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Hirofumi Uchida
Daisuke Miyakawa
Kaoru Hosono
Arito Ono
Taisuke Uchino
Iichiro Uesugi

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HIT-REFINED PROJECT
Institute of Economic Research, Hitotsubashi University
Naka 2-1, Kunitachi-city, Tokyo 186-8603, JAPAN
Tel: +81-42-580-9145
E-mail: hit-tdb-sec@ier.hit-u.ac.jp
http://www.ier.hit-u.ac.jp/ifn/

Natural Disaster and Natural Selection†

Hirofumi Uchida (Kobe University)‡

Daisuke Miyakawa (Nihon University)

Kaoru Hosono (Gakushuin University)

Arito Ono (Mizuho Research Institute)

Taisuke Uchino (Daito Bunka University / RIETI)

Iichiro Uesugi (Hitotsubashi University / RIETI)

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‡ Graduate School of Business Administration, Kobe University, 2-1 Rokkodai, Nada, Kobe 657-8510, Japan. Tel.&Fax.: 81-78-803-6949, E-mail: uchida@ b.kobe-u.ac.jp.

Natural Disaster and Natural Selection

Abstract

In this paper, we investigate whether a natural selection works for firm exit after a massive natural disaster. By using a unique data set of more than 84,000 firms after the Great Tohoku Earthquake, we examine the impact of firm efficiency on firm bankruptcy both inside and outside the earthquake-affected areas. We find that more efficient firms are less likely to go bankrupt both inside and outside the affected areas, which indicates the existence of the natural selection. However, we also find that firms located inside the earthquake-affected areas are less likely to go bankrupt than those located outside of the areas. We also apply the same methodology to the case of the Great Hanshin-Awaji Earthquake, and find qualitatively similar results.

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

JEL classification codes: L10

1. Introduction

Natural disasters inflict serious damage to firms. They destroy firms' tangible assets such as buildings and equipment as well as human capital, and thereby deteriorate production capacity of the firms. These adverse impacts might sometimes be fatal and force the firms to close down their businesses.

An intriguing question concerning firm exit caused by natural disasters is how the selection works, or in other words, what characteristics the firms that natural disasters force to exit have. As for the impact of natural disasters on economic growth, empirical studies find mixed evidence, and some of them even report a positive impact.[1] As a possible mechanism behind the positive impact, some studies find that natural disasters might enhance productivity of the economy's corporate sector (Skidmore and Toya 2002, Crespo-Cuaresma et al. 2008). Such evidence suggests that a *natural selection* might work, where natural disasters force inefficient firms to exit. However, because the existing evidence is based on aggregate data, detailed mechanisms behind the impact of disasters are unclear, and no studies have examined the selection of firms after natural disasters based on micro-level data on firm exits.[2]

A closely related question that is inseparably intertwined with the one above is how the selection in the wake of natural disasters differs from that in other, i.e., non-disaster,

[1] For a survey see, for example, Noy and Vu (2010) and Loayza et al. (2012), and references therein.
[2] As for the impact of natural disasters on economies' corporate sector, some studies focus on the impact of natural disasters on firm recovery (Leiter et al. 2009, De Mel et al. 2011, Hosono, et al. 2012). However, few studies have explicitly examined the impact on firm exit. To the best of our knowledge, there is one study that examines the impact of the Great Hanshin-Awaji Earthquake on firm exit (Cole et al. 2013). However, this paper does not investigate the impact of the Great Tohoku Earthquake, and does not put much emphasis on how the selection of firms worked.

environments. Since the early pioneering works such as Schumpeter (1939), Alchian (1950), and Jovanovic (1982), there has been long-standing literature that explores the mechanism through which the market eliminates inefficient firms, especially during the recession period (e.g., Bertin, et al. 1996, Bresnahan and Raff 1991, Caballero and Hammour 1994, 1996, 2005). Evidence is also abundant in Japan. To clarify the factors that contributed to the Japan's so called "lost decades" from 1990s, many studies find evidence suggesting that banks suffering from a large amount of non-performing loans supported inefficient *zombie* firms to evergreen, and made the selection of firms *unnatural* (see, e.g., Kim 2004, Ahearne and Shinada 2005, Nishimura et al. 2005, Peek and Rosengren 2005, Fukao and Kwon 2006, Caballero et al. 2008).[3] However, to the best of our knowledge, no studies, including those introduced thus far, have compared the selection of firms in disaster and non-disaster environments.

To answer the questions raised above, this paper examines whether the natural or unnatural selection works for firms in the aftermath of the devastating Great Tohoku Earthquake (also known as the Great East-Japan Earthquake) that hit the Tohoku area of Japan on March 11, 2011.[4] We use data of many small- and medium-sized enterprises (SMEs) in the Tohoku area, which include information on firms' attributes, financial

[3] Note that as far as small- and medium-sized enterprises are concerned, there is also evidence that is inconsistent with the simplistic story that evergreening loans contributed to keep zombies alive (Sakai et al. 2010). There is further evidence suggesting that (large) zombie firms recovered afterwards through restructuring (Fukuda and Nakamura 2011).

[4] This earthquake together with accompanying tsunami and the accident of the nuclear plant in Fukushima brought about 27,154 casualties (18,131 dead, 2,829 missing, and 6,194 injured) (Fire and Disaster Management Agency of the Government of Japan: http://www.fdma.go.jp/bn/higaihou/pdf/jishin/146.pdf (in Japanese)) and as of this writing, many people around the vast areas adjacent to the nuclear plant are still suffering from the evacuation.

statements, their main banks, and the information on firms' exit after the earthquake. We also use information on the location of firms' headquarters inside or outside the earthquake-affected areas to identify firms that were directly damaged by the earthquake.

In our analysis, we run a probit model regression for firm exit. Our dependent variable is an indicator for bankruptcy, one of the most important forms of firm exit. Our main independent variable is firms' credit score calculated by a credit research company, which is a good proxy for firm efficiency. We run the regressions for firms that are located inside and outside the affected areas, and compare how the selection works between firms that are directly damaged and those that are not.

From the regression results, we first find that the probability for firm bankruptcy is lower for more efficient firms both inside and outside the affected areas. This finding supports the hypothesis that a natural selection works, irrespective of the presence/absence of damage caused by the earthquake. Second, by comparing the firms inside and outside the affected areas, we find that the firms inside the areas are less likely to go bankrupt than those located outside. This finding indicates that damage from the earthquake decreased, not increased, firm exit. One possible reason for this decrease is public and private aids that have been provided to damaged firms or firms in the affected areas, such as the moratorium for delinquent payments introduced immediately after the quake. Third, these findings are robust to the exclusion of sample firms in the areas affected by tsunami, where voluntary closures are more likely and the selection of firms may have worked differently.

