# Termination of Bank-Firm Relationships

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Abstract. Using a matched sample of Japanese banks and firms, we examine what factors determine the termination of the bank-firm relationship. The constraints on bank capital in a Japanese banking crisis increased relationship terminations, implying the presence of a capital crunch in it. Moreover, the "flight-to-quality" behavior of bank prevailed instead of "evergreening" in relationship terminations. We also found that a longer duration of the relationship strongly decreased the probability of termination when Japan's banking system was stable. Such duration effects weakened when the system was fragile, however, the longer duration still had the intertemporal smoothing effects of loan prices.



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*Keywords*: matched lender-borrower data, bank-firm relationship, capital crunch, evergreening, flight to quality, duration effect, long-term contract.



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**1. Introduction** Bank loan markets have been studied extensively in economics literature as a mechanism that amplifies adverse shocks and as a source of macroeconomic fluctuations, given its importance as a main funding source in many developed and developing economies.

The main feature of a bank loan market is that it has a decentralized matching mechanism that can lead to financial frictions. Some recent theoretical studies show that the matching structure amplifies an adverse shock, thereby provoking a prolonged stagnation (Den Haan et al. (2003) and Becsi et al. (2005; 2013)).[1] As predicted by the theoretical studies, we observe in Figure 1 a substantial increase in terminations between Japanese banks and listed borrowing firms in the late 1990s and early 2000s, when the Japanese economy experienced low growth rates and a banking crisis (see Section 2 for the definition of termination of a relationship).

Other studies have focused on a bank lending system based on a specific bank-firm relationship, the so-called relationship banking. To investigate the costs and benefits of relationship lending, these studies have mainly examined the cross-sectional variation in the strength of the relationships between banks and borrowing firms (see Boot (2000) and Degryse and Ongena (2008) for empirical surveys of relationship banking). However, very few studies have paid attention to why and how bank-firm relationships develop over time in terms of pros and cons of relationship banking.

In this paper, we fill the gap between studies highlighting the decentralized structure of bank loan markets and those focusing on the role of a tight bank-firm relationship by addressing what factors contribute to relationship terminations. Specifically, we examine when and how banks' financial condition and the duration of relationships affect relationship terminations. To this end, we use a loan-level matched sample of Japanese lending banks and their borrowing firms over a period of 20 years. Our matched data allow us to track

[1] Dell'Ariccia and Garibaldi (2005) empirically demonstrated that a credit contraction is more volatile than a credit expansion within the US banking industry, thereby making particular note of the search process as a driving factor in generating the asymmetric volatility of the credit. Nakashima and Takahashi (2017) empirically examined the effects of relationship termination on firm investment. They demonstrated that the effects on firm investment through the decrease in bank loan changes due to relationship terminations would be larger than those through the decrease in bank loan changes within continuing relationships because a search friction exists for newly establishing bank-firm relationships.

when a bank-firm relationship terminated and how long it continued.

Our analysis exploits the fact that the Japanese banking sector fell into a severe banking crisis and experienced regulatory changes in the late 1990s and the early 2000s. Such drastic changes in financial conditions would affect banks' and firms' decisions on whether to terminate their existing relationships. Hence, the inclusion of both sample periods before and after the late 1990s and the early 2000s enables us to uncover the characteristics of bank-firm relationships by conducting a comparative analysis of sample periods, including those that overlap with the banking crisis as well as the regulatory changes. Our abundant dataset from 1990 to 2010 allows us to more comprehensively isolate the mechanism of relationship terminations.[2]

We examine the association between banks' financial condition and relationship terminations in terms of three non-mutually exclusive explanations for the lending behavior of banks with impaired capital in terms of relationship terminations: the capital crunch, evergreening, and the flight-to-quality hypothesis.[3] In the face of Japan's banking crisis in the late 1990s, some empirical studies, including those by Woo (2003), Watanabe (2007), and Gan (2007), demonstrated that the Japanese banking sector in this period experienced a capital crunch, in which many banks restrained their lending.[4] However, Peek and Rosengren (2005), Watanabe (2010), and Giannetti and Simonov (2013) found evidence of evergreening and the misallocation of bank loans to distressed firms in the late 1990s and the early 2000s.

Almost all prior studies on the lending behavior of impaired banks investigated bank loan changes in continuing bank-firm relationships, or conducted them without distinguishing between loan changes in continuing relationships (Gan (2007)) and in relationship establishments and terminations (Woo (2003) and Watanabe (2007)).[5] However, as

[2] It is difficult to come up with a matched sample because many banks experienced mergers and acquisitions (hereafter, M&A) and divestitures in Japan from the late 1990s to the early 2000s. To deal with this problem, we carefully constructed our dataset considering all M&A and divestitures of Japanese banks. See Section 2 and the Appendix for details.

[3] In Section 4, we define each hypothesis formally. For a theoretical study of impaired bank's lending behavior, see e.g. Diamond and Rajan (2000).

[4] For empirical studies of capital crunches in the US, see Bernanke and Lown (1991), Peek and Rosengren (1995), and Berrospide and Edge (2010).

[5] Peek and Rosengren (2005), Gan (2007), and Giannetti and Simonov (2013) used matched datasets of

pointed out by theoretical studies on the matching structure, a bank loan market would see matching and search frictions. Furthermore, maintaining relationships would mitigate asymmetric information problems between banks and borrowing firms or help them accumulate a relationship-specific asset. Therefore, the mechanism of adjusting bank loans in continuing relationships should be different from the case of terminating and establishing relationships.[6] For example, even if impaired banks lent more to distressed borrowers, once they decided to terminate such relationships, they could preferentially choose the relationships with their non-distressed firms. Indeed, in formal testing, we found evidence of a capital crunch as well as flight-to-quality behavior in distressed banks in relationship terminations. That is, in the late 1990s and the early 2000s, when the Japanese banking system was in severe distress, impaired banks were more likely to terminate relationships than non-impaired ones; however, impaired banks' relationships with profitable borrowers were more likely to be maintained than the non-impaired banks' ones.

Our finding extends the capital crunch hypothesis to lender-borrower relationship terminations. In other words, a capital crunch also occurred with extensive margins in bank loans. Furthermore, a capital crunch appeared with the flight-to-quality behavior of distressed banks in relationship terminations; therefore, the flight-to-quality scenario offers a more plausible explanation of the relationship terminations arising in a capital crunch than the evergreening scenario. Our finding implies that "misallocation" in the bank loan market was not supported in relationship terminations.

As discussed above, few studies have examined the dynamic evolution of bank-firm relationships mainly because of the limited availability of a lender-borrower matched sample. Among them, Ongena and Smith (2001), Farinha and Santos (2002), and Miyakawa (2010) empirically examined the termination of lender-borrower relationships by focusing on whether a longer duration decreased the likelihood of terminating relationships. On-

Japanese banks and borrowing firms; hence, their analysis of bank lending focused on the intensive margin of bank loans. On the other hand, Woo (2003) and Watanabe (2007; 2010) used bank-level panel dataset; consequently, their analysis did not distinguish between the intensive and extensive margins of bank loans.

[6] Most theoretical models abstract from detailed evaluation functions of each relationship; they assume there is some production function that determines the value of a relationship. Our econometric model can be interpreted as a reduced form of this function, although we do not separate the values for banks and firms.

gena and Smith (2001) and Farinha and Santos (2002) presented that more relationships would terminate as their durations became longer, using a matched sample from Norway and Portugal. However, Miyakawa (2010) presented that fewer longer relationships would terminate by using a matched sample in Japan through 1999. Like Miyakawa (2010), we use a matched sample in Japan; however, our analysis covers the more recent sample period through 2010. Thus, our empirical analysis draws the same result and implication for the duration effect as Miyakawa (2010). This suggests the existence of a relation-specific value in every Japanese bank-borrower relationship that facilitates the reusability of information over time and intertemporal transfers in loan pricing.

To understand the mechanism of this duration effect, we further examine the duration of relationships with high and low credit-risk firms. Using firms' asset volatility as a proxy for their credit risk, we find that the probability of ending relationships with highly volatile firms decreases as the duration of the relationship increases even during a financial turmoil, while that with low-volatility firms does not. Our finding suggests that long-term contracts in Japanese bank-borrower relationships were aimed at intertemporally smoothing loan prices by offsetting short-term losses through long-term rents generated by firms with higher uncertainty, as demonstrated by the theoretical literature on relationship banking (see Berlin and Mester (1998) and Song and Thakor (2007)).

Our paper is organized as follows. Section 2 details the methodology for estimation of the termination function and explains our loan-level matched dataset. Section 3 reports the estimation results for the termination function. Section 4 examines the effect of banks' weaker financial health on the termination of relationships with its borrowing firms. In this section, we also examine which of the three scenarios is more plausible to explain relationship terminations between impaired banks and borrowing firms by testing capital crunch, evergreening, and the flight-to-quality hypothesis. In Section 5, we extend our termination analysis by controlling for lender- and borrower-side factors more thoroughly. Furthermore, we identify the contribution of lender- and borrower-side factors and thereby examine whether relationship terminations are affected more by banks' or firms' decisions. Section 6 examines a duration effect on the termination of bank-firm relationships. Section 7 provides concluding comments. The Appendix explains how we define a relationship termination in the cases of M&A, business transfer, and divestiture.

## 2. Estimation Model and Matched Data

We examine what factor contributes to terminating relationships between Japanese banks and their borrowers by using not only lender-side but also borrower-side attributes with the loan-level matched data. To this end, we first define a termination of bank-firm relationship, and then introduce our estimation model and method to analyze it. We then describe the construction of our dataset, before defining a new relationship as well as firm and bank variables included in the estimation model.

