Natural Disasters, Bank Lending, and Firm Investment[1]

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Abstract

Natural disasters damage lending capacity of banks, providing natural experiments to examine whether such damage tightens the financial constraint on borrowing firms. This paper studies the impact of financial constraint created by the Great Hanshin-Awaji earthquake that occurred in Japan in 1995 on firm investment through the channel of firm-bank relationships. By using unique firm-level data combined with the information on physical damage caused by the earthquake, we find that the investment ratio of firms that is located *outside* the earthquake-hit area but transacts with a main bank located *inside* the area is smaller than those transacting with a main bank located *outside* the area. This result implies that the exogenous shock to bank lending capacity has a significant negative impact on firm investment. We also find that the finding above is robust to two alternative measures of bank damage, i.e., the damage to the headquarter and the damage to the branch network. However, the impact of the former measure emerges immediately after the earthquake, while that of the latter emerges with a one-year lag. This difference in the timing of the impacts implies that there are two different channels of bank damage on client firms: one through the banks' impaired managerial capacity to originate loans, and the other through their deteriorated risk-taking capacity.

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1. Introduction

Does lending capacity of banks affect borrowing firm activities? A vast literature has tried to answer this question since the seminal work by Bernanke (1983). However, researchers face a difficulty of identification. While lending behavior affects borrowing firms' performance, the performance of borrowing firms itself has a significant impact on the way lenders extend loans. This paper tackles this difficulty by taking advantage of a natural experiment aspect of a natural disaster that allows us to single out a pure exogenous shock to firms' financing from banks.

A natural disaster may deprive the information on borrowers' creditworthiness accumulated by the disaster-hit banks and destroy their managerial capacity to originate loans, including the ability to screen and process loan applications. A natural disaster also damages the borrowing firms located in the neighborhood of the banks, deteriorating the banks' loan portfolio and risk-taking capacity. In either case, a disaster reduces the damaged banks' lending capacity. Thus for those firms that are not directly damaged by the disaster, lending banks' damage from the disaster is an exogenous shock that may affect the availability and costs of external funds those firms can access. A natural disaster thus provides us a good laboratory for studying the effect of banks' lending capacity on borrowing firms' investment.

By utilizing this natural experiment aspect of a disaster, this paper examines whether bank damages have an adverse impact on the investment of undamaged borrowing firms when the Great Hanshin-Awaji earthquake hit the area around Kobe City and Awaji Island in western Japan in January 1995. To do so, we construct and use a unique firm- and bank-level data set compiled from various sources. The data set includes information on the firms' main banks[2], bank and firm damages, and firm investment, as well as the financial statements of firms and banks. Our sample consists of the four groups of firm-bank matches between damaged/undamaged firms and their damaged/undamaged banks. By comparing undamaged firm-damaged bank matches with undamaged firms-undamaged bank matches, we are able to single out the effect of the bank damage on the investment of undamaged firms.

Our main findings are summarized as follows. First, firms located *outside* the earthquake-hit area but transacting with a main bank located *inside* the area reduce investment, as compared to those transacting with a main bank located *outside* the area. This result implies that the exogenously damaged bank lending capacity has a significant effect on firm investment. Second, the finding above is robust to two alternative measures of bank damage, i.e., the damage to the headquarter capturing deteriorated managerial capacity of the bank to process loan applications at the back office and the damage to the branch networks capturing deteriorated financial health and risk-taking capacity. Our finding implies that both of these transmission mechanisms are effective. However, we

[2] Our data set includes the information on the banks that firms transact with. Among those banks, we identify a firm's main bank with the bank that the firm regards as the most important one. See Section 5 for more details.

also find that the impact of the former measure emerges immediately after the earthquake, while that of the latter emerges with a one-year lag. This difference in the timing of the impacts implies that the effect of impaired managerial capacity emerges immediately after the earthquake, while that of the deteriorated bank health emerges after some interval.

This paper is closely related to, and contributes to, two strands of literature.[3] One is the studies on the effects of bank lending on firm activities (e.g., Bernanke 1983, Peek and Rosengren 2000). Many of such studies suffer from the identification problem, and we can overcome the problem by taking advantage of the natural experiment aspect of natural disasters. There is one study that circumvents the identification problem by focusing on collateral damage of US firms stemming from the shocks on their lending banks in Japan (Peek and Rosengren 2000). However, they use aggregate data in their analysis. Our firm-level data with the main bank identity allows us to conduct more precise tests.

Although our primary interest is in collateral damage that undamaged firms suffer from damaged banks, we also investigate the direct impact of the earthquake on damaged firms' investment behavior. Thus, the other strand of related literature is on the effects of natural disasters on the corporate activities and macroeconomy. Many of these studies use country- or region-level data, and so are unable to clarify the effects on individual firms. Our firm-level data allows us to extract more information by taking firm heterogeneity into consideration. Exceptionally, Leiter et al., (2009) and De Mel et al., (2010) use firm-level data to investigate the recovery of disaster-hit firms, but our uniqueness rests on the fact that we investigate the negative impact of disaster-hit banks on their non-damaged borrowers as well as the recovery of damaged firms.

The rest of the paper is structured as follows. Section 2 reviews the related literature in more details. Section 3 briefly describes the Great Hanshin-Awaji Earthquake. Sections 4 and 5 respectively describe our data and methodology. Section 6 presents the estimation results. Section 7 summarizes the results.

2. Literature Review

2.1 Bank loan and Firm Activities

A vast literature empirically examines the effects of bank lending on the real economy. In his seminal paper, Bernanke (1983), using aggregate data, showed that the bank failures significantly reduced aggregate production of the US economy during the Great Depression. His study, however, has been challenged on the grounds that loan supply shocks are not identified from loan demand shocks in his study. In other words, the observed relationship between bank failure and aggregate production may simply capture the fact that recession caused bank failure. For example, using the US state-level data over the 1990-91 recession periods, Bernanke and Lown (1991) find no

[3] See section 2 for more detailed literature review.

significant relationship between bank lending and employment growth after controlling for industry composition, suggesting that the credit crunch was not a major cause of the 1990-91 recession.

This paper is also closely related to event studies examining the effect of bank failures on the market values of their client firms. Slovin et al. (1993) first analyzed the share price of firms with lending relationships with a (de facto) failed US bank (Continental Illionis Bank), which is followed by subsequent studies of Bae et al. (2002), Yamori and Murakami (1999) and Brewer et al. (2003a). All of these studies find a significant effect of bank failure on the firm value of their borrowers[4]. Yamori (1999) investigates the failure of a Japanese regional bank located in the earthquake-hit Hanshin area (Hyogo Bank), and find that the stock market did distinguish solvent banks from problematic banks.[5] The advantage of these event studies is their being able to clearly identify bank failure shocks using a high-frequency (daily) data. However, they have limitations as well. First, event studies hinge on the assumption of market efficiency as well as rational behavior by market investors, which rules out the possible overreaction to the bank failures. Second, event studies cannot be applied to non-listed firms. This paper directly focuses on the real activity of firms, i.e., investment behavior, and hence does not depend on the market efficiency/rationality assumptions. We also cover unlisted firms, most of which are small- and medium-sized firms that are likely to be most affected by shocks from lending banks.

Some other studies directly investigate the effects of bank failure or deteriorated bank health on client firms using firms' financial statement data.[6] Hori (2005) examine the profitability of firms that borrowed from a failed large Japanese bank (Hokkaido-Takushoku Bank), and find adverse effects for those client firms with low credit rating. Minamihashi (2011) analyzes the failures of two long-term credit banks in Japan, and finds that bank failures significantly decrease investment of their client firms[7]. Gibson (1995, 1997) find that client firms of low credit-rated Japanese banks significantly reduce investment during the 1994-95 period.[8,9] However, these studies suffer from the identification problem because the association between bank failure or deteriorated bank health and client firms' bad performance might reflect a reverse causality.

To solve for this identification problem, Peek and Rosengren (2000) examine whether the state-level construction activity in the US is affected by the deterioration of the health of their lending banks in Japan through lending from their US branches. They find that the deterioration of Japanese banks' financial health has a negative impact on the construction activity in the U.S., which

[4] Note, however, that Brewer et al. (2003a) also find that the magnitude of these negative effects on the firm value of the borrowers are not significantly different from that of the same effects on all other sample firms.
[5] See Brewer et al., (2003b) as well.
[6] Using only bank balance sheet data, Woo (2003) and Watanabe (2007) find that weakly capitalized Japanese banks reduced their lending in 1997 when the Ministry of Finance started to require rigorous self-evaluation of loans.
[7] See also Fukuda and Koibuchi (2007).
[8] See also Nagahata and Sekine (2005).
[9] Also note that Peek and Rosengren (2005), using the data of Japanese listed firms over 1993-1999, find that banks expanded loans to unprofitable firms during this period. See also Caballero et al.,(2008) for such "zombie" lending practices by Japanese banks in the 1990s.

supports the causality running from bank lending capacity to firm activities.[10]

This paper employs an identification strategy similar to that in Peek and Rosengren (2000) because we examine the effect of the damaged banks on the firms that are located *outside* the earthquake-hit area. However, we have an advantage of being able to capture the effects of the damaged banks more clearly because we use the firm- and bank-level data rather than the state-level aggregate data in Peek and Rosengren (2000) that cannot control for firm and bank heterogeneity.