To obtain more evidence on the firm selection after natural disasters, we also apply our methodology to another devastating earthquake in Japan: the Great Hanshin Earthquake that hit the areas around Kobe city and Awaji Island on January 17, 1995. By running similar probit model regressions, we again find that the natural selection works both inside and outside the affected areas, but that the bankruptcy probability is lower inside the affected areas. On balance, our findings suggest that the natural selection works for firms in Japan after the earthquake, but that public intervention supports damaged firms to survive.

The remaining part of this paper is composed of as follows. The next section details our empirical approach including data and the econometric model for estimation. Section 3 reports our main results and the results for a robustness check. Section 4 is for the analysis of the Great Hanshin-Awaji Earthquake, and the final section concludes the paper.

2. Empirical approach

2.1. Data and sample selection

The main source of our data is firm-level credit files compiled by Teikoku Databank ltd. (TDB), a leading private business credit bureau in Japan. Information on firms' attributes, financial statements, and their lending banks is available from the credit files.

From the TDB database, we first pick those firms whose headquarters are located in the six prefectures in the Tohoku area of Japan (Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima) at the time of the Great Tohoku Earthquake. The areas seriously damaged by the earthquake are located inside these prefectures, and therefore damaged as well as non-damaged firms are included in our sample. We exclude those firms that are located outside the Tohoku area to exclude heterogeneity in unobserved firm characteristics stemming from region-specific factors. The TDB database also contains information on whether or not the firms went bankrupt during the post-earthquake period from March 2011 to November 2012. The number of firms that were headquartered in the six prefectures, and for which we have information on firm bankruptcy, is 98,070.

We then eliminate firms for which any of the variables to be used in the regression analysis (which will be explained in details below) is not available, firms that belong to financial industries, and firms for which no industry information is available. This reduces the number of our sample firms to 84,012. These 84,012 firms are used for our analysis.

2.2. Regression and variables

2.2.1. Regression

We run a probit model regression of firm exit of the following form.

$$\Pr[Bankrupt_i = 1] = \Pr[y_i^{*}>0] = \mathbf{\Phi}[y_i^{*}],$$

where

$$y_i^{*}=\mathbf{X}_i\,\mathrm{b}+\mathrm{e}_i,$$

$\mathbf{\Phi}$ represents the cdf of the standard normal distribution, and i =1, ..., N is an indicator for each of the N sample firms. The variable *Bankrupt* is an indicator of firm bankruptcy. The variable y_i^{*} is the latent variable to determine the probability of bankruptcy

Pr[$Bankrupt_i = 1$], and the vector X_i indicates the independent variables to determine y_i*. The final term e_i is an ordinary error term.

To alleviate problems caused by any endogeneity, we use the pre-earthquake value of the independent variables, except for the proxies for earthquake damage. More precisely, the variables from the financial statements are as of the end of the fiscal year 2010, i.e., March 31, 2011.[5] As for other variables, we use those in year 2010 (January to December 2010). Depending on the frequency of TDB's research on firms, information for some firms is available for multiple times (at multiple data points within 2010). In such cases, we use the most recent data.

2.2.2. Main variables

Bankruptcy and firm damage

Our dependent variable is an indicator of firm bankruptcy, *Bankrupt*. This is a dummy variable taking the value of one if the firm is defined by TDB as going bankrupt from March 2011 to November 2012 and zero otherwise. Although going bankrupt generically means that firms are unable to repay debt and deemed as insolvent, it is difficult to exactly define bankrupt firms. We thus follow the definition by TDB.[6]

We focus on exit in the form of bankruptcy due to data availability, but bankruptcy is

[5] Although March 31 is after the earthquake (March 11), most of the economic activities reflected in the financial statements of fiscal year 2010 is before the earthquake.

[6] TDB defines bankrupt firms as 1) those filing for legal protection under the Corporation Reorganization Law, 2) those filing for legal protection under the Civil Rehabilitation Law, 3) those filing for bankruptcy protection under the Bankruptcy Law, 4) those filing for special liquidation under the Corporate Law, 5) those to which banks suspended banking transactions, which is triggered by firms' default on their promissory bills twice in a six-month period, and 6) those that voluntarily started debt renegotiation outside the court.

not the only form of firm exit. Other forms of exit that are also commonly used in Japan are voluntary business closure, suspension of operations and dissolutions, which are not (at least directly) associated with default or insolvency.[7] Neglecting these forms of exit and focusing only on bankruptcy may not only underestimate the overall incidences of firm exit, but also result in biased estimation to the extent that voluntary business closures change the relationship between firm bankruptcy and efficiency. In our case, the bias may be serious if we include in the sample those firms that are located in the areas along the coast, because such firms were devastated by massive tsunami and were unable to report their status and/or to file for bankruptcies. In order to circumvent the possible bias caused by the inclusion of these tsunami areas, we implement an additional analysis by limiting our sample firms to those that escaped from damage by tsunami.

Another important variable is an indicator for firms damaged by the earthquake, F_DAMAGED. Because no information is available on direct damage that firms suffered from the earthquake,[8] To construct this variable, we identify whether firms' headquarters are located inside the earthquake-affected areas based on the most recent location information available before the earthquake. The affected areas are defined as cities and towns that were stipulated as areas heavily damaged by the earthquake in the Japanese Government's Act Concerning Special Financial Support to Deal with a Designated Disaster of Extreme Severity, which includes areas affected by the tsunamis and by the

[7] To be more precise, being acquired by other firms in mergers and acquisitions is another form of firms exit.

[8] We cannot identify firm damage using financial statement information because the balance sheet information on physical capital stock is of book values, and few firms record special losses due to the earthquake.

nuclear plant accident in Fukushima prefecture. The firm damage variable F_DAMAGED takes a value of one if the firms' headquarters are located inside these affected areas and zero otherwise.[9]

Table 1 shows the breakdown of our sample firms depending on whether *Bankrupt* = 0 or 1 and whether F_DAMAGED = 0 or 1. Row (a) of this table shows the numbers of observations in our main sample that will be used for the regression analyses. As shown in column (1), we have 400 firms that are recorded as bankrupt firms in our sample, which account for 0.476% of the sample. Columns (2) and (3) split the sample depending on firms' location. Among the 84,012 firms, 53,904 of them (64.16%) are located outside the affected area (F_DAMAGED = 0) and the rest of 30,108 firms (35.84%) are inside the area (F_DAMAGED = 1).

We observe that the rate of bankruptcy is slightly higher for firms in the non-affected area (0.516%: column (2)) than in the affected area (0.405%: column (3)). As shown in column (4), the difference in the bankruptcy rates is statistically significant. This suggests that the earthquake reduced the probability of firm bankruptcy by a significant margin. Note, however, that this finding might just be an artifact of the difference in the characteristics of firms inside and outside the affected areas. Also we are not yet sure whether the probability of bankruptcy differs depending on firm efficiency.

For reference, we also report in row (b) the same numbers of firms when we use an expanded sample for which we have information on *Bankrupt* and F_DAMAGED (and do

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[9] Due to data availability, we cannot capture firms' damage 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.

not necessarily have all the information on other regression variables). The bankruptcy probabilities in row (b) are quite similar to those in the row (a), indicating that the elimination of sample firms due to missing variables does not cause serious bias.