### 2.1. Estimation Model and Method

We define a termination of a relationship in fiscal year $t$ as a case where firm $i$ borrows from bank $j$ at the end of year $t-1$ but not at that of year $t$. To examine what factors contributed to relationship terminations between Japanese banks and their borrowers, we employ the probit model. Specifically, we define a termination function of bank-borrower relationships as follows:

$$\mathrm{TERM}_{ijt} = 1\left[y_{ijt} \geq 0\right],$$

$$y_{ijt} = \mathrm{a} + \mathbf{FIRM'_{it-1}b} + \mathbf{BANK'_{jt-1}c} + \mathbf{RELATE'_{ijt-1}d} + \mathbf{DURATION'_{ijt-1}f} + \epsilon_{\mathrm{ijt}}, \quad (1)$$

$$\epsilon_{ijt} \sim N(0,1),$$

where $\mathrm{TERM}_{ijt}$ denotes a termination dummy variable that takes the value one if the relationship between firm $i$ and lending bank $j$ terminates in year $t$.

$\mathbf{FIRM_{it-1}}$ and $\mathbf{BANK_{jt-1}}$ indicate covariate vectors including observable characteristics of firm $i$ and lending bank $j$ at the end of year $t-1$, respectively. $\mathbf{RELATE_{ijt-1}}$ indicates the relationship factors that capture the characteristics of a relationship between lending bank $j$ and its borrowing firm $i$ at time $t-1$. To highlight the importance of a duration effect on the probability of termination in our study, the termination function (1) is explicitly written with a vector of duration dummy variables, $\mathbf{DURATION_{ijt-1}}$. The duration dummies indicate the number of years the relationship between lending bank $j$ and its borrowing firm $i$ has been continued up to year $t-1$.

In addition to the probit model, we also employ a logit model, however, since the estimation results are qualitatively the same, we report only the estimation results based on the probit model. In section 5, we will also employ a linear probability model with bank- and firm-fixed effects, and thus attempt to show the robustness of estimation results based on the probit model.

As discussed in the Introduction, the purpose of our analysis is to examine what factors determine the relationship termination. However, we should not exclude the possibility that the effect of each factor on terminations is time-varying as the Japanese regulatory system as well as the macroeconomic and financial conditions have changed drastically over time.[7] Accordingly, it would be best to incorporate the possible time-varying effects of each factor. To this end, we adopt the strategy of a period-by-period estimation of the termination function. Such a rolling estimation strategy allows us to control for period-by-period changes in the macroeconomic environment, thus avoiding the misspecification of a termination mechanism. We employ this empirical strategy in the following analysis of the relationship termination.[8]

2.2. **Construction of Loan-level Matched Sample** We use a loan-level dataset: a matched sample of Japanese banks and their listed borrowing firms. Our loan-level data is constructed on the basis of the Corporate Borrowings from Financial Institutions Database compiled by Nikkei Digital Media Inc. This Nikkei database collects information on corporate borrowings (long-term debt with a maturity of more than one year and short-term debt with a maturity of one year or less) classified by each Japanese bank. This Nikkei database, compiled through original Nikkei research, includes about 500,000 observations consisting of more than 100 Japanese banks, 2,000 listed borrowing firms, and 18,000

[7] For example, in terms of a credit crunch study in Japan, Woo (2003) found that after 1998 the stipulated capital asset ratio was associated with the growth rate of bank loans while this did not matter earlier.

[8] Previous studies on relationship terminations, including those by Ongena and Smith (2001), Farinha and Santos (2002), and Miyakawa (2010), arbitrarily selected a sample of a certain period and then applied the non-rolling estimation approach to the entire sample period. Given that lending banks and their borrowing firms are expected to change their relationships according to changes in the macroeconomic environment, the non-rolling estimation approach based on an arbitrarily selected sample period can provide imprecise estimates on covariates, thus resulting in a misunderstanding of a bank's and a firm's decisions on relationship terminations. See also Section 6 for details.

banking relationships for our sample period from 1990 to 2010 (see Table 1).

We combined the Nikkei database with a financial statement data of Japanese banks and their listed borrowing firms, compiled by Nikkei Digital Media Inc. Japanese banks' fiscal year ends on March 31, however, the fiscal years of their borrowing firms do not necessarily end on the same date. When combining the Nikkei database with the financial statement data, we match bank-side information to borrower-side information in the same fiscal year.

Our loan-level dataset has two types of selection biases. One arises from the exit of some domestic listed companies from our loan-level data, for example, because of their bankruptcy or their management buyout. We are not able to identify reasons for listed companies to exit from our dataset. To deal with such a potential bias, we adopt the strategy of excluding firms from our sample in year $t$ when the firm became unlisted between the end of year $t-1$ and $t$. In the estimation of the termination function, this strategy might lead to the underestimation of borrower-side effects on terminations.

A second bias is related to a bank's survivorship. The Japanese banking sector saw M&A, business transfers, (hereafter BT), and divestitures from the late 1990s to the early 2000s. To construct our loan-level data set, we scrutinized whether continuing banks took over a credit claim of merged or failed banks on its borrowing firms before and after the relevant M&A, BT, or divestiture. The Appendix explains how we define the termination indicator and the duration of a bank-firm relationship in the cases of M&A, BT, and divestiture in more detail.

A failure to track a credit claim transfer appropriately will lead to an excessive counting of terminations. To mitigate this problem and to control for banks' business restructuring effect on terminations, we include seven dummy variables in the termination function (1), which indicate an M&A, nationalization, privatization, BT, change in corporate name, coming under a financial holding company, and divestiture. [9]

2.3. **Termination and New Relationship** In addition to a terminated relationship, we identify a "new relationship" and thereby examine whether a firm that established a

[9] In this paper, we treat banks under the same financial holding company as different banks.

new relationship in year $t-1$ is more likely to terminate other relationships in year $t$. We define a new relationship as one in which a new relationship is established as well as one where a terminated relationship is revived. In this paper, however, we do not distinguish between these two. In other words, a new relationship in year $t$ is simply defined as a case where firm $i$ borrowed from bank $j$ at the end of year $t$ but had not borrowed from that bank at the end of year $t-1$. Figure 2 shows historical paths of the total numbers of the respective indicators.

2.4. **Bank, Firm and Relationship Factors** In this subsection, we define bank, firm, and relationship factors included in the covariate vectors, $\mathbf{FIRM_{it-1}}$, $\mathbf{BANK_{jt-1}}$ and $\mathbf{RELATE_{ijt-1}}$, thereby providing a more concrete specification of the termination function (1) as our baseline termination model.

The bank covariates, $\mathbf{BANK_{jt-1}}$, include a variable typically characterizing its financial fragility to investigate how a bank's financial condition affects the probability of termination. To this end, we include the one-period lag of the book leverage ratio ($\mathrm{BLEV}_{jt-1}$), defined as $100 \times \left(1 - \frac{\text{Book Value of Equity}}{\text{Book Value of Total Assets}}\right)$. In addition to this ratio, we also use the lowly capitalized bank dummy ($\mathrm{LOWCAP}_{jt-1}$) and the nonperforming loan ratio ($\mathrm{NPL}_{jt-1}$), thus conducting a robustness check on estimation results for the leverage ratio in Section 4.[10]

The coefficient of the bank's financial health indicators, including the bank leverage ratio, can either be positive or negative. It would be positive when Japanese banks' financial health deteriorates and the Japanese banking system falls into a capital crunch. According to Woo (2003) and Watanabe (2007), many Japanese banks were in a badly impaired capital state in the late 1990s and this severely constrained the supply of bank credit. If we assume that the relationship termination can be ascribed to the bank's capital crunch, our expected sign for an estimated coefficient on the bank book leverage ratio is positive.[11] However, as pointed out by Peek and Rosengren (2005), if a bank with impaired capital conducts a window dressing to avoid a further deterioration of their balance sheets, we expect that impaired banks would be more likely to maintain relationships with their borrowing firms.

[10] The detailed definition of two alternative bank soundness variables are given in Section 4.

[11] If we use the capital asset ratio as an indicator of banks' financial condition instead of the book leverage ratio, our expected sign of the capital asset ratio will be negative under the capital crunch hypothesis.

It implies a negative coefficient for the book leverage ratio. Moreover, during a non-financial crisis or an economic boom, we can expect that banks with higher leverage will take more credit risks, as demonstrated by Adrian and Shin (2010). In this case, our expected sign is negative because a negative estimate implies that highly leveraged or more risk-taking banks would decide to preserve their existing relationships rather than to terminate them.

In addition to the bank financial indicator, we include a major bank dummy variable ($\mathrm{MAJOR}_{jt-1}$) and a size variable ($\mathrm{BSIZE}_{jt-1}$). The major bank dummy variable takes one if bank $j$ is a city bank or long-term bank, zero otherwise. The bank size is calculated as the logarithm of the book value of total assets.

For firm covariates $\mathbf{FIRM_{it-1}}$ to be included, we consider firm's 10 characteristics: book leverage ratio ($\mathrm{FLEV}_{it-1}$), volatility of firm assets ($\sigma_{A,it-1}$), return on assets ($\mathrm{FROA}_{it-1}$), firm size ($\mathrm{FSIZE}_{it-1}$), firm age ($\mathrm{FAGE}_{it-1}$), sales growth ($\mathrm{FSALE}_{it-1}$), the liquid asset ratio ($\mathrm{FLIQUID}_{it-1}$), the firm marry dummy ($\mathrm{FMARRY}_{it-1}$), the firm termination dummy ($\mathrm{FTERM}_{it-1}$), and the industry dummy variables ($\mathrm{INDUSTRY}_i$).