2.2 Natural Disaster and Economic Recovery

Natural disasters cause serious damage but invite subsequent recovery to the economy. Disasters directly destroy capital and labor, causing business interruptions of affected firms, and indirectly damage non-affected firms that are connected with affected firms through the upstream and downstream in the supply chain. However, as the destroyed capital is replaced to new one, affected firms' output and productivity tend to recover eventually. Although there is some divergence in their empirical findings, cross-country evidence on balance shows that updating technology and/or factor composition as well as factor accumulation affect the extent of the after-shock recovery (Skidmore and Toya, 2002; Okuyama, 2003; Kahn 2005; Stromberg 2007; Toya and Skidmore, 2007;Crespo-Cuaresma et al., 2008; Sawada et al. 2011).

Compared with rich evidence on the impact of natural disasters on macroeconomy, few studies have explored firm-level impacts and subsequent recovery. Notable exceptions are Leiter et al. (2009) and De Mel et al. (2010). Leiter et al. (2009) study the capital accumulation, employment, and productivity growth of European firms damaged by floods. They find that the accumulation of physical capital and the employment growth are significantly higher in regions experiencing a major flood-event, and that the positive effect prevails for firms with a higher share of intangible assets.

De Mel et al. (2010) conduct surveys to enterprises in Sri Lanka after the 2004 Tsunami and examine firm recovery after the disaster. They randomly provide grants to some sample firms and investigate the impact of the grants on the recover, which serves as a natural experiment to examine the financial constraint damaged firms face. However they do not investigate borrowing from banks that are main fund provides for damaged firms.[11] Our uniqueness lies in our investigating the impact of disaster-hit banks on their non-damaged borrowers as well as damaged ones.

3. Summary of the Great Hanshin-Awaji Earthquake

The Great Hanshin-Awaji Earthquake occurred on January 17, 1995. The total loss originated from this huge natural disaster is estimated to be 9.9 trillion yen, including 630 billion yen in

[10] Calomiris and Mason (2003) and Ashcraft (2005) take some other identification strategies.

[11] Sawada and Shimizutani (2008) reveal that consumption of households hit by the Great Hanshin-Awaji Earthquake is affected by the amount of collateralized assets they own, suggesting the importance of borrowing constraint on households after the disaster.

business sector losses.[12] Table 1 summarizes the damage estimates, including the number of death tolls and the numbers of destroyed housing units are compiled by the Fire and Disaster Management Agency of the Government of Japan as of May 19, 2006. The table indicates that the number of casualties is more than 6,000 and the number of complete losses of housing is about thousands. We can also see a large variation in the extent of damages across earthquake-hit and its adjacent areas.[13] The damages, in terms of the ratios of casualties and of completely- and half-destroyed housing units, are concentrated in some specific areas of Kobe city including its Higashinada-ward, Nada-ward, and Nagata-ward.[14][15]

To comprehend characteristics of firms located in the earthquake-hit areas at the time of the earthquake, it is helpful to overview the data obtained from Teikoku Databank, one of the leading business credit bureaus in Japan. They compile a comprehensive firm-level database that stores information about firms' characteristics, e.g., their location, and basic financial variables. Because this database covers most of the firms in Japan, we can grasp a general idea of firms in the damaged areas.

Table 2 summarizes the industry composition in the earthquake-hit area as compared to the whole firms in the Teikoku Databank data as of 1994. It shows that in the earthquake-hit area, the shares of wholesale and manufacturing firms are larger and those of construction, retail and restaurant industries are smaller than the nation-wide average.[16,17] Firms' financial condition as of 1994 is summarized in Table 3. It shows that firms in the area hit by the earthquake exhibit a higher capital ratio and lower profit ratio than the nation-wide average. We need to take into account these characteristics when we study the impact of the earthquake on firm's capital investment, because they potentially affect firms' access to external finance.

Since the information about transacting banks is also included in the database of Teikoku Databank, we can also grasp an idea of lenders in the damaged areas. To do so, it is important to differentiate damaged banks, i.e., those banks whose headquarters are in the earthquake-hit areas,

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[12] The data source of these figures is Hyogo Prefecture (http://web.pref.hyogo.jp/wd33/wd33_000000010.html).

[13] The number of housing unit losses is from http://web.pref.hyogo.jp/pa20/pa20_000000006.html. This table covers all cities and towns of Hyogo Prefecture and a part of Osaka Prefecture (nine cities and five towns), both of which were targets of the Act concerning Special Financial Support to Deal with the Designated Disaster of Extreme Severity by the Government of Japan.

[14] To calculate these ratios, we use the 1990 census for population data (the Ministry of Internal Affairs and Communications, the Government of Japan) and the 1993 housing survey for housing units (the Ministry of Construction).

[15] We need to be careful about the relative sizes of completely, half-, and completely or half-destroyed rates, because the Fire Defense Agency and the Ministry of Construction (housing survey) use slightly different definitions. Due to this inconsistency, the completely- or half-destroyed rate in Nagata-ku (more than 90%) seems to be extremely high. For only a limited number of cities and towns, we can use alternative survey data collected by the Architectural Institute of Japan, which covers around 80% of the housing in Japan. If we use these data, the completely-, half- and completely or half-destroyed rates are 25.6%, 22.0%, and 47.6%, respectively.

[16] These numbers are computed from the database provided by Teikoku Databank, which tends to have a smaller coverage for the agricultural, forestry and fishery industries. In order to study the shares of these industries, we need to rely on other data sources.

[17] Using the same data set, Uchida et al. (2012) compare various characteristics of firms damaged by the Great Hanshin-Awaji Earthquake with the national averages in further details.

from undamaged banks, as shown in Table 4. Banks in the earthquake-hit areas, i.e., the banks whose headquarters are in the earthquake-hit regions (hereafter called the regional lenders) play a dominant role as a relationship-lender of the firms located in the area, and so we can predict that the damaged banks' loss of financing capacity might have caused a serious constraint to the firms in the area. Table 5 shows the share of damaged firms that have lending relationships with the regional lenders.[18] The fact that more than 80% of the firms transact with the regional lenders implies potential severity of the damage to firms that brought about by the damaged banks.

4. Data

4.1 Data sources

To construct our data set for the study of firms' capital investment around the Great Hanshin-Awaji Earthquake, we mainly rely on two firm-level data sources. First, the information about firm's capital investment and financial conditions is obtained from the Basic Survey of Business Structure and Activities (BSBSA: *Kigyo Katsudou Kihon Chosa* in Japanese), which is compiled by the Ministry of Economy, Trade, and Industry in Japan. The main purpose of this survey is to quantitatively comprehend the dynamics of Japanese enterprises including capital investment, export, FDI, and R&D investment. To this aim, the survey covers the universe of enterprises in Japan with 50 or more employees whose paid-up capital or investment fund is over 30 million yen. From this data source, we use firm-level data of capital investment and capital stock.[19]

Second, we rely on the firm-level database provided by Teikoku Databank that we described above. As mentioned above, in addition to the information about firms' characteristics, the Teikoku Databank data have a list of banks that each firm transacts with, where they rank the banks in the order of the importance to the firm. As it is customary to consider the top-listed bank as the firm's most important bank, we define the bank as the firm's *main bank*. Using this information of main bank identity, we further augment the data provided by Teikoku Databank with the banks' financial information obtained from Nikkei NEEDS Financial Quest provided by Nikkei, Inc. (Nihon Keizai Shimbun sha) and the other two paper-based sources.[20] This augmented dataset is further merged with the first data set from the BSBSA.

4.2 Sample Selection

The central theme of this paper is to investigate how capital investments of firms are affected by the huge earthquake. We treat the firms whose headquarters are located in the earthquake-hit area

[18] In this table we take into account all the banks that are listed in the Teikoku Databank data as the firms' transacting banks.

[19] We alternatively used the change of capital stock plus depreciation to compute an indirect measure of capital investment. However, we found that investment measured in this way involved serious measurement errors.