Efficiency

The main empirical question of this paper is whether the selection of firms is natural or unnatural, i.e., whether or not inefficient firms are more likely to go bankrupt. Many existing studies on the firm selection use firms' total factor productivity (TFP) as a measure of firm efficiency. However, even a crude measure of TFP requires financial statement data of the firms. In our data set, the number of observations with financial statement data is very small, especially for firms located inside the affected area. We thus decide not to use TFP measures.

Instead, we use firms' score, F_SCORE, that TDB calculates as a proxy for firm efficiency. The score takes an integer value on a 1–100 scale, and evaluates the soundness of the firm's management, its repayment ability, and its creditworthiness as a safe trade counterpart, from a third-party's viewpoint. The score for a firm is calculated as the sum of subscores for seven different elements: business history (its maximum score is 5), capital structure (12), firm size (19), profitability (10), funding capacity (20), CEO's ability (15), and firms' future growth potential (19). These elements are based not only on financial statement information but also on qualitative information on managerial efficiencies. This score is calculated on an unsolicited basis, i.e., the firms do not pay for being rated.[10]

In Table 2, we report the descriptive statistics for F_SCORE on its first row. The mean firm score (F_SCORE) is 45.3. The scores for damaged and non-damaged firms are around 45 and economically comparable, although the test statistic shows that the mean score for damaged firm is significantly smaller than that for non-damaged ones.

2.2.3. Control variables

We also use many control variables to isolate the impact of the main variables on firm bankruptcy. The definition and the descriptive statistics of these variables are shown in the remaining part of Table 2, where the statistics are also compared depending on whether the firms are damaged or not by the earthquake. First, we use variables that represent firm characteristics. We use three such variables: F_EMP, the number of employees (firm size); F_AGE, the age of the firm; and F_NBANK, the number of banks that the firm transacts with. We also use industry dummies.[11] Table 2 shows that the sample firms on average have 13 employees, are 30 years old, and transact with two banks.

Second, we use variables that represent characteristics of the main banks of our sample firms.[12] Three of the variables are based on financial statement information:

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[10] TDB does not regard the score as a measure of the probabilities of default (pd).

[11] Shares of firms that belong to each industry to our whole sample firms (84,012 firm) are: Agriculture, Forestry, or Hunting (0.93%), Mining (0.21%), Construction (35.6%), Manufacturing (10.78%), Wholesale (10.69%), Retail or Restaurants (18.11%), Transportation, IT, or Utilities (3.38%), Real estate (4.15%), and Services (16.17%).

[12] To follow widely used convention, we identified the main bank as the top bank on the list of firms' transacting banks in the TDB database. Information for the financial variables for the main banks 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.

B_ROA, ROA of the main bank defined as ordinary profit over total asset; B_CAP, capital asset ratio (book value) of the main bank; and B_lnASSET, the natural logarithm of the main bank's total asset (bank size). We also use dummy variables to indicate the type of the main banks: B_REGIONAL for regional banks that are medium-sized banks whose banking operations are regionally focused; B_REGIONAL2 for second-tier regional banks that also operate regionally but they tend to be smaller in size; B_SHINKIN for Shinkin banks that are cooperative banks specializing in providing commercial banking services to member SMEs and individuals; with city banks (largest banks operating nationwide) and trust banks (large banks that can also offer trust services) being the default.[13]

3. Results

3.1. Main results

Table 3 shows our main results. In this table, we not only report the result for the entire sample but also the results for subsamples. Among the four panels of Table 3, Panels (A) and (B) are for the whole sample in the case with and without F_DAMAGED as an independent variable, Panel (C) is for the sample with F_DAMAGED = 1, and Panel (D) is for the sample with F_DAMAGED = 0. For each panel, the marginal effects of the respective variables are shown in the "dF/dx" column together with the probability values in the "p-value" column. Probability values are calculated using the heteroskedasticity-robust standard errors.[14]

[13] For different types of banks in Japan, see Uchida and Udell (2010).

[14] We do not introduce an interaction term between F_DAMAGED and F_SCORE to the specification of Panel (B) due to a possible multicollinearity problem between F_DAMAGED*F_SCORE and F_SCORE, whose correlation coefficient is 0.9859. Instead, we split

Looking first at the marginal effects of control variables in Panels (A) and (B), the probability of firm bankruptcy is higher for larger firms (F_EMP), for older firms (F_AGE), for firms transacting with a larger number of banks (F_NBANK), and for firms transacting with less profitable (B_ROA) and less capitalized (B_CAP) banks. The sign of marginal effect on the bank capital variable is consistent with the findings in previous studies on capital crunch, which reveal that less capitalized banks shrink lending to meet the regulatory capital requirement (e.g., Peek and Rosengren 1995). Second, the results for subsamples in Panels (C) and (D) show that the signs of marginal effects on the variables explained above are almost the same as the results for the whole sample, except for the statistically insignificant marginal effect of F_EMP, F_AGE, and B_ROA in Panel (C). We also find in Panels (C) and (D) that other variables are also statistically significant.

The variable of our primary interest is the firms' score (F_SCORE). The baseline result in Panel (A) shows that it has a negative and statistically significant coefficient. This means that firms with higher scores are less likely to go bankrupt. This finding is consistent with the natural selection. The magnitude of the coefficient in Panel (A) means that for an average firm, one-point increase in F_SCORE reduces the probability of bankruptcy by 0.043 percentage points. This finding means a 0.250 percentage point decrease in the bankruptcy probability for a one-standard deviation increase in F_SCORE (which is 5.81: see Table 2). Because the average bankruptcy rate is 0.476% as shown in Table 1, the effect of F_SCORE on the bankruptcy probability is economically significant.

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the whole sample by F_DAMAGED, estimate parameters separately, and show the results in Panels (C) and (D) in order to see the effect of F_SCORE on the bankruptcy probability for damaged and undamaged firms.

To examine how the earthquake affects the selection of firms, we need to compare the bankruptcy probability inside and outside the affected areas. In this vein, in Panel (B) we add a dummy variable F_DAMAGED as an additional independent variable. We find that the marginal effect of F_DAMAGED is negative and significant. This finding is consistent with the univariate result shown in column (4) of Table 1. The coefficient estimate indicates that the probability of bankruptcy in the quake-affected area is lower by 0.100 percentage points as compared with the probability outside the area.

The finding of the smaller bankruptcy probability of firms in the affected area might seem counter-intuitive. However, it should be noted that enormous amount of public and private aids were provided to firms in the affected area after the devastating earthquake. Public aids that were provided include a moratorium for delinquent payments, subsidies for reconstruction of damaged facilities, corporate tax reduction, government loans, and a special credit guarantee program. These measures might have contributed to the recovery of damaged firms and to the smaller number of firm bankruptcies in the affected areas.