The book leverage ratio of borrowing firms is constructed in the same way as those of banks. The volatility of firm asset is defined as follows:

$$\sigma_A \;=\; \sigma_E \times \frac{\text{Market Value of Equity}}{\text{Market Value of Firm}}, \tag{2}$$

The market value of a borrowing firm is defined as the sum of the market value of equity and the book value of total liabilities. The market value of equity is calculated by multiplying stock price at the end of year $t-1$ by the number of shares. To estimate the volatility of the equity valuation $\sigma_E$, we calculate the standard deviation of the market value of equity for the last month of a firm's fiscal year, and then express the estimated volatility at annual rates.[12] The return on assets (hereafter, ROA) is constructed by dividing a firm's net

[12] More specifically, we calculate the annualized estimated volatility of the market value of equity as in

$$\sigma_{E,it} = \sqrt{\frac{1}{20-1} \times \sum_{k=d(t)-19}^{d(t)} \left(ret_k - \overline{ret_{d(t)}}\right)^2} \times \sqrt{240},$$

where $d(t)$ denotes the last trading-day of firm $i$'s fiscal year $t$. $ret_k$ denotes the daily rate of change in equity valuation, and $\overline{ret_{d(t)}}$ is the average rate of change in equity valuation of the previous 20 days.

profits by the book value of its total assets and is expressed in percentage terms. The firm size is defined as logarithmic values of a firm's book value of assets. The firm age is defined as the years that have elapsed up to fiscal year $t$ since borrowing firm $i$ started business. The firm sales growth is calculated as the growth rate of gross sales. The firm liquid asset variable is defined as the ratio of the liquid asset to the total book value of assets.

$\text{FTERM}_{it-1}$ denotes the one-period lagged value of a firm termination indicator, which takes the value one if any of firm $i$'s relationships with its lending banks terminated in year $t-1$. We can expect the sign of the coefficient for this variable to be either positive or negative. For example, if a past termination of firm $j$'s relationships negatively affects its financial condition, its sign is expected to be positive; in contrast, if a termination forces the firm to rely more on the continuing banks for its funding, its sign would be negative. In other words, by using the lagged value of a firm's terminations, we can investigate its spillover effects.

The marry dummy variable is an indicator variable that takes the value one if firm $i$ established a new relationship or revived a terminated relationship in year $t-1$. We include the marry variable to examine whether a firm that established a new relationship with a bank in year $t-1$ is more likely to maintain relationships with its lending banks in year $t$. $\text{INDUSTRY}_i$ is the industry dummy variable indicating the industry to which borrowing firm $i$ belongs. We set up industry dummy variables according to 33 industry sectors defined by Japan's Securities Identification Code Committee.

In addition to the 10 borrower-side factors, we include funding source variables to indicate the dependence of a firm's funding on alternative funding sources such as equity and corporate bonds. This is because a firm's dependence on funding sources would affect the significance of the relationship to the firm. For example, by issuing corporate bonds, firms would be less dependent on bank loans, thereby terminating more relationships.

We consider four funding sources in this paper: equity increase, bank loans, corporate bonds, and commercial paper. For a capital increase of borrowing firm $i$, we use the equity increase dummy variable ($\text{EQUITY}_{it-1}$) that takes the value one if the number of issued stocks increases in fiscal year $t-1$. For the remaining four funding sources, we normalize each of them by a firm's book value of total liabilities, and then calculate the one-period lags of the first difference of the normalized funding variables, corporate bond ($\mathrm{CB}_{it-1}$), commercial paper ($\mathrm{CP}_{it-1}$), and bank loans ($\mathrm{LOAN}_{it-1}$).

The relationship factors $\mathbf{RELATE_{ijt-1}}$ contain bank $j$'s lending exposure to firm $i$ ($\mathrm{EXLEND}_{ijt-1}$) and firm $i$'s borrowing exposure to bank $j$ ($\mathrm{EXBORROW}_{ijt-1}$). The lending exposure of bank $j$ to firm $i$ is calculated as a ratio of the loan to bank $j$'s total loan in year $t-1$, while the borrowing exposure of firm $i$ to bank $j$ is calculated as a ratio of the loan to firm $i$'s total loan.[13]

In addition to the two exposure variables, the termination function (1) is specified as including a third relationship factor, the duration dummy variables $\mathbf{DURATION_{ijt-1}}$ indicating the duration of the relationship between lending bank $j$ and its borrowing firm $i$ at time $t-1$. Following the previous studies of Ongena and Smith (2001), Farinha and Santos (2002) and Miyakawa (2010), we define the duration of a relationship as the number of years it remains in our dataset. This is because we cannot observe the true duration of a relationship if it started in a pre-sample period, before 1978. Hence, we use the duration of each relationship defined in our dataset as a first approximation of the true duration. However, considering this data limitation of the left censoring in the framework of the baseline model, we define our duration dummies as an indicator of a tertile of durations (that is, short-, medium- and long-duration dummies) in each fiscal year, instead of the duration itself. In Section 6, we discuss some advantages of our methodology in more detail.[14]

Now, we sum up the covariates included in our baseline termination model—bank factors contained in the book leverage ratio ($\mathrm{BLEV}_{jt-1}$), the major bank indicator ($\mathrm{MAJOR}_{jt-1}$) and the bank size variable ($\mathrm{BSIZE}_{jt-1}$). Firm factors comprise the 10 characteristics of book leverage ratio ($\mathrm{FLEV}_{it-1}$), volatility of firm assets ($\sigma_{A,it-1}$), return on assets ($\mathrm{FROA}_{it-1}$), firm size ($\mathrm{FSIZE}_{it-1}$), firm age ($\mathrm{FAGE}_{it-1}$), sales growth ($\mathrm{FSALE}_{it-1}$), liquid assets ratio

[13] Peek and Rosengren (2005) focused on the relative importance of a borrowing firm from the lender's viewpoint in estimating their loan supply equation, thus using the bank's lending exposure with a matched sample of Japanese banks and their borrowers. From the borrower's viewpoint, Dass and Massa (2011) focused on the relative importance of a firm's bank loans, using the firm's loan-to-asset ratio with US firm-level panel data but not using the firm's borrowing exposure.

[14] In the baseline model, we used duration dummy variables based on the tertile of the duration. Even if we use the duration dummy variables defined by the duration year directly, our conclusion does not change qualitatively.

($\mathrm{FLIQUID}_{it-1}$), marry variable ($\mathrm{FMARRY}_{it-1}$), firm termination variable ($\mathrm{FTERM}_{it-1}$), industry dummy variable ($\mathrm{INDUSTRY}_{i}$); and the four funding variables, equity increase ($\mathrm{EQUITY}_{it-1}$), bank loan ($\mathrm{LOAN}_{it-1}$), corporate bond ($\mathrm{CB}_{it-1}$), and commercial paper ($\mathrm{CP}_{it-1}$). The relationship factors comprise the bank's lending exposure to each borrowing firm ($\mathrm{EXLEND}_{ijt-1}$), firm's borrowing exposure from each lending bank ($\mathrm{EXBORROW}_{ijt-1}$), and the duration dummy variables ($\mathbf{DURATION_{ijt-1}}$). Table 2 details the descriptive statistics for each covariate.

In the next section, we report estimation results for the baseline termination function specified by including the above bank, firm, and relationship factors.

**3. Estimation Results of the Baseline Model** This section reports estimation results for four categorized factors included in our baseline termination model: 1) the bank factors; 2) the firm factors, excluding the funding factors and the industry dummy variables; 3) the firm funding factors; and 4) the relationship factors, excluding the duration dummy variables. Figure 3 shows the estimated average marginal effects (hereafter, AMEs) obtained by employing the period-by-period estimation method.

3.1. **Bank Factors** In Figure 3-1, we report estimation results of AMEs for the bank factors. The positive and significant estimates for the bank's book leverage ratio ($\mathrm{BLEV}_{jt-1}$) from the late 1990s to 2005 indicate that highly leveraged banks were more likely to terminate the relationships with their borrowing firms during these periods.[15] This result supports the existence of a capital crunch in relationship terminations at that time. To show the robustness of our estimation results, in the next section, we will estimate the termination model using alternative indicators of a bank's financial health and capital condition.

The AMEs for the major bank indicator ($\mathrm{MAJOR}_{jt-1}$) has positive estimates, indicating that city banks and long-term banks were more likely to terminate relationships than other

[15] One can calculate a macroeconomic impact of the bank's book leverage ratio on relationship termination by multiplying an estimated marginal effect by the standard deviation of the book leverage ratio. The marginal effect of the book leverage ratio at its median value of 97% from 1996 to 2005 is estimated to be 0.5% and the standard deviation from 1996 to 2005 is 3.8%. Hence, the impact of the book leverage ratio on relationship termination is calculated as 1.9% ($= 0.5 \times 3.8$) and its magnitude is significant economically.

banks such as local banks. The bank size variable ($\mathrm{BSIZE}_{it-1}$) have negative estimates for almost all sample periods, which implies that large banks are less likely to terminate their relationships.

From the estimation results of the bank factors, we can infer that highly leveraged small banks were more likely to terminate relationships with their borrowers from the late 1990s to 2005.