[20] The two sources are "Financial Statements of Shinkin Banks in Japan" and "Financial Statement of Credit Cooperatives in Japan", edited by Financial Book Consultants, Ltd. (Kinyu tosho konsarutanto sha), former and latter of which contain the information on the financial statement of credit union and shinkin bank, respectively.

as the damaged firms (i.e., treatment group). The earthquake-hit area is defined as the nine cities and five towns in Hyogo and Osaka Prefectures, which were the targets of the Act concerning Special Financial Support to Deal with the Designated Disaster of Extreme Severity by the Government of Japan.[21] Corresponding to this, we choose only firms located in Hyogo and Osaka Prefectures as the control group in order to reduce differences in unobserved characteristics that may stem from region-specific factors. To further control for demographic changes of the firm cohort and to control for other unobservable factors affecting firm investment, we also restrict our sample to the firms which do not exit from the sample over the five years from the earthquake. To exclude outliers, we drop observations which dependent or each independent variable falls in 0.5% of both tails. The sample period is three fiscal years, which in most of the case starts from April and ends in March, following the occurrence of the earthquake (i.e., t = FY1995, 1996, and 1997).[22] As a result, our dataset consists of 270 damaged firms and 1,250 undamaged firms. These 1,520 firms are our sample firms for the empirical analysis in the following sections.[23]

Note that the number of observation in our estimation is smaller than that in the data originally obtained from Teikoku Databank mainly due to the following three reasons. First, matching with BSBSA data to use the level of precisely measured capital investment substantially reduces the size of our sample. Second, the sample is also reduced because we restrict our sample to firms in Hyogo and Osaka Prefectures. Third, fixing the cohort of firms to create a balanced panel also reduces the sample.

5. Methodology and Variables

5.1 Regression

We estimate the following Tobin's Q-type investment equation that is augmented by the firm and bank damage variables as well as the proxies for the firm financial constraints and the bank lending capacity:

$$\begin{aligned}\frac{I_{it}}{K_{it-1}} &= \beta_0 + \beta_1 F\_SALEGROWTH_{it-1} + \beta_2 F\_DAMAGE_i + \beta_3 B\_DAMAGE_{it-1} \\ &+ \beta_4 F\_DAMAGE_i * B\_DAMAGE_{i,t-1} + \beta_5 F\_CONSTRAINTS_{i,t-1} \\ &+ \beta_6 B\_CAPACITY_{it-1} + \varepsilon_{it} \qquad for \;\; t = 1995, 1996, 1997. \qquad (1)\end{aligned}$$

The dependent variable is the capital investment ratio defined as the ratio of investment during

[21] These consist of Toyonaka City, Kobe City, Amagasaki City, Nishinomiya City, Ashiya City, Itami City, Takarazuka City, Kawanishi City, Akashi City, Tsuna Town, Hokutan Town, Ichinomiya Town, Goshiki Town, and Higashiura Town. As of the writing of this paper, Goshiki Town has been merged into Sumoto City; Tsuna, Hokutan, Ichinomiya, and Higashiura Towns have been merged into Awaji City.

[22] For example, 1995FY starts from April 1995 and ends in March 1996 for most of the firms. For these firms, the Great Hanshin-Awaji Earthquake on January 17, 1995 occurred in 1994FY.

[23] The sample size slightly varies over the sample periods since we drop outliers for each year.

period *t* to the capital stock measured as of the end of period *t*-1. Q theory predicts that this ratio is correlated with Tobin's Q, and so it is used comprehensively in existing empirical studies on investment. Considering the possibility that the effect of earthquake damage and recovery change over time, we run a cross-sectional regression for each fiscal year.

5.2 Explanatory Variables

We use a proxy for Tobin's Q and a variety of additional variables that may affect investment explained below. For all the variables except for the time invariant ones, we take a one-year lag.

5.2.1 Proxy for Tobin's Q

Since most of our sample firms are not listed on stock exchanges, we cannot use Tobin's Q defined as the ratio of the market value to the replacement cost of capital, which represents firm's investment opportunity. As a proxy for the opportunity, we use the growth rate of firm's sales (*F_SALESGROWTH*) as used in extant studies including Shin and Stulz (1998), Whited (2006), and Acharya et al. (2007). *F_SALESGROWTH* is expected to take a positive sign.

5.2.2 Firm damage

Damaged firms lose a part or all of their physical capital, resulting in large marginal products of capital and hence they should have more demand for capital than undamaged firms. To capture the demand for capital for the purpose of recovery from the damage, we use *F_DAMAGE*, which takes the value of one if the firm is located at the earthquake-hit area that we defined above. We predict that this variable has a positive impact on the investment ratio.

5.2.3 Bank damage

Our main interest lies in the effects of the bank damage on borrowing firms' investment. To capture this, we include a proxy for the damage of the firm's main bank, *B_DAMAGE*. For this purpose, we use two alternative variables as *B_DAMAGE*. First, *B_HQDAMAGE* is a dummy variable that takes the value of one if the headquarters of the bank is located in the earthquake-hit area. Because this variable mainly captures the damage to the headquarters, it represents the degree of the impairment in the managerial capacity to process loans, including the back-office operation, such as the ability to process applications for large-amount loans or to manage total risk of the entire loan portfolio of the bank.

Second, *B_BRDAMAGE* is the share of the main bank's branches located in the earthquake-hit area to its total number of branches. Compared to *B_HQDAMAGE*, this variable captures the damage to the main bank's branch network. It thus represents the damage to the bank's physical capital such as the ability to process applications for relatively small-amount loans under the branch managers' authority. It also captures the ratio of damaged and non-performing borrowers in the neighborhood of the branches, which is likely to negatively affect the bank's risk-taking capacity. These damages are expected to deteriorate the banks' lending capacity, and thereby invite more constraints to their borrowers. We thus predict that each of these variables has a negative coefficient.

5.2.4 Collateral damage

In addition to *F_DAMAGE* and *B_DAMAGE*, we also add their interaction term as an explanatory variable. This is to differentiate the impact of the bank damage on damaged firms from its impact on non-damaged firms. We are most interested in the effect of bank damage on their non-damaged borrowers, which is captured by the coefficient on the single term, *B_DAMAGE*. On the other hand, the effect of bank damage on their damaged borrowers is captured by the sum of the coefficients on *BK_DAMAGE* and its intersection with *F_DAMAGE*. Since damaged firms are more likely to be financially constrained when their main banks are also damaged, the intersection term is expected to have a negative sign.

5.2.5 Firm's financial constraint

We also use a vector of other variables representing firms' financial constraint, *F_CONSTRAINT*. More specifically, we use firm's size represented by the natural logarithm of total asset (*F_LNASSET*), leverage computed as the ratio of total liability to equity (*F_LEV*), profitability represented by the ratio of current income to total asset (*F_ROA*), liquidity proxied for by the ratio of liquidity asset to total asset (*F_CASH*).

Recent studies, including Whited (2006), Bayer (2006), and Hennessy et al. (2007), feature financial friction as an important factor generating variations in firm investment. Firms with higher profitability (*F_ROA*), more liquidity (*F_CASH*), and a larger size (*F_LNASSET*) are less likely to be financially constrained, Note, however, that those firm characteristics could be also related to future profitability, as discussed in Abel and Eberly (2011) and Gomes (2001). In either interpretation, we expect that these variables have positive coefficients. On the other hand, since firms with higher leverage *(F_LEV*) are more likely to be financially constrained, we expect that *F_LEV* has a negative coefficient.

5.2.6 Bank's lending capacity

Finally, we also use a vector of variables representing the main bank's lending capacity, *B_CAPACITY*. More specifically, we control for the size, financial stability, and profitability of the main bank for each firm. As a size variable, we use the natural logarithm of the bank's total asset (*B_LNASSET*). As proxies for the financial health and profitability of the main bank, we use the risk-unadjusted capital-asset ratio (*B_CAP*) and the ratio of operating profit to total asset (*B_ROA*), respectively. Banks with high profitability (*B_ROA*) and greater stability (*B_CAP*) are less likely to be constrained by capital requirements, and are thus more likely to provide loans to their client firms, which promotes client firms' investment. A larger bank (*B_LNASSET*) can diversify its loan portfolio and is hence likely to be less severely affected by the disaster. Thus these variables are expected to have a positive coefficient on the dependent variable.

Note, however, that many researchers (e.g., Ito and Sasaki, 2002; Shrieves and Dahl, 2003; Peek and Rosengren, 2005; Caballero et al., 2008) point out that Japanese banks manipulated and reported increased profits and capital by, e.g., underreporting of loan loss reserves, double-gearing of subordinated debt with affiliated life insurance companies, and rolling over loans to non-performing borrowers during the 1990s that we study. These researchers argue that such accounting manipulations are more likely to be observed for financially unhealthy banks. To the extent that this claim holds true and that *B_ROA* and *B_CAP* may not capture true profits and capital, their coefficients may be insignificant.