To compare the selection of firms inside and outside the affected areas, we need to compare the effect of F_SCORE inside and outside the areas. We thus split our sample depending on the value of F_DAMAGED and run the same regressions.[15] Panels (C) and (D) show the results for the coefficients on F_SCORE for different subsamples. We find in these panels that the marginal effect coefficient on F_SCORE is not only negative and

[15] Alternatively, we can add an interaction term of F_SCORE and F_DAMAGED in the specification of Panel (B). However, we decided not to do so because we find that the coefficient for correlation between F_SCORE and the interaction term is very high (at 0.9859), which will cause multicollinearity when both variables are used at the same time.

significant in both panels but also they are quantitatively very similar. The coefficients indicate that for an average firm, one-point increase in F_SCORE reduces the probability of firm bankruptcy by 0.039 percentage points for those that were damaged and by 0.040 percentage points for those that were undamaged.

3.2. Discussion and interpretations

To comprehend the economic significance of the results we have obtained, this subsection provides an illustrative description of the overall effects of firm efficiency on the bankruptcy probability. Using the estimates for their coefficients for our main variables together with those for the other variables shown in Table 3, we illustrate the difference in the impact of firm efficiency between damaged and undamaged firms.

The first two panels (A) and (B) of Figure 1 indicate the predicted bankruptcy probabilities for firms (solid line) with their 95% confidence intervals (dotted lines) in the cases of inside (Panel (A)) and outside (Panel (B)) the affected areas. In each of the panels, the height of each line (Y-axis) shows the predicted probabilities, which are measured for different values of F_SCORE (X-axis) around its mean for the range of four sigmas (i.e., four standard deviations). To obtain the predicted probabilities, we first calculated the predicted values of the latent variable y_i*, and then obtained the corresponding probabilities that follows the standard normal distribution.

The two solid lines depicted in these panels confirm the findings in the previous subsection. They are downward-sloping, meaning that the bankruptcy probability declines as the firm's score improves both inside and outside the affected areas. These findings are consistent with the natural selection where efficient firms are less likely to go bankrupt.

To compare the selection of firms inside and outside the affected areas, we depict in Panels (C) and (D) the levels and slopes of the solid lines in Panels (A) and (B). On the one hand, Panel (C) compares the level of the bankruptcy probabilities. The panel shows that damaged firms (black line) have lower bankruptcy probabilities than undamaged firms (gray line) for all the different values of F_SCORE in this panel. The difference of probabilities between the cases of F_DAMAGED=1 and =0 ranges between 0.02 percentage points to 0.1 percentage points.

On the other hand, Panel (D) measures along the y-axis the slope of the solid lines in Panels (A) and (B) (i.e., the marginal effects of F_SCORE) for different values of F_SCORE. The result indicates that the two slopes overlap with each other, with an intersection in the medium range of F_SCORE. The small magnitude of the differences between the two curves indicates that there is no economically significant difference in the marginal effect of F_SCORE between firms with F_DAMAGED=1 and =0. This means that the relationship between firm efficiency and the bankruptcy probability is almost the same with or without the earthquake, and in this sense there is no difference in the natural selection between firms inside and outside the affected areas. However, as shown in Panel (C), firms located inside the earthquake-affected areas are less likely to go bankrupt.

3.3. Robustness check

As explained in Section 2.2.2, due to data availability, we have focused solely on one form of firm exit, i.e., bankruptcies, and ignored other forms of firm exit such as voluntary closure, suspension of operations, or dissolutions. However, ignoring other forms of exit may bias our analysis to the extent that these other forms of firm exit change the relationship between bankruptcy and firm attributes. The bias may be in particular serious if we include the areas where firms are more likely to voluntarily close their businesses after the earthquake. This is likely to be the case in the areas along the coast of the quake-affected areas, because massive tsunami devastated the areas and had many firms unable to report their status and/or to file for bankruptcies. In order to circumvent a possible bias caused by the inclusion of such firms, we implement additional analysis by limiting our sample firms to those that did not suffer from damage by tsunami.

Among the 84,012 sample firms in the main analysis, there were 4,602 of them whose headquarters were located in areas inundated by the tsunamis caused by the Great Tohoku Earthquake. Among these firms, 17 firms went bankrupt during our sample period and so the ratio of bankruptcies is 0.37% in the tsunami area, which is smaller than the bankruptcy ratio for rest of the Tohoku area, 0.49%. Anecdotal evidence suggests that many firms that had their buildings and equipment swept away by the tsunami have suspended their operations ever since, which may be the reason for the smaller-than average rate of bankruptcies in the area.

Table 4 shows our estimation results excluding the firms that were located in the tsunami area. The format of this table is the same as that of Table 3: we report the whole-sample baseline results without F_DAMAGED (Panel (A)), whole-sample results with F_DAMAGED as an additional independent variable (Panel (B)), results for the sample with F_DAMAGED=1 (Panel (C)), and results for the sample with F_DAMAGED =0 (Panel (D)).

The results are qualitatively the same with those in Table 3. The bankruptcy ratio is lower for damaged firms than for undamaged firms, and the marginal effects for firm efficiency variable F_SCORE are negative and statistically significant, and their levels are comparable. Overall, even after excluding the area inundated by the tsunami, we find that the selection mechanism is natural, and that the bankruptcy probability is lower in the affected areas.

4. Great Hanshin-Awaji Earthquake

To obtain more evidence on the firm selection after natural disasters, we apply the same methodology to the case of the Great Hanshin-Awaji Earthquake that hit the areas around Kobe city and Awaji Island of Japan on January 17, 1995, 16 years before the Great Tohoku Earthquake.[16] Before the Great Tohoku Earthquake, the Great Hanshin-Awaji Earthquake had been considered as an “unprecedented” disaster that would happen only once in one hundred years.

There are many differences between the two earthquakes. Compared with the Great Tohoku Earthquake, the affected areas of the Great Hanshin-Awaji Earthquake are far concentrated, mostly in urban areas. The latter did not accompany tsunamis, but instead inflicted many casualties by fires it broke out. However, both earthquakes brought about

[16] The number of casualties is 50,227 (6,432 dead, 3 missing, and 43,792 injured) (the Cabinet Office of the Government of Japan: http://www.bousai.go.jp/4fukkyu_fukkou/hanshin_awaji/101.pdf).

massive damages not only to human beings but also to firms in the affected areas. Thus, by comparing the findings between the two earthquakes, we might be able to draw more information on how the selection works.

4.1. Data and Methodology

We use data from the same sources (the TDB database) and the same empirical model (probit model of firm bankruptcy) as those in previous sections. From the database, we choose firms that were headquartered in Hyogo prefecture (whose capital is Kobe city) and its adjacent Osaka prefecture at the time of the earthquake. The damage was concentrated in a specific area around Kobe and in a small part of Osaka, and we can consider firms located outside these areas as adequate control firms that have similar region-specific characteristics. We define the affected area as the towns and the cities in the two prefectures that were included in the Japanese Government's Act Concerning Special Financial Support to Deal with a Designated Disaster of Extreme Severity. As in the case of the Great Tohoku Earthquake, the indicator variable F_DAMAGED takes the value of one if the firm was located in this affected area and zero otherwise.