3.2. **Firm Factors** Figure 3-2 shows the estimation results for the firm covariates. The AMEs for the firm's book leverage ratio ($\mathrm{FLEV}_{it-1}$) is estimated to have negative values before 1998 and after the mid-2000s, indicating that highly leveraged firms are less likely to face relationship terminations than lowly leveraged ones. In contrast, it has significantly positive values for some periods in the late 1990s and the early 2000s. Given that these periods correspond to the time when the Japanese financial system was in turmoil, this result suggests that Japanese banks evaluated firms' financial condition more stringently for these periods.[16]

The volatility of firm asset ($\sigma_{A,it-1}$) is estimated to have significantly positive values from 1998, while the sign of AMEs was unstable in the early 1990s. This means that highly volatile firms were more likely to face relationship terminations after the late 1990s. From these results for the firm leverage and volatility variables, in the late 1990s and the early 2000s, a higher risk of firms was significantly associated with their relationship terminations, while this was not always the case before.

The firm size ($\mathrm{FSIZE}_{it-1}$) provides significantly positive estimates after 1997. Estimated AMEs for the firm ROA ($\mathrm{FROA}_{it-1}$) show significantly positive values in the early 1990s, while they are significantly negative after the mid-1990s. In this latter period, bank relationships of highly profitable firms were more likely to last. With respect to the sales growth rate ($\mathrm{FSALE}_{it-1}$), their estimates take negative values through all periods except a few years such as 1994. These negative estimates show that a firm's strong growth was associated with higher probability of continuing relationships.

[16] Ongena and Smith (2001) concluded that highly leveraged, smaller, younger and more profitable firms maintained shorter relationships using a Norwegian dataset and claimed that firms were not locked into their relationships.

These results—that is, bank relationships of small and profitable firms with high growth were more likely to continue—imply that to some extent firms were locked into their specific relationships or there were some relation-specific assets, as Miyakawa (2010) pointed out. We will discuss further the presence of a hold-up problem in Section 6, by focusing on the duration dependence.

The firm age ($\text{FAGE}_{it-1}$) coefficient is negative for almost all sample periods, although the negative estimates are not necessarily significant. The result indicates the likelihood that a relationship with an older firm was more likely to continue than one with a younger one.

The estimates of AMEs for the firm liquid assets ($\text{FLIQUID}_{it-1}$) indicate that firms with more liquid assets were more likely to experience relationship terminations, except for 1999. This result underscores the fact that fiscal year 1999 was when the banking crisis was at its height; in a normal period, a higher liquid assets ratio would imply more terminations while in 1999 firms with high liquid assets ratio were able to maintain their relationships with banks.

The marry indicator ($\text{MARRY}_{jt-1}$) has significantly positive estimates in some periods during the 2000s, indicating a firm that established a new relationship in the previous year is more likely to experience relationship terminations.

The positive values for the one-period lag of the borrowing firm's termination indicator ($\text{FTERM}_{it-1}$) indicates that borrowing firms that had experienced a relationship termination in a previous year were more likely to face the termination of other relationships in the next year.

3.3. **Firm Funding Factors** Figure 3-3 presents the estimation results for the firm funding factors. For the equity increase dummy variable ($\text{EQUITY}_{it-1}$), the estimates have either positive or negative values, varying over time. Specifically, they have significantly positive estimates in 1995, 1999, and 2008-2009, indicating that firms with increasing equity would face relationship terminations. In other words, bank relationships of firms that did not increase their equity were more likely to last. This result implies that bank loans were substitutes for equity in these periods. The year 1999 and 2008-2009 were times when the financial markets were in turmoil. Therefore, we can infer that firms that had difficulty in issuing equity were more able to maintain relationships.

Regarding the debt funding tools, the estimated AMEs for corporate bonds ($\mathrm{CB}_{it-1}$) show positive values before 1997 and negative values after 1998, except for a few years. This result implies that before 1997, the increase in corporate bond issue was associated with a higher probability of relationship terminations, while the opposite is true after 1998. Before the deterioration of banks' financial condition, firms with corporate bonds substituted their bank loans with corporate bonds as a tool of debt funding. However, as the financial market environment worsened, corporate bond becomes complementary to bank loans; whereas an increase in corporate bonds is associated with an increase in the probability of maintaining relationships.

As for commercial paper ($\mathrm{CP}_{it-1}$), the estimated AMEs show that on average, a bank loan was complementary to commercial paper except for the year 1992 and 2004-2006. In other words, firms that increased dependence on commercial paper were more able to maintain their relationships with banks, especially during the banking crisis of the late 1990s. This result may reflect the fact that only a few firms with a well-established reputation issued commercial papers in the Japanese credit market. Furthermore, positive AMEs in the non-crisis period indicate that firms with increased commercial papers were likely to experience relationship terminations, which implies that commercial papers were substitutes for bank loans in a normal period.

The estimates of AMEs for the dependence on bank loans ($\mathrm{LOAN}_{it-1}$) indicate that the more a firm depended on bank loans, the fewer relationship terminations it faced. The magnitude of AMEs is bigger in 1999 and 2009-2010. This result suggests that during a financial turmoil, the dependence on bank loans accelerates.

In sum, the effects of using alternative funding sources on relationship terminations vary by period. Particularly, during the height of Japan's banking crisis in 1999, bank loans were complementary to corporate bonds and commercial papers, while being a substitute for equity.

3.4. **Relationship Factors** For the two relationship factors (see Figure 3-4), the firm's borrowing exposure ($\mathrm{EXBORROW}_{ijt-1}$) has significantly negative values for the overall sample period, with the impact being the biggest in 1999. Moreover, a bank's lending exposure ($\text{EXLEND}_{ijt-1}$) is significantly negative for the overall period, with the impact being the biggest in 1998. This implies that an increase in a firm's and a bank's dependence on a particular relationship is associated with a higher probability of maintaining the relationship, especially during a financial turmoil.

These results are in line with Hoshi et al. (1991) who demonstrated that a tight relationship with banks mitigates the effect of financial stress on the firm's investment.[17] Although few studies have investigated the mechanism of relationship banking after the 2000s, our study provides evidence that even after the banking crisis, the relationship banking system was still active in the Japanese bank loan market.[18]

We report estimation results for the duration dummy variables ($\mathbf{DURATION_{ijt-1}}$) in Section 6.

3.5. **Results of the Baseline Model** Since we will reassess the estimation results of the bank book leverage ratio using alternative indicators for a bank's financial health in the next section, here we summarize our analytical results only for the firms. First, the mechanism of terminations in terms of firms' risks, measured by their leverage and volatility, changed at the end of the 1990s. That is, firms with higher risk were more strongly and significantly associated with relationship terminations.

Second, larger and less profitable firms with slower sales were more likely to face terminations.

Third, older firms faced fewer terminations for almost all sample periods.

Fourth, a firm that experienced a relationship termination in a previous year was more likely to experience a termination in the current year. Furthermore, a firm that established a new relationship in the previous year more tends to face a relationship termination.

Lastly, the more a firm depended for its bank loans on a particular bank, the less likely were its bank relationships to come to an end.

[17] Note that the result may merely imply to the window-dressing behavior of banks instead of the positive effect of mitigating financial stresses. Therefore, we will further investigate the effects of a longer duration by controlling lending and borrowing exposure in Section 6.

[18] Uchino (2013) demonstrated that the close relationship between banks and firms in Japan raises the probability of an increase in bank lending based on Japanese loan-level data of the late 2000s.

**4. Bank's Financial Health and Relationship Termination** In this section, we investigate the effect of banks' financial condition and its interaction effect with firms' characteristics on relationship terminations. In particular, we discuss our three main hypotheses and the criteria to assess each of them: the capital crunch, the evergreening, and the flight-to-quality.

4.1. **Capital Crunch, Evergreening and Flight to Quality** As discussed above, the capital crunch scenario is an extension of a capital crunch hypothesis, which is used to explain the lending behavior of lowly capitalized banks in continuing relationships (Gan (2007)), or to do it without distinguishing loan changes in continuing relationships from relationship establishments and terminations (Woo (2003) and Watanabe (2007)). In this scenario, a lowly capitalized bank is likely to terminate the relationship with its borrowing firms, whether the firms are distressed or not. In fact, in subsection 3.1, we showed that banks with a higher bank book leverage ratio are more likely to terminate their relationships.

To further examine this issue, we introduce two alternative indicators of a bank's financial condition: the lowly capitalized bank indicator ($\mathrm{LOWCAP}_{jt-1}$) and the nonperforming loan ratio ($\mathrm{NPL}_{jt-1}$) as discussed in subsection 2.4. The lowly capitalized bank indicator, $\mathrm{LOWCAP}_{jt-1}$, is defined as a dummy variable indicating whether each bank's capitalization is low. More specifically, following Peek and Rosengren (2005), if a bank's reported capital ratio based on the BIS banking regulation is less than 2% points above the target capital ratio (8% for international banks and 4% for domestic banks), we conjecture that the bank's capitalization is low; that is, $\mathrm{LOWCAP}_{jt-1} = 1$, else $\mathrm{LOWCAP}_{jt-1} = 0$. Note that after 2006, almost all banks have the zero value for the lowly capitalized bank indicator, and hence we conduct an estimation with this indicator through 2005. The nonperforming loan ratio of bank $j$ is defined as a ratio of outstanding amounts of nonperforming loans over the total value of loans. Using these two variables, instead of the bank book leverage ratio, as a bank financial condition variable, we estimate the baseline termination model to address the capital crunch scenario.

According to Peek and Rosengren (2005), a lowly capitalized Japanese bank whose reported capital ratio was close to the target capital ratio stipulated by the BIS regulation

(8% for international banks and 4% for domestic banks) was more likely to evergreen loans to unprofitable firms in continuing relationships because of its window-dressing motives.[19] The evergreening scenario of relationship termination assumes that banks with low capitalization are more likely to maintain relationships with their distressed borrowing firms than with non-distressed ones.