5.3 Summary statistics and univariate analysis

Table 6 Panel A shows the summary statistics for firm variables over our sample periods. Note that the number of observation is smaller than that in the data originally obtained from Teikoku Databank due to the reasons mentioned in the previous section. These three panels respectively correspond to the three fiscal years covered by our sample periods. The three columns in each panel correspond to the summary statistics for the whole sample, a subsample of damaged firms (with *F_DAMAGE*=0), and the subsample of undamaged firms (with *F_DAMAGE*=0), respectively. As mentioned above, all the statistics are computed by excluding outliers (i.e., eliminating 0.5% of observations in both tails).

As a preliminary analysis, in Table 6 Panel A, we conduct *t*-tests for the difference in means between the capital investment ratios of the samples with *F_DAMAGE*=1 and *F_DAMAGE*=0. The results show that the difference is statistically different from zero in 1996 fiscal year. The larger investment ratio for the damaged firms implies that they significantly increased investment, presumably for the recovery purpose, in the year subsequent to the earthquake. The financial characteristics of main banks for the damaged and undamaged firms do not systematically differ. For example, the damaged firms tend to have a relationship with the main bank that capital ratio is lower but ROA is higher than that for undamaged firms in year 1996. But, these are not statistically different in year 1997. On the other hand, *B_HQDAMAGE* and *B_BRDAMAGE* are always higher for the damaged firms. In the regression analysis in the next section, we explicitly examine whether and how the damages to the firms and the banks affect firms' capital investment.

Table 6 Panel B shows the summary statistics of the bank characteristics over the three years.

The upper three panels show the statistics for all main banks in our sample, for the main banks with *B_HQDAMAGE*=1, and for those with *B_HQDAMAGE*=0. In the lower panels, we classify banks according to whether *B_BRDAMAGE* is greater than or smaller than its median value.[24] We find that the differences in means of the bank characteristic variables are all significantly different from zero between banks with above and below the median of *B_BRDAMAGE*. Note that this does not necessarily mean that the damaged banks exhibit deteriorated financial conditions. Although *B_CAP* tends to be higher for the banks with smaller *B_BRDAMAGE*, *B_ROA* in year 1997 is higher for the banks with greater *B_BRDAMAGE* (0.014) than that with smaller *B_BRDAMAGE* (0.006). Since these characteristics could be potentially correlated with the banks' capability to provide loans, we need to properly control for such characteristics in our empirical analysis. Table 7 summarizes the correlation coefficients among the firm and bank characteristics.

6. Regression Results

6.1 Baseline Results

Table 8 shows the baseline estimation results. For each year, we report the results for the two specifications in each column: one using (1) *B_HQDAMAGE* and the other using (2) *B_BRDAMAGE* as the bank damage variable (*B_DAMAGE*). We find that *F_SALESGROWTH*, the proxy of Q, takes a positive coefficient in all the years for both of the *B_DAMAGE* variables, but it is not statistically significant in any case. *F_DAMAGE* takes positive coefficients for years 1996 and 1997, which are significant for either of the B_DAMAGE variables (except for *B_BRDAMAGE* in year 1996), suggesting that earthquake-hit firms tended to recover their damaged capital from one year after the earthquake. The results for specification (1), for example, show that among the firms that do not transact with a damaged main bank, the investment ratios of damaged firms are larger by 3.6 percentage points and 2.6 percentage points in years 1996 and 1997, respectively, than those of undamaged firms.

Turning to the variables of our primary interests, we find that *B_DAMAGE* takes negative and significant coefficients in 1995 (for specification (1)) or in 1996 (for specification (2)), implying that a firm that is not hit by the earthquake is adversely affected if its main bank is hit by the earthquake. Since bank damage is an exogenous financial shock for firms located outside the earthquake-hit area, this result strongly suggests that exogenous shocks to bank lending capacity affect client firm investment. The impact of the bank damage on undamaged firms is economically significant as well. The investment ratio of undamaged firms that transact with a damaged main bank is smaller by 8.5 percentage points in 1995 than that of undamaged firms that transact with an undamaged main bank.

An interesting finding is that the timing of the impacts of bank damage is different between

[24] The median is computed using the samples with positive *B_BRDAMAGE* only. For the banks with zero value of *B_BRDAMAGE* is classified as those below the median.

B_HQDAMAGE (specification (1)) and *B_BRDAMAGE* (specification (2)). The negative and significant impact of *B_HQDAMAGE* on the client firm investment is observed immediately after the earthquake in 1995, while the significant impact of *B_BRDAMAGE* is observed one year later in 1996. The difference might stem from what these variables respectively represent. That is, *B_HQDAMAGE* represents the impaired back-office operation at the headquarter such as making decisions to accept or reject applications of large-amount loans, while *B_BRDAMAGE* reflects the damages to physical capital (branches) and loan portfolio losses caused by deteriorated borrowers' financial conditions due to the earthquake. Our finding of the lagged impact of *B_BRDAMAGE* might imply that the adverse effect of impaired capital/portfolio on client firms' investment takes place after the direct and immediate impact of impaired headquarter operation.

The interaction term of *F_DAMAGE* and *B_DAMAGE* is not significant in any year in either specification. This suggests that bank damage affect client firms' investment irrespectively of whether the firm is damaged by the earthquake or not.

All the *F_CONSTRAINT* variables have coefficients with expected signs, though the level of statistical significance varies across variables and years. *F_ROA* and *F_CASH* have significantly positive coefficients in all years in both specifications, while *F_ LNASSET* has significantly positive coefficients only in 1996, and *F_LEV* has no significant coefficients.

Finally, banks' lending capacity variables (*B_CAPACITY*) have coefficients with inconsistent signs over time and none of them is significant. These results are consistent with many researchers' assertion that balance sheet variables do not reflect true bank financial conditions.

6.2 Damage of Small Banks

In the baseline estimation, we did not take into account any differences among damaged banks. However, compared to larger regional banks, Shinkin banks *(shinyo kinko* in Japanese) and credit cooperatives, which are small credit unions (*shinyo kumiai* in Japanese), are smaller in size and their operating areas are concentrated. [25] It might be difficult for these banks to diversify loan portfolios, which makes them susceptible to the earthquake. To the extent that this is the case, firms transacting with damaged Shinkin banks or credit cooperatives as their main banks might be affected more severely.

To take this possibility into consideration, we now let *B_HQDAMAGE* or *B_BRDAMAGE* interact with a small bank dummy *SMALL* that takes the value of one if the firm's main bank is either a Shinkin bank or a credit cooperative. The interaction term is expected to have a negative sign. Note that in this specification, we implicitly assume that the effect of damaged regional banks on firm investment is the same as that of undamaged banks.

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[25] Uchida and Udell (2010) describe the differences in various types of banks in Japan including regional banks and Shinkin banks.

Table 9 shows the results. Regarding specification (1), the coefficients on *B_HQDAMAGE*SMALL* are statistically significant and negative both in 1995 (as in the baseline case) and in 1996 (unlike the baseline one). The absolute value of the coefficient in 1995 is larger than that in the baseline result. That is, the investment ratio of undamaged firms transacting with damaged Shinkin banks or credit cooperatives is smaller by 11.1% in 1995 relative to undamaged firms transacting with undamaged (or damaged regional) main banks. These results are consistent with our prediction that firms whose primary bank was a damaged Shinkin bank or credit cooperative suffered more severely than those whose primary bank was a damaged larger bank (i.e., regional bank). In the second specification using *B_BRDAMAGE*, the coefficients on its intersection with *SMALL* is significant and negative in 1996 (as in the baseline result). Note that all the other explanatory variables have similar coefficients to those in the baseline results.

6.3 Effects of Bank Failure

We have thus far interpreted the negative impact of bank damage on the investment ratio as representing the severe borrowing constraint that damaged banks brought about. However, an alternative interpretation is also possible. To be precise, among the earthquake-hit banks, there is a relatively large regional bank, Hyogo Bank, that failed in August 1995. A reported major reason for the failure is the accumulation of loans to real estate industries that the bank had expanded in the 1980s and turned non-performing when the land price bubble burst in the early 1990s, although damage from the earthquake might also have contributed to the failure. To the extent that our *B_DAMAGE* variable captures this *bad bank* effect of the failure of Hyogo Bank, it might not represent a purely exogenous shock from bank damage stemming from the earthquake to the borrowing firms.

To rule out this bad bank effect, we check the robustness of the results we have obtained so far by excluding those firms that transacted with Hyogo Bank as their main banks from our sample. Table 10 shows the results. All the variables take very similar coefficients to those in the baseline results. Especially, B_HQDAMAGE and B_BRDAMAGE take significantly negative coefficients in 1995 and 1996, respectively. Thus, we confirm that our baseline results are not driven by the failure of Hyogo Bank.

7. Conclusion

This paper investigates the effect of financial frictions on firm investment. To overcome the difficulty in identifying the friction that is purely exogenous to firms, we utilize the natural experiment aspect of the Great Hanshin-Awaji Earthquake. Using unique firm-level data set in which bank and firm damages together with information of bank-firm relationship and of financial statements are available, we examine the adverse impact of bank damages on the investment of their client firms that are not directly hit by the earthquake.