Because the Great Hanshin-Awaji Earthquake took place 16 years before the Great Tohoku Earthquake, the period during which we can collect bankruptcy data is much longer than the one for the recent Great Tohoku Earthquake (1 year and 8 months period: see section 2.1). Thus we take the three year window after the earthquake (January 1995 to December 1997) and define the bankruptcy dummy, but to distinguish from the variable for the Great Tohoku Earthquake, we label the variable *Bankrupt3*. We adopt the three year window because it is hard to imagine that the effect of the earthquake lasts more than three years, and for the purpose of eliminating the effect of the banking crisis in the late 1990s.[17]

Table 5 shows the breakdown of our sample firms depending on the value of the bankruptcy dummy (rows) and F_DAMAGED (columns). A set of upper rows (A) reports the numbers of bankrupt and surviving firms based on *Bankrupt3* (three year window). For information we also report in the remaining set of rows (B) the numbers of bankrupt and surviving firms based on *Bankrupt* (1 year and 8 months window). Similar to Table 1, we also report the numbers of the firms for the regression sample (row (a)) and for the largest possible sample (row (b)). For the regression, we use the sample shown in row (A)-(a).

As shown in row (b) of column (1), we have the bankruptcy and location information for 122,745 firms. Among these firms, 3,297 (or 1,759) firms (2.69% (or 1.43%)) are recorded as bankrupt firms within the 3 year (or 1 year and 8 months) window. Because the information for the other variables is unavailable for many firms, the number of observations for the regression reduces to 13,485 (row (a)), among which 375 (2.78%) (or 141 (1.05%)) are recorded as bankrupt firms. From column (4) we find that the bankruptcy rate is higher for firms located outside the affected area than those located inside, which is consistent with the finding in Table 1 for the Great Tohoku Earthquake. However, due to the smaller sample, the difference is statistically less significant when we

[17] When we use a dummy that represents bankruptcies during the 1 year and 8 months period (from January 1995 to September 1996), the regression results are qualitatively the same as those using *Bankrupt3*, and thus we will not report the results.

use the regression sample. Compared with Table 1, we find that the ratio of bankrupt firms is higher on average. The bankruptcy rate for the whole regression sample was 0.476% in Table 1, but it is 2.781% in this table (row (A)-(a) of column (1)). Even if we take the same length of the window period, the bankruptcy rate is 1.046% (row (B)-(a) of column (1)).

The list of the independent variables of the regression analysis is shown in Table 6 together with their summary statistics. Similar to Table 2, we also break down the statistics depending on the value of F_DAMAGED. As shown in the table, most of the variables are the same as those for the Great Tohoku Earthquake. However, there are two differences. Most importantly, F_SCORE is not available in this analysis, which makes it impossible to exactly compare the results between the two earthquakes. As an alternative for F_SCORE, we use ROA of the firm, F_ROA, which is defined as the ratio of net current profit to total asset as a proxy for firm efficiency. Another difference is the inclusion of a new bank type dummy, B_COOPERATIVE, which takes the value of one if the firm's main bank is a credit cooperative. There were no firms in the regression sample for the Great Tohoku Earthquake, whose main banks are credit cooperatives, but there are some in this regression sample for the Great Hanshin-Awaji Earthquake. Similar to the analysis on the Great Tohoku Earthquake, to circumvent any endogeneity we use the most recent values of the independent variables that are available during the past one year of the earthquake except for variables that indicate earthquake damage.

4.2. Results

Table 7 reports the results for the probit model regression of firm bankruptcy. The format of the table is the same as the one of Table 3. It not only presents the result for the entire sample but also shows the results for subsamples: Panels (A) and (B) are for the whole sample (without and with F_DAMAGED as an independent variable), Panel (C) is for the sample of damaged firms, and Panel (D) is for the sample of undamaged firms.[18]

Looking first at the control variables in Panel (A), the probability of firm bankruptcy is higher for smaller firms (F_EMP), for younger firms (F_AGE), for firms transacting with a larger number of banks (F_NBANK), and for firms transacting with less profitable banks (B_ROA). Second, looking at the subsample results for in Panels (C) and (D), the signs of the marginal effects on the variables explained above are almost the same as the results for the whole sample, with the only exception being the statistically insignificant marginal effect on B_ROA in Panel (C).

On the control variables, there are several differences from the results for the Great Tohoku Earthquake. For example, signs of the coefficients on F_AGE and F_EMP are opposite to those obtained for the Great Tohoku Earthquake in Table 3 and the coefficient for B_CAP is not statistically significant as opposed to the negative and significant coefficient in the case of the Tohoku Earthquake.

As for the variable of our primary interest, firms' efficiency measure (F_ROA), its marginal effect is positive and significant in all panels from (A) to (D). This means that

[18] To compare the results with the ones for the Great Tohoku Earthquake we report the results when the sample is split depending on the value of F_DAMAGED. In the case of this sample for the Great Hanshin-Awaji Earthquake, however, the collinearity problem between F_DAMAGED*F_ROA and F_ROA is not severe because the correlation coefficient is 0.0475.

efficient firms with higher ROAs are less likely to go bankrupt, which is consistent with the results for the Great Tohoku Earthquake in Table 3. This finding serves as evidence for the natural selection after the Great Hanshin-Awaji Earthquake.

We also find that the coefficient for F_DAMAGED is significant with a negative sign. This indicates that firms in the affected area, which are highly likely to be damaged firms, are less likely to go bankrupt. This finding is again consistent with our finding for the Great Tohoku Earthquake in Table 3. Public and private aids might have contributed to the survival of firms in the affected area.

4.3. Discussion and interpretations

As we did in Figure 1, to understand the economic significance of the results in Table 7, we provide in Figure 2 a graphical presentation of the relationship between firm efficiency and firm bankruptcies in the case of the Hanshin-Awaji Earthquake. The upper two panels (Panels (A) and (B)) of Figure 2 illustrate the predicted bankruptcy probabilities (solid line) for firms in the damaged and undamaged areas and their confidence intervals (dotted lines). The two solid lines in these panels confirm the findings reported in Section 4.2. They are downward-sloping, indicating that the bankruptcy probability declines as the firm's ROA improves. Similar to the results for the Tohoku Earthquake, this finding is consistent with the natural selection.