The flight-to-quality scenario has the opposite assumption of the evergreening one; that is, it assumes that lowly capitalized banks are more likely to maintain relationships with non-distressed firms than with distressed ones. It is noteworthy that the flight-to-quality scenario is not compatible with the evergreening one in relationship terminations; however, it may coexist with the evergreening behavior of an impaired bank's lending in continuing relationships, as discussed in Introduction. Such an accommodation is based on our presumption that the mechanism of a bank's decision in relationship terminations should be different from that in lending on the premise of the continuation of existing relationships, as discussed in the Introduction.

To assess the two mutually exclusive hypotheses—evergreening and flight-to-quality—for relationship termination, we include an interaction term consisting of the lowly capitalized bank indicator and a borrowing firm's ROA ($\text{LOWCAP}\times\text{FROA}_{ijt-1}$) together with this bank's financial indicator.[20] Furthermore, to conduct a robustness check on our results, we also estimate a version of the baseline termination model that includes a highly leveraged bank indicator ($\text{HBLEV}_{jt-1}$) and its interaction term with firm ROA, instead of the lowly capitalized bank indicator and its interaction term.[21] The highly leveraged bank indicator is defined as a dummy variable, which takes the value one if its book leverage ratio is in the highest tertile, and zero otherwise.

In this section, we examine which of the three hypotheses offers a plausible explanation

[19] The background mechanism of the window-dressing behavior is that a lowly capitalized bank is reluctant to allow less profitable firms go bankrupt because the bankruptcy would force this bank to disclose the resulting impaired capital at an even lower level. In addition, refer to Watanabe (2010) and Giannetti and Simonov (2013) for empirical studies of the evergreening of bank credit in Japan.

[20] As we discuss below in more detail, we should note that a significant coefficient on the interaction term does not always imply a significant interaction effect in a nonlinear model.

[21] When conducting the robustness check, we use the highly leveraged bank indicator, but not the nonperforming loan ratio indicator. This is because the bank book leverage ratio yields the most complete data among our available bank capital (or leverage) variables.

for the termination of bank-firm relationships by examining an interaction effect of a bank's financial condition and its borrowing firm's profitability. The problem with examining the validity of each hypothesis is that we analyze an interaction effect of two variables in a nonlinear model. Unlike a linear model, a non-zero coefficient on an interaction term in a nonlinear model does not necessarily imply the existence of an interaction effect. Rather, in a nonlinear model, even if a coefficient on an interaction term is zero, the model can still incorporate an interaction effect.[22] This point is well known in the literature (see Ai and Norton (2003) for details). Nonetheless, there is no well-established methodology to analyze interaction effects in a nonlinear model. Some studies suggest using a linear probability model (see e.g. Duchin and Sosyura (2014)) while others include an interaction term in their nonlinear models.[23] The two approaches have both pros and cons: a linear probability model does not give us a consistent or unbiased estimator; however, it offers a straightforward interpretation of the estimated coefficients. In contrast, in a nonlinear model with an interaction term, it is difficult to interpret its marginal effect, even as it gives us a consistent estimator. We discuss below how we match possible estimation results and our hypotheses in a nonlinear model.

We formalize the three hypotheses on the basis of AMEs using a probit model described in equation (1). First, we denote the AME of a discrete variable $z$ as follows:

$$\text{AME}(z) = E_x\left[\Pr(\text{TERM}_{ijt} = 1|z = 1, X = x_{ijt}) - \Pr(\text{TERM}_{ijt} = 1|z = 0, X = x_{ijt})\right], \quad (3)$$

where $E_x[s]$ denotes a expected value of random variable $s$ over $x$. For a continuous variable $z$,

$$\text{AME}(z) = E_{xz}\left[\left.\frac{\partial \Pr(\text{TERM}_{ijt} = 1)}{\partial z}\right|_{z=z_{ijt}, X=x_{ijt}}\right], \quad (4)$$

[22] Only in the case where coefficients on two variables are zero, testing whether a coefficient on an interaction term is significantly non-zero or not provides us a straightforward interpretation regarding an interaction effect of two variables.

[23] As an example of the latter approach, Peek and Rosengren (2005) tested the evergreening hypothesis by discussing the significance of an interaction term between a borrowing firm's ROA and a lowly capitalized indicator of lending banks.

where $X$ denotes all covariates except for $y$. Then, we define the capital crunch hypothesis as a case where the following condition holds:[24]

$$\text{AME(LOWCAP)} > 0. \tag{5}$$

In other words, the change of the LOWCAP variable from zero to one should be associated with an increase in the termination probability on average to support a capital crunch hypothesis.

A flight-to-quality is demonstrated when we have

$$\text{AME(FROA}|\text{LOWCAP} = 1) < 0, \tag{6}$$

and

$$\text{AME(FROA}|\text{LOWCAP} = 1) < \text{AME(FROA}|\text{LOWCAP} = 0), \tag{7}$$

where AME(FROA|LOWCAP = 1) denotes an AME of the firm ROA for relationships with lowly capitalized banks (LOWCAP = 1). Equation (6) means that an increase in firm ROA lowers the termination probability for lowly capitalized banks. Equation (7) implies that the marginal effect of firm ROA is greater for such banks than for others; that is, lowly capitalized banks were more likely to maintain relationships with firms of high profitability than non-lowly capitalized banks. If these two conditions hold, the flight-to-quality hypothesis is supported.

In contrast, we define the evergreening behavior of lowly capitalized banks as follows:

$$\text{AME(FROA}|\text{LOWCAP} = 1) > 0, \tag{8}$$

and

$$\text{AME(FROA}|\text{LOWCAP} = 1) > \text{AME(FROA}|\text{LOWCAP} = 0). \tag{9}$$

[24] When using the highly leveraged bank indicator, $\text{HBLEV}_{jt-1}$, as a proxy for bank financial health, we substitute HBLEV for LOWCAP.

We should note that we do not distinguish between these two scenarios on the basis of the sign of AMEs of the firm ROA for non-lowly capitalized banks, AME(FROA|LOWCAP = 0). Instead, we only ensure that non-lowly capitalized banks behave differently from lowly capitalized ones in these two hypotheses. Moreover, a significant coefficient on the interaction term is not always associated with one of the two hypotheses in a nonlinear model.[25]

4.2. **Bank's Financial Health** In subsection 3.1, we found that highly leveraged banks were more likely to terminate relationships with their borrowing firms from the late 1990s to the early 2000s. For the late 1990s, as pointed out by Woo (2003), Gan (2007), and Watanabe (2007), many Japanese banks suffered their badly impaired capital. Furthermore, the regulatory framework for Japanese banks changed drastically in the late 1990s and early 2000s, forcing banks to deal with bad assets more aggressively.[26]

The estimation results reported in subsection 3.1 suggest that a capital crunch occurred in terms of relationship terminations. Taking into account our estimation results of the bank book leverage ratio and the findings of previous studies, we can infer that banks facing constraints imposed by the statutory capital requirement were reluctant to maintain relationships with their borrowing firms in the late 1990s to the early 2000s. To bolter this inference, we include the lowly capitalized bank indicator ($\text{LOWCAP}_{jt-1}$) or the nonperforming loan ratio ($\text{NPL}_{jt-1}$) as a bank's financial health variable, instead of the bank book leverage ratio ($\text{BLEV}_{jt-1}$).

Figure 4 shows estimated AMEs of the bank financial health variables, LOWCAP (upper) and NPL (lower). In fiscal years 1990, 1994, 1995, 1997, and 2003, the estimated AMEs of LOWCAP had positive values. Hence, we infer that lowly capitalized banks would terminate their relationships during the banking crisis period from the 1990s to the early 2000s. For the nonperforming loan ratio, its AMEs were estimated to have significantly positive values from the late 1990s to 2001.

Summing up the estimation results for the three bank financial variables (BLEV, LOWCAP, and NPL), we can conclude that banks' capital constraints significantly affected re-

[25] For example, Equation (7) holds even if the coefficient of the interaction term is not significant.

[26] See, for example, Watanabe (2007) and Sakuragawa and Watanabe (2009) for detailed discussions about bank regulation changes in Japan.

lationship terminations in the late 1990s and the early 2000s. Our results suggest the existence of a capital crunch in terms of relationship terminations in the 1990s as well as in the early 2000s. In the next subsection, we further study which type of firms—significantly profitable or less profitable—were more likely to face terminations with these lowly capitalized banks.

4.3. **Lowly Capitalized Bank and Lowly Profitable Firm** Our finding that highly leveraged (lowly capitalized) banks were more likely to terminate their lender-borrower relationships, particularly during the banking crisis period of the late 1990s and the early 2000s, brings up another question: Did lowly capitalized banks terminate relationships with distressed or non-distressed firms? In other words, we investigate which of the two scenarios—evergreening or flight-to-quality—were more plausible to explain impaired banks' behavior in relationship terminations.

To address this question, we include—in addition to a bank health variable—an interaction term consisting of a bank's financial variable and a borrowing firm's ROA, $\text{LOWCAP}\times\text{FROA}_{ijt-1}$ or $\text{HBLEV}\times\text{FROA}_{ijt-1}$, into the baseline termination model, as discussed in subsection 4.1. Note that a significant coefficient of the interaction term does not necessarily imply a significant interaction effect. Therefore, in this analysis, we report an AME of the firm ROA conditional on the value of bank financial condition variables (LOWCAP or HBLEV).

Figure 5 shows the estimation results for AMEs of $\text{FROA}_{it}$ conditional on the value of $\text{LOWCAP}_{jt}$. Estimates for AMEs for other variables are omitted because estimated AMEs of the other variables were almost the same as those shown in Figures 3 and 4.