We have found that the investment ratio of firms that is located *outside* the earthquake-hit area but has a main bank *inside* the area is smaller as compared to those without such a main bank. This result implies that the deteriorated lending capacity of damaged banks exacerbates financial frictions, and forces the firms to reduce their investment. We have also found that the finding of the negative impact is robust to two alternative measures of bank damage, i.e., the damage to the headquarter and the damage to the branch network. However, while the impact of the former measure emerges immediately after the earthquake, that of the latter emerges with a one-year lag. This difference in the timing of the impacts implies that there are two different channels of bank damage on client firms: one through the banks' impaired managerial capacity to originate loans, and the other through their deteriorated risk-taking capacity.

Tables

Table 1: Damage estimates of the Great Hanshin-Awaji Earthquake

		No. Death	No. Complete Destruction	No. Half Destruction	Death rate	Complete-Destruction rate	Half-Destruction rate	Complete or Half Destruction rate
Earthquake-Hit Regions		**6,405**	**104,455**	**140,681**	**0.17%**	**16.50%**	**22.23%**	**38.73%**
Kobe city	Higashinada-ku	1,470	12,832	5,085	0.77%	50.50%	20.01%	70.51%
	Nada-ku	931	11,795	5,325	0.72%	54.13%	24.44%	78.57%
	Hyogo-ku	553	8,148	7,317	0.45%	35.55%	31.92%	67.47%
	Nagata-ku	917	14,662	7,770	0.67%	60.21%	31.91%	92.12%
	Suma-ku	401	7,466	5,344	0.21%	27.68%	19.81%	47.50%
	Tarumi-ku	25	1,087	8,575	0.01%	2.78%	21.95%	24.73%
	Kita-ku	13	251	3,029	0.01%	0.63%	7.67%	8.31%
	Chuo-ku	243	5,156	5,533	0.21%	33.39%	35.84%	69.23%
	Nishi-ku	9	403	3,147	0.01%	1.19%	9.28%	10.46%
Amagasaki city		49	5,688	36,002	0.01%	7.60%	48.07%	55.67%
Nishinomiya city		1,126	20,667	14,597	0.26%	31.30%	22.11%	53.41%
Ashiya city		443	3,915	3,571	0.51%	31.67%	28.89%	60.57%
Itami city		22	1,395	7,499	0.01%	4.39%	23.57%	27.96%
Takarazuka city		117	3,559	9,313	0.06%	9.12%	23.86%	32.98%
Kawanishi city		4	554	2,728	0.00%	1.56%	7.70%	9.26%
Akashi city		11	2,941	6,673	0.00%	5.51%	12.51%	18.02%
Sumoto city		4	203	932	0.01%	1.71%	7.83%	9.54%
Awaji city		58	3,076	3,976	0.11%	NA	NA	NA
Toyonaka city		9	657	4,265	0.00%	1.12%	7.27%	8.39%
Non Earthquake-Hit Regions		**22**	**445**	**3,427**	**0.00%**	**0.04%**	**0.30%**	**0.33%**

Note: Non Earthquake-Hit Regions are the cities and towns not struck by the earthquake. All the rates in the non earthquake-hit regions are the average of all the cities and towns not struck by the earthquake. The number of death tolls and the numbers of destroyed housing units are compiled by the Fire and Disaster Management Agency of the Government of Japan as of May 19, 2006. To calculate each rate, we use the 1990 census for population data and the 1993 housing survey for housing units.

Table 2: Industry composition in the earthquake-hit region

	Firm information			
	Earthquake-hit regions		National	
	No. firms	Share	No. firms	Share
AGRICULTURAL, FORESTRY, and FISHERIES	68	0.1	4,639	0.5
MINING	29	0.0	2,576	0.3
CONSTRUCTION	11,421	12.6	179,102	17.6
MANUFACTURING	18,291	20.1	186,654	18.3
WHOLESALE	28,987	31.9	217,107	21.3
RETAIL and RESTAURANT	11,538	12.7	195,127	19.2
FINANCE and INSURANCE	687	0.8	6,777	0.7
REALTY	5,206	5.7	45,666	4.5
TRANSPORTATION and COMMUNICATIONS	3,249	3.6	35,730	3.5
UTILITY	8	0.0	283	0.0
SERVICE	11,346	12.5	145,097	14.2
OTHERS	1	0.0	17	0.0
N.A.				
Total	90,831	100.0	1,018,775	100.0

Note: These numbers are computed from the database provided by Teikoku Databank.

Table 3: Firms' financial condition in the earthquake-hit region

	Capital Ratio		Operating Profit / Sales	
	Earthquake-hit regions	National	Earthquake-hit regions	National
No. Firms	12380	115098	12320	113584
Mean	0.159	0.144	-0.016	0.120
Std.	0.481	2.138	6.589	17.761
Median	0.153	0.148	0.015	0.016

Note: Capital ratio = Equity / Total Asset. We exclude the outlier by discarding the top and bottom 1% samples. These numbers are computed from the database provided by Teikoku Databank.

Table 4: Summary of regional lenders

Prefecture	Name and type of Financial Institution		Loan outstanding (100 million yen)	No. Branches
Osaka	Suito shinkin	（Shinkin bank）	1720	19
	Houwa shinso	（Credit union）	377	8
Hyogo	Hyogo bank	（Regional bank 2）	27443	-
	Hanshin bank	（Regional bank 2）	8772	-
	6 shinkin total		19752	192
	8 shinso total		4381	66

Note: This table summarizes the banks whose headquarters are in the earthquake-hit regions (“regional lenders”), which are lenders for the firms located in the earthquake-hit region. Regional bank 2 means the member banks of the Second Association of Regional Banks. We define the regions struck by the Great Hanshin-Awaji earthquake as 8 cities and 5 towns in Hyogo prefecture including Kobe city as well as Toyonaka city in Osaka prefecture. Shinkin means Shinkin bank. Sinso means credit union.

Table 5: Relationships with the regional lenders

Share of firms having relations with damaged banks		
	No. Firms	%
Yes	9559	81.7
No	2140	18.3
Total	11694	100

Note: This table shows the share of earthquake-hit firms that have lending relationships with the regional lenders in our data set. The sample period is 1994.

Table 6 Panel A: Summary statistics for sample firms

1995FY

	All Sample			F_DAMAGE=1			F_DAMAGE=0			t-test for (F_DAMAGE=1) = (FDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
F_INVESTMENTRATIO	1,515	0.140	0.239	268	0.159	0.271	1,247	0.135	0.232	-1.4698	0.1418
F_SALESGROWTH	1,514	0.005	0.108	263	-0.013	0.128	1,251	0.009	0.103		
F_LNASSET	1,521	8.585	1.201	270	8.417	1.249	1,251	8.621	1.188		
F_LEV	1,507	6.346	11.437	265	5.041	9.739	1,242	6.624	11.752		
F_ROA	1,520	0.028	0.046	266	0.023	0.057	1,254	0.030	0.044		
F_CASH	1,524	0.633	0.165	269	0.618	0.169	1,255	0.636	0.164		
F_DAMAGE	1,530	0.176	0.381	270	1.000	0.000	1,260	0.000	0.000		
B_LNASSET	1,530	24.121	1.126	270	24.184	1.096	1,260	24.108	1.133	-0.9845	0.3250
B_CAP	1,530	0.036	0.005	270	0.036	0.005	1,260	0.036	0.005	0.1109	0.9117
B_ROA	1,530	0.003	0.004	270	0.003	0.003	1,260	0.004	0.004	1.7436	0.0814
B_HQDAMAGE	1,530	0.010	0.102	270	0.030	0.170	1,260	0.006	0.079	-3.4100	0.0007
B_BRDAMAGE	1,530	0.078	0.093	270	0.112	0.137	1,260	0.071	0.079	-6.6456	0.0000

1996FY

	All Sample			F_DAMAGE=1			F_DAMAGE=0			t-test for (F_DAMAGE=1) = (FDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
F_INVESTMENTRATIO	1,536	0.142	0.226	269	0.165	0.246	1,250	0.137	0.219	-1.8619	0.0628
F_SALESGROWTH	1,521	0.021	0.111	267	0.023	0.139	1,254	0.020	0.104		
F_LNASSET	1,538	8.612	1.195	270	8.444	1.240	1,251	8.650	1.182		
F_LEV	1,538	6.365	11.284	266	5.199	10.404	1,255	6.553	11.260		
F_ROA	1,536	0.030	0.043	264	0.027	0.049	1,255	0.031	0.042		
F_CASH	1,542	0.637	0.166	269	0.619	0.174	1,256	0.641	0.164		
F_DAMAGE	1,529	0.177	0.381	270	1.000	0.000	1,259	0.000	0.000		
B_LNASSET	1,546	24.137	1.137	270	24.189	1.104	1,259	24.123	1.155	-0.8527	0.3940
B_CAP	1,546	0.032	0.006	270	0.031	0.006	1,259	0.032	0.006	1.7595	0.0787
B_ROA	1,546	0.007	0.008	270	0.009	0.010	1,259	0.007	0.007	-3.5598	0.0004
B_HQDAMAGE	1,546	0.004	0.088	270	0.026	0.159	1,259	0.004	0.063	-3.7261	0.0002
B_BRDAMAGE	1,546	0.077	0.088	270	0.109	0.133	1,259	0.070	0.074	-6.6258	0.0000