Panel (C) of Figure 2 compares the levels of the bankruptcy probability for firms with F_DAMAGED=1 (black line) and =0 (gray line). The panel shows that the bankruptcy probability is substantially lower for firms inside the affected areas than for those outside for all of the values of F_ROA depicted in this panel (i.e., four sigmas around the mean). The magnitude of the difference in the bankruptcy probability ranges from 0.70 to 1.10 percentage points. Panel (D) shows along the y-axis the slopes of the solid lines that are illustrated in Panels (A) and (B) (i.e., the marginal effects of F_ROA). The panel indicates that the slope (or the marginal effect) is increasing in F_ROA both inside and outside the affected areas, but its absolute value is always smaller for firms outside (gray line) than for those inside (black line). On balance, our findings in the case of the Great Hanshin-Awaji Earthquake is mostly consistent with those in the case of the Great Tohoku Earthquake because we find the natural selection both inside and outside the affected areas and the lower bankruptcy probability inside the area. The only exception is the smaller slope (or the marginal effect) of F_ROA on the bankruptcy probability, which means that in the case of the Great Hanshin-Awaji Earthquake, the natural selection is more intensive outside the affected area.

5. Conclusion

In this paper, we investigated the selection of firms using a large sample of firms located inside and outside the affected areas of the Great Tohoku Earthquake. We found smaller bankruptcy probabilities for firms with higher credit scores, which suggests the presence of the natural selection. However, we also found that the bankruptcy probability is lower for firms located inside the earthquake-affected area. We also applied the same empirical methodology to the case of the Great Hanshin-Awaji Earthquake to find qualitatively similar results.

For the purpose of clarifying the detailed mechanisms behind the impact of natural disasters on economic growth, our finding has an important implication. Our findings imply that although the two great earthquakes did not change firms' natural selection, they did decrease the overall bankruptcy probability. The former finding implies that the earthquakes had a neutral effect on the growth of the economy. However, the latter finding implies that the disasters had a negative impact on the overall growth, since there is a smaller number of inefficient firms going out of business and a smaller increase in the share of efficient firms in the economy.

Some studies have argued that natural disasters can improve the productivity of the corporate sector by forcing out inefficient firms while keeping efficient ones in the market. Our findings cast doubt on this simplistic story. However, we are not yet complete in clarifying the mechanisms through which natural disasters affect the productivity of the corporate sector. In addition to clarifying the effect of natural disasters on firm exit, we need to examine the impacts of natural disasters on other aspects of firm dynamics, including the effects on firm recovery, on the productivity of surviving firms, and on startups, which are all important research agenda for future studies.

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Table 1 Bankruptcy rate and firm damage (Great Tohoku Earthquake)

		(1) Whole sample		(2) F_DAMAGED=0		(3) F_DAMAGED=1		(4) t-test for H_0: Bankruptcy rate (F_DAMAGED=0) = Bankruptcy rate (F_DAMAGED=1)	
		Obs.	%	Obs.	%	Obs.	%	difference	p-value
(a) Regression sample	Bankrupt = 0	83,612	99.524	53,626	99.484	29,986	99.595		
	Bankrupt = 1	400	0.476	278	0.516	122	0.405	0.1105	0.0256 **
	Total	84,012	100.000	53,904	100.000	30,108	100.000		
(b) Whole data	Bankrupt = 0	97,605	99.526	61,871	99.482	35,734	99.601		
	Bankrupt = 1	465	0.474	322	0.518	143	0.399	0.1192	0.0089 ***
	Total	98,070	100.000	62,193	100.000	35,877	100.000		

Bankrupt is a dummy variable taking a value of one if the firm is recorded as bankrupt after the earthquake. F_DAMAGED is a proxy for firm damage that is a dummy variable taking a value of one if the firm is located in one of the cities or towns identified as affected by the earthquake in the Act on Special Financial Support to Deal with a Designated Disaster of Extreme Severity.

Table 2 Summary Statistics (Great Tohoku Earthquake)

Variable		(1) Whole sample			(2) F_DAMAGED=1			(3) F_DAMAGED=0			(4) t-test for H_0: mean (F_DAMAGED=1) = mean (F_DAMAGED=0)	
		Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	difference	p-value
F_SCORE	TDB's score of the firm.	84,012	45.33	5.81	30,108	44.83	6.10	53,904	45.61	5.62	0.77847	0.000 ***
F_EMP	The number of employees of the firm.	84,012	13.32	58.57	30,108	14.43	62.17	53,904	12.70	56.46	-1.72704	0.000 ***
F_AGE	The age of the firm.	84,012	29.95	17.43	30,108	29.14	16.62	53,904	30.41	17.85	1.27027	0.000 ***
F_NBANK	The number of banks that the firm transacts with.	84,012	2.08	1.23	30,108	2.13	1.33	53,904	2.05	1.17	-0.07678	0.000 ***
B_ROA	The ratio of operating profit to total assets of a firm's main bank.	84,012	0.00209	0.00123	30,108	0.00239	0.00100	53,904	0.00193	0.00131	-0.00046	0.000 ***
B_CAP	The equity to assets ratio of a firm's main bank	84,012	0.04597	0.01101	30,108	0.04678	0.01102	53,904	0.04551	0.01098	-0.00127	0.000 ***
B_LNASSETS	The natural logarithm of the total assets owned by a firm's main bank	84,012	21.08736	1.25752	30,108	21.31628	1.43284	53,904	20.95950	1.12796	-0.35677	0.000 ***
B_REGIONAL	Dummy taking a value of one if the firm's main bank is a regional bank.	84,012	0.63896	(NA)	30,108	0.58974	(NA)	53,904	0.66644	(NA)	0.07670	0.000 ***
B_REGIONAL2	Dummy taking a value of one if the firm's main bank is a second-tier regional bank.	84,012	0.15733	(NA)	30,108	0.18507	(NA)	53,904	0.14184	(NA)	-0.04322	0.000 ***
B_SHINKIN	Dummy taking a value of one if the firm's main bank is a Shinkin bank.	84,012	0.18600	(NA)	30,108	0.19633	(NA)	53,904	0.18023	(NA)	-0.01610	0.000 ***

Table 3 Probit Model Estimation for Bankruptcy (Great Tohoku Earthquake)

Dependent variable: Bankrupt (dummy for bankruptcy during the one year and eight months period after the earthquake)

	Panel (A)			Panel (B)			Panel (C)			Panel (D)		
	Whole sample			Whole sample, using F_DAMAGED			F_DAMAGED=1 only			F_DAMAGED=0 only		
	dF/dx	p-value		dF/dx	p-value		dF/dx	p-value		dF/dx	p-value	
F_SCORE	-0.00043	0.00	***	-0.00043	0.00	***	-0.00039	0.00	***	-0.00040	0.00	***
F_DAMAGED				-0.00104	0.00	***						
F_EMP	0.00000	0.04	**	0.00000	0.05	**	0.00000	0.65		0.00001	0.02	**
F_AGE	0.00002	0.03	**	0.00002	0.03	**	0.00002	0.17		0.00002	0.05	*
F_NBANK	0.00119	0.00	***	0.00120	0.00	***	0.00114	0.00	***	0.00105	0.00	***
B_CHIGIN	0.00225	0.21		0.00280	0.11		0.00374	0.09	*	0.24711	0.00	***
B_CHIGIN2	0.00226	0.38		0.00397	0.18		0.01344	0.05	**	0.99394	0.00	***
B_SHINKIN	0.00191	0.51		0.00414	0.22		0.01721	0.05	*	0.98830	0.00	***
B_ROA	-0.39307	0.00	***	-0.33258	0.01	**	0.21021	0.58		-0.33724	0.01	***
B_CAP	-0.04094	0.03	**	-0.04491	0.01	**	-0.05962	0.09	*	-0.04506	0.03	**
B_LNASSETS	-0.00006	0.85		0.00019	0.55		0.00118	0.04	**	-0.00023	0.54	
Industry dummies	yes			yes			yes			yes		
Obs	84012			84012			28306			53904		
Pseudo R-squared	0.0737			0.0753			0.1			0.0671		
Log likelihood	-2350.8158			-2346.7745			-707.64649			-1624.7795		

Note: ***,***, and * indicate significance at the 1, 5, and 10% level, respectively.