If we focus on the sign of AMEs of FROA, we see three distinct phases in our sample periods, in terms of interaction effects of the bank financial condition and firm profitability on the probability of relationship terminations. The three periods are 1992, 1993-1998, and post-1999.

During the first period, by fiscal 1992, the AMEs of FROA for lowly capitalized banks are positive; however, those for non-lowly capitalized ones are negative. These results indicate that lowly capitalized banks were more likely to maintain relationships with less profitable firms, whereas non-lowly capitalized banks did the opposite.

In contrast, in the second period from 1993 to 1998, the responses of lowly and non-lowly capitalized banks switched; that is lowly capitalized banks were more likely to terminate relationships with less profitable firms, whereas non-lowly capitalized banks were more likely to maintain relationships with less profitable firms.

Finally, in the last period after 1999, the estimated AMEs of FROA with both banks were negative. This implies that the less profitable the firms were, the more likely they were to terminate their relationships, whether or not the banks' capital condition was good.

To formally show the difference in the AMEs of the firm ROA between lowly and non-lowly capitalized banks, we perform a Wald test for the null hypothesis that the two AMEs are the same. Namely, we test the following null hypothesis:

$$\mathrm{H}_0 : \mathrm{AME}(\mathrm{FROA}|\mathrm{LOWCAP} = 1) = \mathrm{AME}(\mathrm{FROA}|\mathrm{LOWCAP} = 0). \quad (10)$$

Table 3 reports p-values for the $\chi^2$ test statistics, indicating that the difference in AMEs of the firm ROA between lowly and non-lowly capitalized banks was significant in 1995, 1996, 1998, 2000, and 2001.

In the early 1990s, the period before 1992, the estimated AMEs seemed to support the evergreening behavior of banks. However, Table 3 indicates that the difference in the AMEs between lowly and non-lowly capitalized banks was not significant at the 10% significance level in this period. This implies that, according to our definition in subsection 4.1, there is no evidence of the evergreening behavior that is particular to distressed banks in the early 1990s.

From 1993, the sign of AMEs of FROA for lowly capitalized banks was negative and that for non-lowly capitalized banks was less negative or even positive until 2001. Therefore, the significant difference in the AMEs between lowly and non-lowly capitalized banks in Table 3 implies that in these periods, lowly capitalized banks were more likely to terminate relationships with less profitable firms than non-lowly capitalized banks. In other words, the relationships with lowly capitalized banks were more sensitive to a firm's profitability than those with healthy banks in 1995, 1998, 2000, and 2001. These results support the flight-to-quality scenario where lowly capitalized banks prefer maintaining relationships with more profitable firms.

Figure 6 illustrates the estimation results obtained by using the highly leveraged bank variable ($\text{HBLEV}_{jt-1}$) instead of lowly capitalized bank indicator ($\text{LOWCAP}_{jt-1}$). From Figure 6, we see qualitatively similar results as from the lowly capitalized bank indicator. However, not much difference is observed before and after 1999; from 1993, banks were more likely to terminate relationships with less profitable firms, whether or not highly leveraged.

Table 4 also reports the Wald test for the difference in the AMEs between highly and non-highly leveraged banks. Table 4 indicates that in 1995 and 2003, highly leveraged banks were more likely to terminate relationships with lowly profitable firms than non-highly leveraged banks.

We also find no evidence for the evergreening scenario for highly leveraged banks. For some periods such as 1999, even though the difference was significant, the AME of firm ROA for highly leveraged banks was not significant at the first place as shown in Figure 6. This implies that we cannot support that highly leveraged banks were likely to maintain relationships with less profitable firms. Furthermore, in some periods like in fiscal year 2004, the difference between highly and non-highly leveraged banks was statistically significant, however, AMEs for highly and non-highly leveraged banks were negative. This indicates that highly leveraged banks were less sensitive to firms' profitability; however, they still tended to terminate relationships with lowly profitable firms, which does not support the evergreening behavior in our definition. This robustness check implies that the evergreening scenario is not supported, while the flight-to-quality scenario is plausible.

Our estimation result is more supportive of the flight-to-quality scenario, rather than the evergreening scenario, which Peek and Rosengren (2005) and Watanabe (2010) suggested to understand Japanese banks' lending decisions from the middle to the late 1990s. Unlike our study, however, they found it on the basis of the continuation of the existing relationships between Japanese banks and their borrowing firms (Peek and Rosengren (2005)) or without considering the difference between the intensive and the extensive margins of bank loans (Watanabe (2010)).

If we agreed with the findings of Peek and Rosengren (2005), the difference between our finding based on relationship terminations and their findings would suggest that during a banking crisis, lowly capitalized banks are more likely to increase loans to their unprofitable borrowing firms as long as relationships continue; however, once they decide to terminate such unviable relationships, they prefer to break up relationships with their unprofitable firms.

4.4. **Termination of Unviable Relationships** Summing up our analysis in this section, the flight-to-quality scenario is the most plausible to explain relationship terminations between lowly capitalized banks and their distressed borrowing firms. That is, lowly capitalized banks would terminate relationships with their unprofitable firms during Japan's banking crisis of the late 1990s and early 2000s. The impairment of bank capital during the banking crisis period of the late 1990s would inhibit impaired banks from preserving unviable relationships with their unprofitable borrowers, thus resulting in their selection of viable relationships with their profitable borrowers.

**5. Robustness and Extension of Termination Analysis** In this section, we extend the termination analysis in two dimensions. First, we control for lender- and borrower-side factors more thoroughly to show the robustness of our empirical results thus far. To this end, instead of the probit model, we use the linear probability model with fixed effects, in which we control for the total loan supply and demand factors through time*bank and time*firm fixed effects. In addition, we focus on distressed firms just before bankruptcy to control for firms' initiatives in relationship terminations since such distressed firms would face cash flow problems and hence would not take the initiative in terminating relationships.

Second, we examine to what degree the termination of a bank-firm relationship is driven by the bank or the firm. For this purpose, we compare the contribution of estimated lender- and borrower-side factors to terminations using the linear probability model with fixed effects.

5.1. **Robustness of Termination Analysis** A distinctive analytical advantage of using loan-level matched data is that one can simultaneously control for the demand and supply factors in an equation specified at loan-level unit. To exploit this analytical advantage, we included various types of bank and firm observable covariates in the probit equation (1) (see subsection 2.1). However, in this termination equation, we may not have sufficiently controlled for lender- and borrower-side factors due to omitted variables. To address this potential problem of the omitted variable bias, we use the linear probability model with fixed effects. Thus, we attempt to show the robustness of our estimation results obtained using the probit equation.

The fixed effect (hereafter, FE) approach was developed by some important previous research that used loan-level matched data in order to control for the loan demand and supply factors elaborately (see e.g. Khwaja and Mian (2008) and Jiménez et al. (2014)). In this approach, the total loan demand and supply factors are embodied in firm $i$'s and bank $j$'s time-variant unobservables, each denoted as $\text{FirmFE}_{it}$ and $\text{BankFE}_{jt}$. If the FEs can fully capture the total loan demand and supply factors, the FE approach would allow us to identify the effects of bank and firm observable covariates.

More concretely, we introduce the following two equations to identify the effects of bank and firm observable covariates on relationship terminations:

$$\begin{aligned}\text{TERM}_{ijt} &= \text{a} + \text{FirmFE}_{it} + \mathbf{BANK'_{jt-1}c} + \mathbf{RELATE'_{ijt-1}d} + \mathbf{DURATION'_{ijt-1}f} \\ &\quad + \text{BankFE}_j + \epsilon_{ijt}, \end{aligned} \tag{11}$$

$$\begin{aligned}\text{TERM}_{ijt} &= \text{a} + \mathbf{FIRM'_{it-1}b} + \text{BankFE}_{jt} + \mathbf{RELATE'_{ijt-1}d} + \mathbf{DURATION'_{ijt-1}f} \\ &\quad + \text{FirmFE}_i + \epsilon_{ijt}, \end{aligned} \tag{12}$$

where $\text{TERM}_{ijt}$ is a dummy variable that takes a value of one if firm $i$ borrowed from bank $j$ at the end of year $t-1$ but not at the end of year $t$.

Equation (11) indicates the termination equation to disentangle the effects of bank observable covariates ($\mathbf{BANK_{jt-1}}$) from those of the total firm-side factors specified as the firms' fixed effects ($\text{FirmFE}_{it}$). On the other hand, equation (12) indicates the termination equation to disentangle the effects of firm observable covariates ($\mathbf{FIRM_{it-1}}$) from those of the total bank-side factors specified as the banks' fixed effects ($\text{BankFE}_{jt}$).

The bank observable covariates ($\mathbf{BANK_{jt-1}}$) is composed of the three bank variables including the bank leverage ratio ($\text{BLEV}_{jt-1}$), while the firm observable covariates ($\mathbf{FIRM_{it-1}}$) is composed of the nine firm variables including the firm ROA ($\text{FROA}_{it-1}$ ) and the volatility of firm asset ($\sigma_{A,it-1}$) and the four firm funding variables (see subsection 2.4 for definition of all of the bank and firm variables). In equations (11) and (12), we also include bank and firm time-invariant unobservables ($\mathrm{BankFE}_j$ and $\mathrm{FirmFE}_i$) as well as the bank and firm observables.