1997FY

	All Sample			F_DAMAGE=1			F_DAMAGE=0			t-test for (F_DAMAGE=1) = (FDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
F_INVESTMENTRATIO	1,541	0.136	0.201	269	0.150	0.206	1,250	0.134	0.201	-1.1648	0.2443
F_SALESGROWTH	1,531	0.034	0.098	267	0.023	0.125	1,247	0.037	0.091		
F_LNASSET	1,536	8.639	1.195	269	8.466	1.237	1,245	8.678	1.185		
F_LEV	1,532	6.112	10.744	266	4.757	8.870	1,245	6.338	10.906		
F_ROA	1,537	0.034	0.039	265	0.031	0.042	1,250	0.036	0.038		
F_CASH	1,536	0.635	0.166	268	0.610	0.175	1,246	0.641	0.164		
F_DAMAGE	1,523	0.177	0.381	269	1.000	0.000	1,254	0.000	0.000		
B_LNASSET	1,545	24.195	1.137	269	24.232	1.132	1,254	24.183	1.143	-0.6848	0.4935
B_CAP	1,545	0.032	0.006	269	0.031	0.005	1,254	0.032	0.006	1.0512	0.2933
B_ROA	1,545	0.003	0.003	269	0.003	0.003	1,254	0.003	0.003	-1.0966	0.2730
B_HQDAMAGE	1,545	0.009	0.095	269	0.026	0.159	1,254	0.006	0.075	-3.1967	0.0014
B_BRDAMAGE	1,545	0.078	0.090	269	0.109	0.134	1,254	0.071	0.077	-6.2947	0.0000

Note: All the statistics are computed by using the samples without outliers (i.e., cut off 0.5% in both tails). F_INVESTMENTRATIO is the ratio of firm's capital investment to one-period lagged fixed asset, F_SALESGROWTH is the growth rate of firm's sales, F_LNASSET is the natural logarithm of firm's total asset, F_LEV is the ratio of firm's liability to equity, F_ROA is the ratio of firm's current profit to total asset, F_CASH is the ratio of firm's liquidity asset to total asset, F_DAMAGE is the dummy variable taking the value of one if the firm is located at one of the cities defined as earthquake-hit cities by Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, B_LNASSET is the natural logarithm of total asset owned by firm's main bank, B_CAP is the equity to asset ratio of firm's main bank, B_ROA is the ratio of operating profit to total asset of firm's main bank, B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of firm's main bank is located in the earthquake-hit area, and B_BRDAMAGE is the ratio of the branches number of firm's main bank located in the earthquake-hit area to the total number of branches.

Table 6 Panel B: Summary statistics for sample banks

1995FY	All Sample			B_HQDAMAGE=1			B_HQDAMAGE=0			t-test for (B_HQDAMAGE=1) = (B_HQDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	57	21.839	1.637	3	20.799	0.657	54	21.897	1.658	1.1341	0.2617
B_CAP	57	0.042	0.015	3	0.043	0.013	54	0.042	0.015	-0.1357	0.8926
B_ROA	57	0.010	0.015	3	0.005	0.003	54	0.010	0.002	0.5667	0.5732

1996FY	All Sample			B_HQDAMAGE=1			B_HQDAMAGE=0			t-test for (B_HQDAMAGE=1) = (B_HQDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	57	21.860	1.649	3	20.817	0.663	54	21.918	1.671	1.1287	0.2639
B_CAP	57	0.041	0.015	3	0.041	0.019	54	0.042	0.015	0.0774	0.9386
B_ROA	57	0.004	0.003	3	0.008	0.001	54	0.004	0.000	-2.4497	0.0175

1997FY	All Sample			B_HQDAMAGE=1			B_HQDAMAGE=0			t-test for (B_HQDAMAGE=1) = (B_HQDAMAGE=0)	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	57	21.860	1.643	3	20.811	0.677	54	21.918	1.664	1.1389	0.2597
B_CAP	57	0.038	0.017	3	0.043	0.020	54	0.038	0.017	-0.4519	0.6531
B_ROA	57	0.009	0.014	3	0.004	0.003	54	0.009	0.014	0.6108	0.5438

Note: All the statistics are computed by using the samples without outliers (i.e., cut off 0.5% in both tails). B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of the bank is located in the earthquake-hit area. B_LNASSET is the natural logarithm of total asset owned by the bank, B_CAP is the equity to asset ratio of the bank, and B_ROA is the ratio of operating profit to total asset of the bank.

1995FY	B_BRDAMAGE>Med(+)			B_BRDAMAGE<Med(+)			t-test for (B_BRDAMAGE>Med(+)) = (B_BRDAMAGE<Med(+))	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	22	22.704	1.388	35	21.295	1.442	-3.4609	0.001
B_CAP	22	0.035	0.007	35	0.046	0.016	2.8249	0.0066
B_ROA	22	0.013	0.004	35	0.008	0.002	-1.2947	0.2008

1996FY	B_BRDAMAGE>Med(+)			B_BRDAMAGE<Med(+)			t-test for (B_BRDAMAGE>Med(+)) = (B_BRDAMAGE<Med(+))	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	22	22.730	1.437	35	21.313	1.551	-3.4511	0.0011
B_CAP	22	0.035	0.007	35	0.045	0.017	2.7122	0.0089
B_ROA	22	0.003	0.001	35	0.004	0.001	0.8137	0.4193

1997FY	B_BRDAMAGE>Me(+)			B_BRDAMAGE<Med(+)			t-test for (B_BRDAMAGE>Med(+)) = (B_BRDAMAGE<Med(+))	
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	t-value	p-value
B_LNASSET	22	22.716	1.442	35	21.322	1.547	-3.3986	0.0013
B_CAP	22	0.031	0.010	35	0.043	0.017	2.69	0.0094
B_ROA	22	0.014	0.021	35	0.006	0.005	-2.0212	0.0481

Note: All the statistics are computed by using the samples without outliers (i.e., cut off 0.5% in both tails). B_BRDAMAGE is the ratio of the branches number of the bank located in the earthquake-hit area to the total number of branches. Med(+) is the median of B_BRDAMAGE conditional of B_BRDAMAGE is positive. B_LNASSET is the natural logarithm of the bank, B_CAP is the equity to asset ratio of the bank, and B_ROA is the ratio of operating profit to total asset of the bank.

Table 7: Correlation matrix

(Obs.= 1462)

1995FY		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F_INVESTMENTRATIO	(1)	1.000											
F_SALESGROWTH	(2)	0.056	1.000										
F_LNASSET	(3)	0.031	-0.009	1.000									
F_LEV	(4)	-0.052	0.033	0.029	1.000								
F_ROA	(5)	0.230	0.130	0.000	-0.125	1.000							
F_CASH	(6)	0.065	0.024	-0.029	0.059	0.046	1.000						
F_DAMAGE	(7)	0.031	-0.070	-0.060	-0.052	-0.046	-0.033	1.000					
B_LNASSET	(8)	0.002	-0.019	0.182	-0.041	-0.038	0.051	0.027	1.000				
B_CAP	(9)	-0.015	-0.051	-0.055	0.069	0.011	-0.072	-0.004	-0.355	1.000			
B_ROA	(10)	-0.023	0.012	-0.055	-0.033	-0.026	0.018	-0.043	-0.216	-0.216	1.000		
B_HQDAMAGE	(11)	0.036	0.004	-0.052	0.000	0.025	-0.024	0.097	-0.250	0.054	0.028	1.000	
B_BRDAMAGE	(12)	0.029	0.016	-0.080	-0.028	0.051	-0.046	0.162	-0.238	0.022	-0.018	0.669	1.000

(Obs.= 1482)