Table 4 Probit Model Estimation for Bankruptcy (Great Tohoku Earthquake, excluding tsunami areas)

Dependent variable: Bankrupt (dummy for bankruptcy during the one year and eight months period after the earthquake)

	Panel (A) Whole sample			Panel (B) Whole sample, using			Panel (C) F_DAMAGED=1 only			Panel (D) F_DAMAGED=0 only		
	dF/dx	p-value		dF/dx	p-value		dF/dx	p-value		dF/dx	p-value	
F_SCORE	-0.00044	0.00	***	-0.00044	0.00	***	-0.00041	0.00	***	-0.00040	0.00	***
F_DAMAGED				-0.00107	0.00	***						
F_EMP	0.00000	0.04	**	0.00000	0.04	**	0.00000	0.54		0.00001	0.02	**
F_AGE	0.00002	0.02	**	0.00002	0.02	**	0.00002	0.08	*	0.00002	0.06	*
F_NBANK	0.00120	0.00	***	0.00121	0.00	***	0.00115	0.00	***	0.00105	0.00	***
B_CHIGIN	0.00187	0.31		0.00247	0.17		0.00371	0.13		0.24488	0.00	***
B_CHIGIN2	0.00159	0.53		0.00326	0.26		0.01483	0.05	*	0.99378	0.00	***
B_SHINKIN	0.00125	0.66		0.00344	0.30		0.02069	0.05	**	0.98774	0.00	***
B_ROA	-0.39320	0.00	***	-0.33781	0.01	**	0.18283	0.66		-0.33797	0.01	***
B_CAP	-0.04071	0.03	**	-0.04529	0.02	**	-0.05411	0.15		-0.04459	0.03	**
B_LNASSETS	-0.00015	0.66		0.00013	0.69		0.00132	0.04	**	-0.00024	0.52	
Industry dummies	yes			yes			yes			yes		
Obs	79393			79393			24464			53235		
Pseudo R-squared	0.0739			0.0754			0.1003			0.068		
Log likelihood	-2245.9032			-2242.095			-618.96782			-1610.1337		

Note: ***,***, and * indicate significance at the 1, 5, and 10% level, respectively.

Table 5 Bankruptcy rate and firm damage (Great Hanshin-Awaji Earthquake)

			(1) Whole sample		(2) F_DAMAGED=0		(3) F_DAMAGED=1		(4) t-test for H_0: Bankruptcy rate (F_DAMAGED=0) = Bankruptcy rate (F_DAMAGED=1)	
			Obs.	Exit rate (%)	Obs.	Exit rate (%)	Obs.	Exit rate (%)	difference	p-value
(A) Bankruptcy during the 3 year period after the earthquake	(a) Regression sample	Bankrupt3 = 0	13,110	97.219	10,739	97.106	2,371	97.733		
		Bankrupt3 = 1	375	2.781	320	2.894	55	2.267	0.0063	0.0892 *
		Total	13,485	100.000	11,059	100.000	2,426	100.000		
	(b) Sample for which Bankrupt3 and F_DAMAGED are	Bankrupt3 = 0	119,448	97.314	95,052	97.180	24,396	97.838		
		Bankrupt3 = 1	3,297	2.686	2,758	2.820	539	2.162	0.0066	0.0000 ***
		Total	122,745	100.000	97,810	100.000	24,935	100.000		
(B) Bankruptcy during the 1 year and 8 month period after the earthquake (to compare with the Tohoku case (Table 1))	(a) Regression sample	Bankrupt = 0	13,344	98.954	10,939	98.915	2,405	99.134		
		Bankrupt = 1	141	1.046	120	1.085	21	0.866	0.0022	0.3359
		Total	13,485	100.000	11,059	100.000	2,426	100.000		
	(b) Sample for which Bankrupt and F_DAMAGED are	Bankrupt = 0	120,986	98.567	96,315	98.472	24,671	98.941		
		Bankrupt = 1	1,759	1.433	1,495	1.528	264	1.059	0.0047	0.0000 ***
		Total	122,745	100.000	97,810	100.000	24,935	100.000		

Bankrupt is a dummy variable taking a value of one if the firm is recorded as an exit firm after the earthquake. Bankrupt3 is similarly defined but consider exits during the 3 year period after the earthquake. F_DAMAGED is a proxy for firm damage that is a dummy variable taking a value of one if the firm is located in one of the cities or towns identified as affected by the earthquake in the Act on Special Financial Support to Deal with a Designated Disaster of Extreme Severity.

Table 6 Summary Statistics (Great Hanshin-Awaji Earthquake)

	(1) Whole sample			(2) F_DAMAGED=1			(3) F_DAMAGED=0			(4) t-test for H_0: mean (F_DAMAGED=1) = mean (F_DAMAGED=0)	
Variable	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.	difference	p-value
F_ROA	94,738	182.10700	7375.53400	18,522	254.14	6482.10	76,216	164.60	7576.70	-89.53597	0.138
F_RET_EMP	13,485	0.00934	0.13534	2,426	0.01	0.11	11,059	0.01	0.14	0.00448	0.140
F_DAMAGED	94,738	0.19551	(NA)	18,522	1	(NA)	76,216	0	(NA)	(NA)	
F_EMP	94,738	37.94	361.02	18,522	32.79	237.20	76,216	39.19	385.13	6.39550	0.031 **
F_AGE	94,738	39.71	14.49	18,522	39.45	14.26	76,216	39.78	14.55	0.32516	0.006 ***
F_NBANK	94,738	2.62	1.60	18,522	2.53	1.55	76,216	2.64	1.61	0.11413	0.000 ***
B_REGIONAL	94,738	0.10577	(NA)	18,522	0.07488	(NA)	76,216	0.11327	(NA)	0.03839	0.000 ***
B_REGIONAL2	94,738	0.11568	(NA)	18,522	0.15511	(NA)	76,216	0.10609	(NA)	-0.04902	0.000 ***
B_SHINKIN	94,738	0.20091	(NA)	18,522	0.24031	(NA)	76,216	0.19134	(NA)	-0.04897	0.000 ***
B_COOPERATIVE	94,738	0.02369	(NA)	18,522	0.02386	(NA)	76,216	0.02364	(NA)	-0.00022	0.086 *
B_ROA	94,738	0.00198	0.00143	18,522	0.00195	0.00138	76,216	0.00199	0.00144	0.00003	0.003 ***
B_CAP	94,738	0.03924	0.04014	18,522	0.03891	0.06204	76,216	0.03932	0.03267	0.00041	0.212
B_LNASSETS	94,738	22.79872	2.05850	18,522	22.66684	2.07654	76,216	22.83077	2.05282	0.16393	0.000 ***

Note: The definitions of the variables are the same as those in Table 1.