Note that the two termination equations should be specified in the linear probability model, and not in the probit model. This is because we cannot employ the FE approach in the probit model since it cannot exclude the FEs through the within transformation. As discussed in subsection 4.1, the linear probability model with FEs and the probit model are not competing but rather complementary partly because the probit model gives a consistent and unbiased estimator but the liner probability model does not, and partly because the linear probability model can control for unobserved loan demand and supply factors elaborately, but the probit model cannot. In the following, given the pros and cons of the two models, we use the FE approach to show the robustness of the estimation results based on the probit model.

Of estimated coefficients on the bank and firm covariates in equations (11) and (12), we focus particular attention on those on the bank leverage ratio, the firm ROA and the volatility of firm asset in the banking crisis period of the late 1990s and the early 2000s, since estimated coefficients on the three variables in this period are considerably important in our termination analysis developed in the previous and next sections. Furthermore, instead of the bank leverage ratio, we also use the lowly capitalized bank indicator ($\mathrm{LOWCAP}_{jt-1}$) as an alternative bank leverage variable in equation (11) (see subsection 4.1 for definition of the lowly capitalized bank indicator). If coefficients on the two types of bank leverage variables are significantly estimated to be positive in equation (11), it implies that a certain level of bank leverage would terminate existing relationships with any types of borrowing firms. On the other hand, if estimated coefficients on the firm ROA and the volatility of firm asset are significantly negative and positive in equation (12), it implies that a certain level of firm's unprofitability and business uncertainty would causally lead to relationship terminations regardless of bank characteristics.

Figures 7 and 8 report estimated coefficients on the two types of bank leverage variables in equation (11) and the two firm variables in equation (12), respectively. When estimating equations (11) and (12), we conducted a rolling linear regression with a five-year window.

The two figures appear to complement the results obtained in Sections 3 and 4. Figure 7 shows that the two bank leverage variables have significantly positive coefficients in the banking crisis period from the late 1990s to the early 2000s, though this tendency is more pronounced for the lowly capitalized bank indicator than for the bank leverage ratio. Figure 8 shows that the firm ROA and the volatility of firm asset have significantly negative and positive estimates, respectively, after the late 1990s, which supports our findings shown in subsection 3.2. Accordingly, as pointed out in subsections 3.1 and 4.2, we can also infer that during the banking crisis period (see the sample means of the lowly capitalized bank indicator (LOWCAP) in Table 2), banks evaluated firm performance more stringently.

To examine in depth whether the capital crunch was really prevailing in the banking crisis period, we conduct an additional analysis by focusing on distressed firms just before bankruptcy. As discussed above, this analysis is aimed at controlling for firms' initiatives in relationship terminations since the distressed firms would face cash flow problems and hence would not lead relationship terminations. If estimated coefficients on bank leverage variables are significantly positive, it evidences the capital crunch hypothesis that lowly capitalized banks are more likely to terminate relationships than non-lowly capitalized banks.

Table 5 reports estimation results obtained using samples of distressed firms just before bankruptcy, which are defined as firms that go bankrupt in the next two years. We use the probit model for two subsample periods: (i) the banking crisis period from 1998 to 2003 and (ii) the post-banking crisis period from 2004 to 2010.[27] We did not use a linear probability model as our subsamples are almost cross sectional data instead of a panel. This table shows that the two types of bank leverage variables (BLEV and LOWCAP) have significantly positive estimates for the banking crisis period, but not for the post-banking crisis period. This result indicates when the capital conditions of Japanese banks severely deteriorated, the capital crunches in the extensive margin would emerge as terminations driven by lowly capitalized Japanese banks.

Finally, in order to conduct a robustness check on the termination analysis of unviable

[27] For the pre-banking crisis period, the number of samples of distressed firms is too small to run regression. Therefore, we do not report estimation results for the pre-banking crisis period.

relationships between lowly capitalized banks and unprofitable firms during the financial turmoil, which was developed in subsections 4.3 and 4.4, we additionally introduce the following termination equation:

$$\begin{aligned}\mathrm{TERM}_{ijt} &= \mathrm{a} + \mathrm{FirmFE}_{it} + \mathrm{BankFE}_{jt} + \mathbf{RELATE}'_{\mathbf{ijt-1}}\mathbf{d} + \mathbf{DURATION}'_{\mathbf{ijt-1}}\mathbf{f} \\ &\quad + \mathrm{gFROA}_{it-1} \times \mathrm{LOWCAP}_{jt-1} + \epsilon_{ijt}, \end{aligned} \tag{13}$$

where the variable $\mathrm{FROA}_{it-1} \times \mathrm{LOWCAP}_{jt-1}$ denotes the interaction term of the firm ROA and the lowly capitalized bank indicator. Note that in contrast to equations (11) and (12), this specification controls for both of the total bank- and firm-side factors using the double FEs. An estimated coefficient $\hat{g}$ on the interaction term measures the difference of the effects of firm profitability on relationship termination between the two cases of $\mathrm{LOWCAP}_{jt-1} = 1$ and $\mathrm{LOWCAP}_{jt-1} = 0$.

Figure 9 reports estimated coefficients on the interaction terms obtained by employing a rolling liner regression with a five-year window for equation (13). This figure clearly shows that the interaction term has significantly negative coefficients for the period from 1995 to 2004, and does not have significantly estimated coefficients for the other sample periods. It suggests that as long as lowly capitalized banks led relationship terminations in the late 1990s and the early 2000s, those banks would more terminate their relationships with unprofitable firms than those with profitable firms; that is, the flight to quality behavior of lowly capitalized banks would occur in relationship terminations during the banking crisis period.[28]

5.2. **Bank's and Firm's Termination Decision** One critical assumption behind our explanation of all the estimation results is that the effects of the bank leverage ratio and lowly capitalized bank dummy on relationship terminations in the late 1990s and the early 2000s reflect banks' decisions after we control for firms' other characteristics. More precisely, our findings that the capital crunch and the flight to quality of banks were prevailed

[28] When including the interaction term of the volatility of firm asset and the lowly capitalized bank indicator in equation (13), we found that it also had negatively estimated coefficients during the banking crisis period.

in those periods is based on the premise that firms did not take initiative in relationship terminations depending on these banks' measures. We have already demonstrated that this is the case by using subsamples of distressed banks who are likely to have strong funding demand. Here, we further show the plausibility of our interpretation that firms did not terminate relationships based on those banks' health, but banks did, by using termination equation with the double FEs;

$$\mathrm{TERM}_{ijt} = \mathrm{a} + \mathrm{FirmFE}_{it} + \mathrm{BankFE}_{jt} + \mathbf{RELATE}'_{\mathbf{ijt-1}}\mathbf{d} + \mathbf{DURATION}'_{\mathbf{ijt-1}}\mathbf{f} + \epsilon_{\mathrm{ijt}}. \quad (14)$$

In this specification with the double FEs, we have the advantage that the loan demand and supply factors ($\mathrm{FirmFE}_{it}$ and $\mathrm{BankFE}_{jt}$) can be identified through a linear regression (see Jiménez et al. (2014)); hence, we can decompose and compare the contribution of the two factors as well as the relationship factors ($\mathbf{RELATE}_{\mathbf{ijt-1}}$ and $\mathbf{DURATION}'_{\mathbf{ijt-1}}$) to relationship terminations. We exploit such advantage to examine whether the termination of a bank-firm relationship is driven by the decision of the bank or the firm.

Table 6 shows the decomposition of the contribution of the bank, firm and relationship factors for subsample periods. When calculating the contribution of the three factors, we standardize each of the contribution so that three covariances between the termination variable and each of the three factors sum to one. Hence, this table shows to what degree the bank, firm and relationship factors contribute the formation of the R-squared in the termination regression. As clearly shown in this table, for the all subsample periods, the contribution of the bank factors is calculated to be about 80 to 85 percent, while those of the firm and the relationship factors are calculated to be about 5 to 10 percent. It indicates that relationship terminations are mainly driven by lender-side decisions.[29]

This result supports the existence of a capital crunch and a flight to quality of banks because the positive coefficients on the bank book leverage ratio and lowly capitalized bank

[29] One still may insist that a bank's fixed effect represents mere a component that is common across the bank's relationships with different firms and does not necessarily mean the bank's decision. Thus, one can concludes that the bank factor reflects the decision of all firms that have a relationship with the bank instead of the decision of the bank. However, it is implausible to interpret that all firms evaluate the bank's factor in a same manner that ends up to an unique bank factor, based on a standard matching model such as one in Becsi et al.(2013).

dummy should be viewed from the bank's perspective, and not from firm's one on average.

5.3. **Robustness of Capital Crunch and Flight to Quality** Our analysis in this section demonstrated that relationship terminations would be largely attributed to lender-side decisions, and not to borrower-side ones. This result justifies our interpretation of a capital crunch and a flight-to-quality in the banking crisis period when many banks suffer from severely low capitalization since firms' variations explain very tiny portion of terminations: i.e. it is likely that the coefficients on banks covariates reflect banks' decisions, and not firms' ones. According to the bank-driven termination view, it would be appropriate to conclude, based on our estimation results obtained using both the probit and linear probability equations (1) and (11) to (14), that Japanese banks with low capital ratios are more likely to terminate relationships during the banking crisis period from the late 1990s to the early 2000s and thus a capital crunch would occur in the extensive margin in this period.[30] Furthermore, the terminations in the banking crisis period would be accompanied with the fight-to-quality behavior of lowly capitalized Japanese banks so that these Japanese banks would terminate more relationships with low-quality firms than those with good-quality ones. These insights into relationship terminations are quite robust to alternative models—the probit model and the linear probability model with the FEs—to analyze relationship terminations.

**6. Duration Effect** In this section, we investigate duration effects on relationship terminations, particularly by focusing on bank's financial health and firm's credit risk.