1996FY		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F_INVESTMENTRATIO	(1)	1.000											
F_SALESGROWTH	(2)	0.052	1.000										
F_LNASSET	(3)	0.085	-0.003	1.000									
F_LEV	(4)	-0.025	0.016	0.038	1.000								
F_ROA	(5)	0.133	0.214	-0.008	-0.158	1.000							
F_CASH	(6)	0.112	0.053	-0.021	0.060	0.062	1.000						
F_DAMAGE	(7)	0.055	0.000	-0.064	-0.033	-0.029	-0.054	1.000					
B_LNASSET	(8)	-0.010	-0.028	0.180	-0.037	-0.004	0.054	0.019	1.000				
B_CAP	(9)	0.008	-0.008	-0.110	0.053	-0.043	-0.041	-0.044	-0.515	1.000			
B_ROA	(10)	0.045	0.009	0.048	-0.007	0.022	-0.061	0.093	0.020	-0.240	1.000		
B_HQDAMAGE	(11)	0.017	0.004	-0.052	0.005	0.009	-0.003	0.094	-0.217	0.053	-0.039	1.000	
B_BRDAMAGE	(12)	-0.023	0.036	-0.078	-0.047	0.034	-0.038	0.157	-0.202	-0.044	0.040	0.604	1.000

(Obs.=1479)

1997FY		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F_INVESTMENTRATIO	(1)	1.000											
F_SALESGROWTH	(2)	0.073	1.000										
F_LNASSET	(3)	0.009	0.083	1.000									
F_LEV	(4)	0.010	-0.001	0.026	1.000								
F_ROA	(5)	0.173	0.201	0.012	-0.183	1.000							
F_CASH	(6)	0.065	0.104	-0.026	0.073	0.046	1.000						
F_DAMAGE	(7)	0.031	-0.057	-0.070	-0.054	-0.040	-0.077	1.000					
B_LNASSET	(8)	0.006	0.000	0.181	-0.033	-0.012	0.065	0.011	1.000				
B_CAP	(9)	-0.024	-0.002	-0.078	0.055	0.009	-0.071	-0.024	-0.364	1.000			
B_ROA	(10)	-0.005	-0.028	-0.080	0.047	-0.014	0.007	0.030	-0.226	-0.095	1.000		
B_HQDAMAGE	(11)	0.024	-0.026	-0.075	0.074	-0.031	-0.003	0.084	-0.261	-0.146	0.154	1.000	
B_BRDAMAGE	(12)	0.004	-0.023	-0.099	-0.045	0.005	-0.030	0.158	-0.280	-0.136	0.140	0.627	1.000

Note: All the statistics are computed by using the samples without outliers (i.e., cut off 0.5% in both tails). F_INVESTMENTRATIO is the ratio of firm's capital investment to one-period lagged fixed asset, F_SALESGROWTH is the growth rate of firm's sales, F_LNASSET is the natural logarithm of firm's total asset, F_LEV is the ratio of firm's liability to equity, F_ROA is the ratio of firm's current profit to total asset, F_CASH is the ratio of firm's liquidity asset to total asset, F_DAMAGE is the dummy variable taking the value of one if the firm is located at one of the cities defined as earthquake-hit cities by Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, B_LNASSET is the natural logarithm of total asset owned by firm's main bank, B_CAP is the equity to asset ratio of firm's main bank, B_ROA is the ratio of operating profit to total asset of firm's main bank, B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of firm's main bank is located in the earthquake-hit area, and B_BRDAMAGE is the ratio of the branches number of firm's main bank located in the earthquake-hit area to the total number of branches.

Table 8: Year-by-year cross-section regression for Investment ratio

Dependent variable: F_INVESTMENTRATIO (t)	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE
	1995FY		1996FY		1997FY	
F_DAMAGE	0.0187	-0.0051	0.0362 **	0.0307	0.0261 *	0.0377 **
	(0.0155)	(0.0247)	(0.0159)	(0.0215)	(0.0143)	(0.0174)
B_DAMAGE (t-1) †	-0.0852 ***	-0.0895	0.0020	-0.1400 **	0.1299	0.0223
	(0.0251)	(0.0592)	(0.0453)	(0.0588)	(0.0930)	(0.0717)
F_DAMAGE ×B_DAMAGE (t-1) †	0.2843	0.3096	0.0393	0.1063	-0.1752	-0.1316
	(0.2164)	(0.2462)	(0.1168)	(0.1357)	(0.1076)	(0.0988)
F_SALESGROWTH (t-1)	0.0669	0.0689	0.0378	0.0390	0.0761	0.0800
	(0.0588)	(0.0587)	(0.0562)	(0.0565)	(0.0499)	(0.0497)
F_LNASSET (t-1)	0.0081	0.0079	0.0194 ***	0.0191 ***	0.0020	0.0018
	(0.0054)	(0.0054)	(0.0053)	(0.0053)	(0.0045)	(0.0045)
F_LEV (t-1)	-0.0004	-0.0005	-0.0002	-0.0002	0.0008	0.0009
	(0.0003)	(0.0003)	(0.0006)	(0.0006)	(0.0012)	(0.0012)
F_ROA (t-1)	1.1232 ***	1.1230 ***	0.6020 ***	0.6037 ***	0.8717 ***	0.8747 ***
	(0.1657)	(0.1662)	(0.1470)	(0.1469)	(0.1458)	(0.1456)
F_CASH (t-1)	0.0937 **	0.0922 **	0.1705 ***	0.1694 ***	0.0865 ***	0.0867 ***
	(0.0435)	(0.0436)	(0.0345)	(0.0344)	(0.0298)	(0.0297)
B_LNASSET (t-1)	-0.0010	-0.0008	-0.0026	-0.0049	0.0013	-0.0017
	(0.0074)	(0.0078)	(0.0067)	(0.0070)	(0.0052)	(0.0055)
B_CAP (t-1)	-0.8434	-0.5128	1.4780	1.1814	-0.1939	-0.8531
	(1.4142)	(1.4517)	(1.3719)	(1.3536)	(1.0602)	(1.0037)
B_ROA (t-1)	-1.4450	-1.2480	1.2178	1.2190	-0.4129	-0.3761
	(1.7792)	(1.8257)	(1.4916)	(1.4824)	(1.6080)	(1.6146)
constant	0.1347	0.1261	-0.0949	-0.0171	-0.0323	0.0579
	(0.2386)	(0.2475)	(0.2305)	(0.2372)	(0.1499)	(0.1562)
# Obs	1,462	1,462	1,482	1,482	1,479	1,479
F	11.34	7.01	5.78	6.05	5.74	5.80
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.0741	0.0733	0.0518	0.0533	0.0545	0.0537
Root MSE	0.2304	0.2305	0.2174	0.2173	0.1988	0.1989
Industry dummies	yes	yes	yes	yes	yes	yes

Notes: Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent level, respectively. All the coefficients are evaluated by the heteroskedasticity robust stadard error. The sample used for each estimation is the firm-level balanced sample from 1995FY to 1999FY, which consists of the fixed cohort of firms surviving over the periods. The number of observation varies over the year since the outliers are dropped from the sample in each year. F_INVESTMENTRATIO is the ratio of firm's capital investment to one-period lagged fixed asset, F_SALESGROWTH is the growth rate of firm's sales, F_LNASSET is the natural logarithm of firm's total asset, F_LEV is the ratio of firm's liability to equity, F_ROA is the ratio of firm's current profit to total asset, F_CASH is the ratio of firm's liquidity asset to total asset, F_DAMAGE is the dummy variable taking the value of one if the firm is located at one of the cities defined as earthquake-hit cities by Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, B_LNASSET is the natural logarithm of total asset owned by firm's main bank, B_CAP is the equity to asset ratio of firm's main bank, B_ROA is the ratio of operating profit to total asset of firm's main bank, B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of firm's main bank is located in the earthquake-hit area, and B_BRDAMAGE is the ratio of the branches number of firm's main bank located in the earthquake-hit area to the total number of branches.

† B_DAMAGE variable is either B_HQDAMAGE or B_BRDAMAGE as indicated in the top of the table.