Table 7 Probit Model Estimation for Bankruptcy (Hanshin-Awaji Earthquake)

	Dependent variable: Bankrupt3 (dummy for bankruptcy during the three years period after the earthquake)											
	Panel (A)			Panel (B)			Panel (C)			Panel (D)		
	Whole sample			Whole sample, using F_DAMAGED			F_DAMAGED=1 only			F_DAMAGED=0 only		
	dF/dx	p-value		dF/dx	p-value		dF/dx	p-value		dF/dx	p-value	
F_ROA	-0.02768	0.00	***	-0.02781	0.00	***	-0.01504	0.00	***	-0.02584	0.01	***
F_DAMAGED				-0.00422	0.03	**						
F_EMP	-0.00006	0.04	**	-0.00006	0.04	**	-0.00006	0.01	**	-0.00005	0.05	**
F_AGE	-0.00049	0.00	***	-0.00048	0.00	***	-0.00019	0.01	***	-0.00050	0.00	***
F_NBANK	0.00269	0.00	***	0.00264	0.00	***	0.00111	0.01	**	0.00282	0.00	***
B_CHIGIN	0.00091	0.87		0.00138	0.80		0.01226	0.18		-0.00247	0.66	
B_CHIGIN2	0.00621	0.31		0.00770	0.22		0.02550	0.02	**	-0.00009	0.99	
B_SHINKIN	0.00367	0.63		0.00539	0.49		0.00942	0.31		-0.00009	0.99	
B_COOPERATIVE	0.01556	0.21		0.01700	0.18		0.00063	0.94		0.01239	0.35	
B_ROA	-2.42098	0.00	***	-2.43987	0.00	***	-0.61506	0.44		-2.51145	0.00	***
B_CAP	0.06057	0.36		0.05044	0.43		0.09445	0.53		0.07746	0.26	
B_LNASSETS	-0.00064	0.65		-0.00044	0.75		0.00184	0.17		-0.00184	0.27	
Industry dummies	yes			yes			yes			yes		
Obs	13485			13485			2350			11059		
Pseudo R-squared	0.2065			0.2079			0.1998			0.2162		
Log likelihood	-1359.37			-1356.9099			-208.75739			-1135.7666		

Note: ***,***, and * indicate significance at the 1, 5, and 10% level, respectively.

Figure 1 Bankruptcy probability and F_SCORE by F_DAMAGED (Great Tohoku Earthquake)

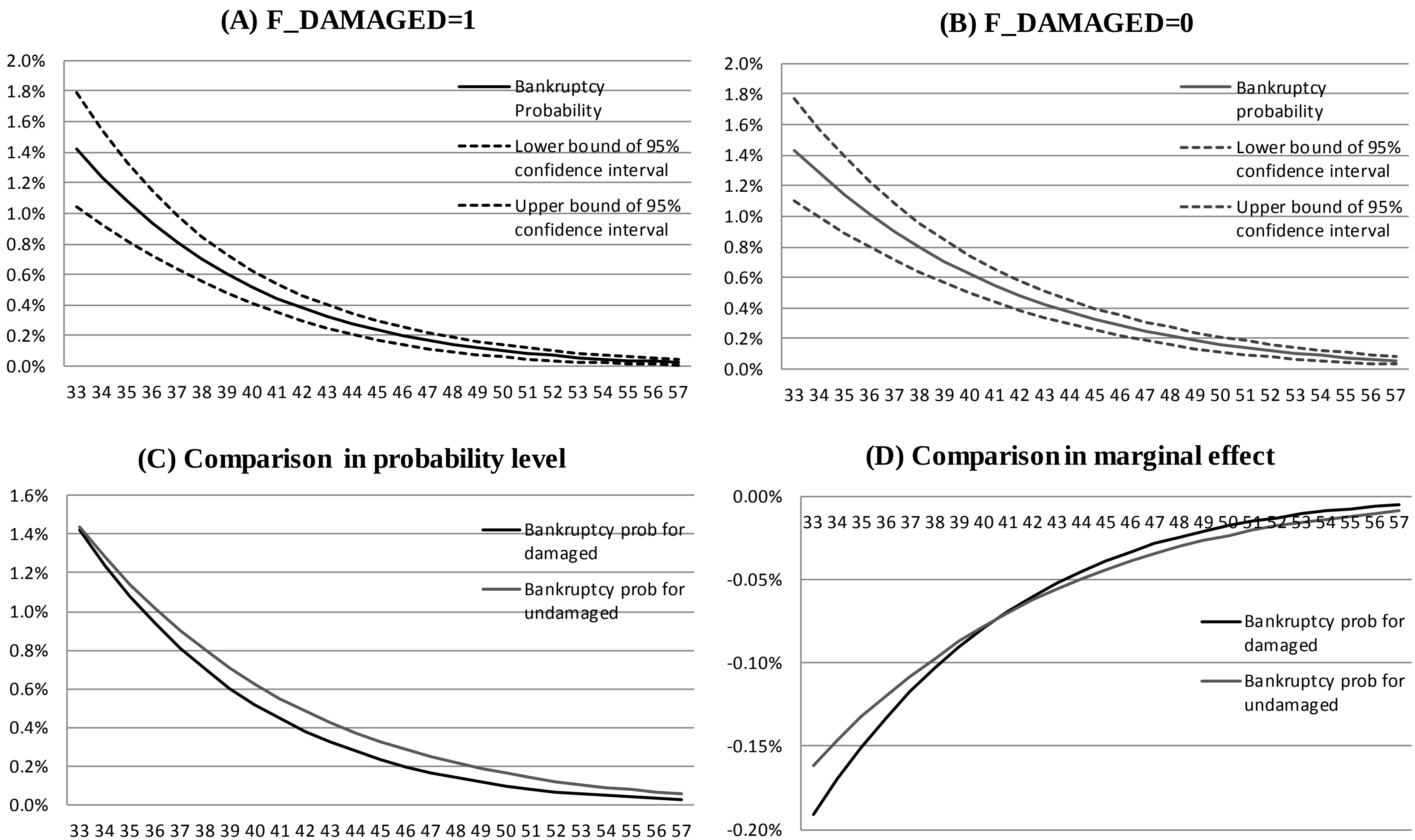

Figure 2 Bankruptcy probability and F_SCORE by F_DAMAGED (Hanshin-Awaji Earthquake)