obs</td>
<td>%</td>
<td>Obs</td>
</tr>
<tr>
<td>Exit = 0</td>
<td>41,508</td>
<td>99.43%</td>
<td>6,901</td>
<td>99.62%</td>
<td>48,409</td>
<td>1,835</td>
</tr>
<tr>
<td>Exit = 1</td>
<td>237</td>
<td>0.57%</td>
<td>26</td>
<td>0.38%</td>
<td>263</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>41,745</td>
<td>100.00%</td>
<td>6,927</td>
<td>100.00%</td>
<td>48,672</td>
<td>1,840</td>
</tr>
</tbody>
</table>

B_INJECTION is a dummy variable that takes a value of one if the firm's main bank obtained public capital injection after the earthquake. For the definitions of Exit and B_HQDAMAGED, please see Table 1.
Table 4 Probit Estimation for Exit Probability

Dependent variable: Exit (dummy for exits during the 1.8 year period after the earthquake)

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B_DAMAGED †</td>
<td>B_DAMAGED</td>
<td>B_DAMAGED</td>
<td>B_DAMAGED</td>
</tr>
<tr>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>B_HQDAMAGED</td>
<td>B_BRDAMAGED</td>
<td>B_HQDAMAGED</td>
<td>B_BRDAMAGED</td>
</tr>
</tbody>
</table>

| | dF/dx | p-value | dF/dx | p-value | dF/dx | p-value | dF/dx | p-value |
| B_DAMAGED † | -0.00421 | 0.05 ** | -0.01873 | 0.01 *** | -0.00479 | 0.04 ** | -0.00480 | 0.04 ** |
| B_INJECTION | -0.00200 | 0.54 | 0.00026 | 0.96 | -0.00346 | 0.24 | -0.00410 | 0.19 |
| B_DAMAGED×B_INJECTION † | 0.03737 | 0.30 | 0.01795 | 0.26 |
| F_SCORE | -0.00404 | 0.00 *** | -0.00046 | 0.00 *** | -0.00402 | 0.00 *** | -0.00042 | 0.00 *** |
| F_SCORE×B_DAMAGED † | 0.00013 | 0.12 | 0.00036 | 0.02 ** | 0.00015 | 0.11 | 0.00015 | 0.10 |
| F_SCORE×B_INJECTION | 0.00003 | 0.75 | -0.00003 | 0.79 | 0.00009 | 0.52 | 0.00015 | 0.45 |
| F_SCORE×B_DAMAGED×B_INJECTION † | -0.00001 | 0.55 | -0.00013 | 0.55 | -0.00025 | 0.50 |
| F_EMP | -0.00000 | 0.02 ** | -0.00000 | 0.02 ** | 0.00001 | 0.02 ** | 0.00001 | 0.02 ** |
| F_AGE | 0.00000 | 0.05 ** | 0.00000 | 0.05 ** | 0.00000 | 0.05 ** | 0.00000 | 0.05 ** |
| F_NBANK | 0.00100 | 0.00 *** | 0.00100 | 0.00 *** | 0.00100 | 0.00 *** | 0.00100 | 0.00 *** |
| F_REGIONAL | 0.26848 | 0.00 *** | 0.25505 | 0.00 *** | 0.25513 | 0.00 *** | 0.25537 | 0.00 *** |
| F_REGIONAL2 | 0.09694 | 0.00 *** | 0.99593 | 0.00 *** | 0.99552 | 0.00 *** | 0.99556 | 0.00 *** |
| F_SHINKIN | 0.99510 | 0.00 *** | 0.99262 | 0.00 *** | 0.99252 | 0.00 *** | 0.99258 | 0.00 *** |
| F_ROA | -0.27286 | 0.04 ** | -0.25056 | 0.07 * | -0.27194 | 0.03 ** | -0.27185 | 0.03 ** |
| B_CAP | -0.05946 | 0.01 *** | -0.05509 | 0.01 *** | -0.06663 | 0.00 *** | -0.06662 | 0.00 *** |
| B_LNASSETS | 0.00032 | 0.52 | 0.00032 | 0.48 | 0.00004 | 0.94 | 0.00005 | 0.93 |

Industry dummies | yes | yes | yes | yes |
Obs | 53904 | 53904 | 53904 | 53904 |
Pseudo R-squared | 0.0718 | 0.0732 | 0.0732 | 0.0732 |
Log likelihood | -1616.5374 | -1614.1795 | -1613.9205 | -1613.9565 |

Notes: ***, **, and * indicate significance at the 1, 5, and 10% level, respectively.
† The B_DAMAGED variable is either B_HQDAMAGED or B_BRDAMAGED as indicated in the column heading.
Figure 1  Natural Selection and Firm/Bank Damages

B_HQDAMAGED=0
B_HQDAMAGED=1