Table 9: Year-by-year cross-section regression for Investment ratio with SMALL

Dependent variable: F_INVESTMENTRATIO (t)	(1) B_DAMAGE = B_HQDAMAGE *SMALL	(2) B_DAMAGE = B_BRDAMAGE *SMALL	(1) B_DAMAGE = B_HQDAMAGE *SMALL	(2) B_DAMAGE = B_BRDAMAGE *SMALL	(1) B_DAMAGE = B_HQDAMAGE *SMALL	(2) B_DAMAGE = B_BRDAMAGE *SMALL
	1995FY		1996FY		1997FY	
F_DAMAGE	0.0189	-0.0090	0.0392 **	0.0457 **	0.0260 *	0.0371 *
	(0.0154)	(0.0282)	(0.0160)	(0.0207)	(0.0143)	(0.0172)
B_DAMAGE (t-1) †	-0.1110 ***	-0.0747	-0.0767 ***	-0.1777 ***	0.0552	-0.0487
	(0.0247)	(0.0696)	(0.0266)	(0.0614)	(0.1660)	(0.0720)
F_DAMAGE	0.4362	0.3637	-0.0537	-0.0344	-0.1479	-0.1092
×B_DAMAGE (t-1) †	(0.3198)	(0.3102)	(0.0394)	(0.1031)	(0.1699)	(0.0962)
F_SALESGROWTH (t-1)	0.0686	0.0702	0.0356	0.0390	0.0770	0.0802
	(0.0595)	(0.0592)	(0.0564)	(0.0562)	(0.0499)	(0.0498)
F_LNASSET (t-1)	0.0086	0.0082	0.0193 ***	0.0190 ***	0.0017	0.0016
	(0.0053)	(0.0053)	(0.0053)	(0.0053)	(0.0045)	(0.0045)
F_LEV (t-1)	-0.0004	-0.0005	-0.0002	-0.0002	0.0009	0.0009
	(0.0003)	(0.0003)	(0.0006)	(0.0006)	(0.0012)	(0.0012)
F_ROA (t-1)	1.1228 ***	1.1208 ***	0.6043 ***	0.6082 ***	0.8721 ***	0.8764 ***
	(0.1658)	(0.1662)	(0.1471)	(0.1469)	(0.1460)	(0.1451)
F_CASH (t-1)	0.0954 **	0.0934 **	0.1710 ***	0.1690 ***	0.0861 ***	0.0859 ***
	(0.0433)	(0.0434)	(0.0345)	(0.0343)	(0.0298)	(0.0297)
B_LNASSET (t-1)	-0.0007	-0.0007	-0.0039	-0.0059	-0.0011	-0.0024
	(0.0072)	(0.0075)	(0.0066)	(0.0068)	(0.0051)	(0.0053)
B_CAP (t-1)	-0.9597	-0.4912	1.5311	1.1580	-0.7729	-0.8886
	(1.4211)	(1.4265)	(1.3595)	(1.3384)	(1.0117)	(0.9939)
B_ROA (t-1)	-1.5220	-1.2204	1.1947	1.2352	-0.3989	-0.4024
	(1.7741)	(1.8067)	(1.4871)	(1.4792)	(1.6138)	(1.6105)
constant	0.1270	0.1171	-0.0647	0.0095	0.0455	0.0846
	(0.2338)	(0.2403)	(0.2259)	(0.2314)	(0.1464)	(0.1516)
# Obs	1,462	1,462	1,482	1,482	1,479	1,479
F	12.08	6.43	6.86	6.39	7.36	6.01
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.0763	0.0738	0.0527	0.0559	0.0535	0.0544
Root MSE	0.2302	0.2305	0.2173	0.2170	0.1989	0.1989
Industry dummies	yes	yes	yes	yes	yes	yes

Notes: Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent level, respectively. All the coefficients are evaluated by the heteroskedasticity robust stadard error. The sample used for each estimation is the firm-level balanced sample from 1995FY to 1999FY, which consists of a fixed cohort of firms surviving over the periods. The number of observation varies over the year since the outliers are dropped from the sample in each year. F_INVESTMENTRATIO is the ratio of firm's capital investment to one-period fixed asset, F_SALESGROWTH is the growth rate of firm's sales, F_LNASSET is the natural logarithm of firm's total asset, F_LEV is the ratio of firm's liability to equity, F_ROA is the ratio of firm's current profit to total asset, F_CASH is the ratio of firm's liquidity asset to total asset, F_DAMAGE is the dummy variable taking the value of one if the firm is located at one of the cities defined as earthquake-hit cities by Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, B_LNASSET is the natural logarithm of total asset owned by firm's main bank, B_CAP is the equity to asset ratio of firm's main bank, B_ROA is the ratio of operating profit to total asset of firm's main bank, B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of firm's main bank is located in the earthquake-hit area, and B_BRDAMAGE is the ratio of the branches number of firm's main bank located in the earthquake-hit area to the total number of branches.

† B_DAMAGE variable is either (1) B_HQDAMAGE times SMALL, which is the dummy variable taking the value of one if firm's main bank is either shinkin bank or credit cooperative union (i.e., small credit unions), or (2) B_BRDAMAGE times SMALL as indicated in the top of the table.

Table 10: Year-by-year cross-section regression for Investment ratio based on SURVIVAL bank sample

Dependent variable: F_INVESTMENTRATIO (t)	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE	(1) B_DAMAGE = B_HQDAMAGE	(2) B_DAMAGE = B_BRDAMAGE
	1995FY		1996FY		1997FY	
F_DAMAGE	0.0188	-0.0080	0.0362 **	0.0297	0.0260 *	0.0360 **
	(0.0155)	(0.0252)	(0.0159)	(0.0215)	(0.0143)	(0.0174)
B_DAMAGE (t-1) [†]	-0.0864 ***	-0.0720	-0.0219	-0.1531 **	0.1526	-0.0044
	(0.0317)	(0.0661)	(0.0461)	(0.0602)	(0.1269)	(0.0751)
F_DAMAGE ×B_DAMAGE (t-1) [†]	0.3440	0.3371	0.0648	0.1201	-0.1975	-0.1070
	(0.2401)	(0.2588)	(0.1165)	(0.1367)	(0.1371)	(0.1016)
F_SALESGROWTH (t-1)	0.0675	0.0688	0.0375	0.0391	0.0823	0.0800
	(0.0590)	(0.0588)	(0.0562)	(0.0565)	(0.0509)	(0.0497)
F_LNASSET (t-1)	0.0082	0.0080	0.0194 ***	0.0191 ***	0.0019	0.0018
	(0.0053)	(0.0054)	(0.0053)	(0.0053)	(0.0045)	(0.0045)
F_LEV (t-1)	-0.0004	-0.0005	-0.0002	-0.0002	0.0007	0.0009
	(0.0003)	(0.0003)	(0.0006)	(0.0006)	(0.0012)	(0.0012)
F_ROA (t-1)	1.1305 ***	1.1243 ***	0.6026 ***	0.6041 ***	0.8701 ***	0.8753 ***
	(0.1665)	(0.1667)	(0.1470)	(0.1469)	(0.1461)	(0.1456)
F_CASH (t-1)	0.0915 **	0.0915 **	0.1711 ***	0.1695 ***	0.0875 ***	0.0864 ***
	(0.0437)	(0.0437)	(0.0346)	(0.0344)	(0.0298)	(0.0297)
B_LNASSET (t-1)	-0.0008	0.0000	-0.0023	-0.0047	0.0010	-0.0021
	(0.0074)	(0.0076)	(0.0067)	(0.0069)	(0.0052)	(0.0054)
B_CAP (t-1)	-0.9136	-0.4306	1.3948	1.2499	-0.3090	-0.9310
	(1.4207)	(1.4399)	(1.4118)	(1.3429)	(1.0881)	(0.9992)
B_ROA (t-1)	-1.4633	-1.1633	1.2063	1.2410	-0.4319	-0.3747
	(1.7805)	(1.8197)	(1.4982)	(1.4829)	(1.6103)	(1.6153)
constant	0.1343	0.1018	-0.0996	-0.0241	-0.0239	0.0736
	(0.2388)	(0.2439)	(0.2324)	(0.2344)	(0.1520)	(0.1533)
# Obs	1,457	1,462	1,479	1,482	1,474	1,479
F	10.60	6.65	5.80	6.07	5.76	5.79
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.0757	0.0739	0.0517	0.536	0.0544	0.0536
Root MSE	0.2306	0.2305	0.2175	0.2172	0.1988	0.1989
Industry dummies	yes	yes	yes	yes	yes	yes

Notes: The samples are limited to the ones that firm's top lender is not failed ("SURVIVAL bank sample"). Standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent level, respectively. All the coefficients are evaluated by the heteroskedasticity robust stadard error. The sample used for each estimation is the firm-level balanced sample from 1995FY to 1999FY, which consists of the fixed cohort of firms surviving over the periods. The number of observation varies over the year since the outliers are dropped from the sample in each year. F_INVESTMENTRATIO is the ratio of firm's capital investment to one-period fixed asset, F_SALESGROWTH is the growth rate of firm's sales, F_LNASSET is the natural logarithm of firm's total asset, F_LEV is the ratio of firm's liability to equity, F_ROA is the ratio of firm's current profit to total asset, F_CASH is the ratio of firm's liquidity asset to total asset, F_DAMAGE is the dummy variable taking the value of one if the firm is located at one of the cities defined as earthquake-hit cities by Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, B_LNASSET is the natural logarithm of total asset owned by firm's main bank, B_CAP is the equity to asset ratio of firm's main bank, B_ROA is the ratio of operating profit to total asset of firm's main bank, B_HQDAMAGE is the dummy variable taking the value of one if the headquarter of firm's main bank is located in the earthquake-hit area, and B_BRDAMAGE is the ratio of the branches number of firm's main bank located in the earthquake-hit area to the total number of branches.

[†] B_DAMAGE variable is either B_HQDAMAGE or B_BRDAMAGE as indicated in the top of the table.

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