Ongena and Smith (2001) and Farinha and Santos (2002) empirically examined duration time until bank-firm relationships terminate using survival analysis. They used bank-firm matched samples from 1979 to 1995 in Norway and from 1980 to 1996 in Portugal. Both the studies showed that bank-firm relationships with a longer duration were more likely to terminate, thus suggesting that the value of the relationship declined over time. Ongena

[30] As for the post-banking crisis period after the early 2000s, the bank leverage variables did not have significantly estimated coefficients (see subsections 3.1, 3.2 and 5.1), but the firm performance variables had significantly estimated ones, indicating that low-quality firms were more likely to face terminations (see subsections 3.2 and 5.1). One possible interpretation of this result based on the bank-driven termination view is that Japanese banks that had experienced the banking crisis evaluated firms' credit risks more strictly.

and Smith (2001) ascribed their finding to the possibility that a firm's apprehension about the hold-up problem, which would arise from a longer relationship with a particular lending bank, inhibits the borrowing firm from maintaining the relationship with the bank over a long period of time.[31]

Miyakawa (2010) applied the survival analysis to a matched sample of Japanese banks and their borrowing firms, whose sample period ran from 1982 to 1999, thereby drawing conclusions that were opposite of the findings of Ongena and Smith (2001) and Farinha and Santos (2002); that is, he demonstrated that bank-firm relationships with a shorter duration were more likely to terminate than those with a longer duration. Miyakawa (2010) attributed this empirical result to the presence of relationship specific assets; that is, the continuation of transactions in a particular bank-firm relationship would facilitate reusability of information and intertemporal transfers in loan prices so that it would enhance the value of that relationship as a relation-specific asset.

These two opposing views about the longer duration were based on different mechanisms of a strong bank-firm relationship. The empirical results of Ongena and Smith (2001) emphasized the hold-up problem as the cost of the strong relationship, while those of Miyakawa (2010) emphasized the presence of relationship specific assets as a benefit of it. Here we reassess whether a longer duration of bank-firm relationships is associated with a higher probability of the relationship termination.

The above mentioned studies assume time-invariant effects of a longer duration; however, our analysis of duration effects incorporates time-varying duration effects. This is because we expect duration effects to depend on the condition of credit markets, especially competitiveness, tightness, and soundness of the bank loan market, as shown in existing studies (see Degryse and Ongena (2008) for a review of duration effects).[32] In Japan,

[31] Many studies have investigated the pros and cons of the strong relationship between lending banks and their borrowing firms (see Boot (2000) for surveys). Positive aspects of the strong relationship include the mitigation of the asymmetric information problem (Battacharya and Thakor (1993)) and the facilitation of intertemporal transfers in loan pricing with implicit long-term contracts (Petersen and Rajan (1995), Berlin and Mester (1998), and Song and Thakor (2007)). Negative aspects of the strong relationship include the hold-up problem (Sharpe (1990) and Rajan (1992)) and the soft-budget problem (Dewatripont and Maskin (1995) and Bolton and Scharfstein (1996)).

[32] For example, if the competitiveness of a bank loan market is so high (low) that a firm's cost of switching a bank would be smaller (larger) than the benefit of mitigating hold-up problems by the switch, a longer

over the 20 years of our sample period, the drastic changes in the financial environment surrounding Japanese firms and banks have occurred. Therefore, we should be skeptical about time-invariant duration effects over our sample periods.

To conduct our duration analysis using the duration-dummy variables, $\mathbf{DURATION_{ijt-1}}$, in the baseline probit model, we classify all durations into a tertile group: short-, medium-, and long-duration dummy variables.[33] We have two reasons for not setting up dummy variables according to each duration year directly: first, we cannot always exactly identify a starting year of each relationship in our dataset because most relationships originated before the beginning of our dataset, or fiscal year 1978. Therefore, we are not able to estimate the duration effects by exactly measuring the duration year of a relationship in terms of the "absolute" time that elapsed from its start. Hence, we focus on its "relative" duration among all relationships in our dataset in each fiscal year.

The second reason, which is closely related to the first, is that our strategy of dividing duration years into a tertile group allows us to study time-varying duration effects. If we employed duration-year dummies instead of duration-quantile dummies, we would not be able to compare duration effects in 1990s with those in 2000s. This is because the use of a raw duration year variable causes the maximum possible duration and the distribution of duration variables to change over time owing to our data limitation of the left censoring, which would result in distorting our estimation results.[34] In this analysis, the first-quantile duration-dummy variable indicates the shortest duration group, while the third-quantile one is the longest duration group.

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duration would imply a higher (lower) probability of its termination. The difference in the competitiveness of credit markets would be one possible explanation for the different results among Ongena and Smith (2001), Farinha and Santos (2002) and Miyakawa (2010); if we assume lower competitiveness in the bank loan market in Japan, it would increase the net benefit of maintaining a tight relationships for banks or increase the cost of switching banks for firms.

[33] We define a quantile on the basis of the maximum duration year instead of the number of observations. For instance, if the maximum duration is nine years, the first quantile group consists of ones with 1-3 year durations, the second with 4-6 years, and the third with 7-9 years.

[34] If we use duration dummies based on a raw duration year in 1990, the longest duration, 12 years, has the highest density because our original data starts in 1978. By construction, relationships for which the 12-year duration dummy variable takes one include all relationships with a duration of more than 12 years. However, in 2000, for instance, the raw duration dummy variable for a 12-year duration takes one only if the relationship duration is truly 12 years. Therefore, we cannot deal with a 12-year duration dummy in 1990 the same as that in 2000.

6.1. **Baseline Model Estimation** In this subsection, we report estimates of duration effects in the baseline probit model.[35] Figure 10 shows estimation results for the AMEs of the second quantile and the third quantile duration-dummy variables in which the first quantile is set as the reference group. The left and right figures plot estimates for the second and third quantile duration-dummy variable, respectively. We can make the following four inferences based on our estimation results.

First, Figure 10 shows that in the early 1990s, the duration effects of tightening relationships were stable and significant; a longer duration of a relationship was associated with a lower probability of its termination. To see this point more clearly, Figure 11 illustrates the term structure of duration effects for selected periods. For example, in 1995, longer duration variables have a significantly larger negative value, which implies that longer durations are associated with a lower probability of relationship terminations. This result is suggestive of the existence of a relationship specific value. Furthermore, the result of the increasing effects of a longer duration coincides with the findings of Miyakawa (2010). We should note that the AMEs of the duration dummies are estimated by controlling for other relationship variables such as borrowing exposure of a firm to its lending bank.

Second, the second quantile duration dummy becomes insignificant in the late 1990s, indicating that the duration effect starts to diminish in the late 1990s. From this result, we can infer that the effect of the tight bank-firm relationship becomes irrelevant to a small difference in their duration. As discussed in subsection 4.1, this period corresponds to the occurrence of a financial crisis and a capital crunch. The deterioration of banks' financial conditions would cause a change in the duration effects. In the next subsection, we will discuss this point in more detail. The decreasing duration effect is observed more clearly in Figure 11; for example, in fiscal 2000, the term structure of the duration effect flattened with the insignificant second quantile duration variable. The early 2000s saw the banks' disposal of nonperforming loans, which had been accumulated after the burst of the bubble economy (see Sakuragawa and Watanabe (2009) for details). The financial condition of Japanese banks would be a plausible explanation for the fading duration effect in the early

[35] We also used the linear probability model with fixed effects for the duration analysis, and we found that the estimation results are qualitatively the same as those obtained using the baseline probit model.

2000s.

Third, Figure 11 indicates that the term structure of duration effects sharpened again for the periods 2004-2007. As in the early 1990s, a longer duration of a relationship implied a lower probability of its termination. This result means the duration effect was restored after the financial turmoil in the late 1990s and the early 2000s, although the duration effect substantially weakened at one point. In this period, the Japanese economy and financial system remained relatively stable and sound. From these results, it is clear that a stable financial system is an important condition for the duration effect to lower the probability of termination.

Lastly, in 2008 and 2009, the estimates of duration effects increased substantially. During the 2008 financial crisis, the banking function remained relatively sound, which allowed the effect of longer duration to kick in by mitigating the asymmetric information problem, as pointed out by Uchino (2013).

The above duration analysis has the following implications; when a banking system is relatively stable, such as the period before 1996 and in the mid-2000s in Japan, the duration effect is apparent in the sense that a longer duration would decrease the likelihood of termination of the relationship between banks and their borrowers. However, when a banking system is relatively fragile, such as the period from 1997 to 2003, the duration effect was weakened. Hence, we can deduce that a relatively stable banking system would be an important condition for a longer duration to decrease the likelihood of the relationship terminating.

In the next subsections, we focus on the banking crisis to investigate whether the duration effect was absent in this period for all relationships.

6.2. **Duration Effect and Bank's Financial Health** In the previous subsection, we found that in the late 1990s and the early 2000s, during the financial system turmoil, the duration effect became weak. To bolster this finding, we use the lowly capitalized bank indicator, $\mathrm{LOWCAP}_{jt-1}$, instead of the bank's book leverage ratio and additionally include its interaction terms with the two duration dummies, the second quantile and the third quantile duration-dummy variables. If the AME of duration dummy variables for lowly capitalized banks (banks of $\mathrm{LOWCAP}_{jt-1} = 1$) does not have negative estimates only in the banking crisis period of the late 1990s and the early 2000s, and the duration dummies for non-lowly capitalized banks (banks of $\text{LOWCAP}_{jt-1} = 0$) have negative ones in the whole sample period including the banking crisis period, we can infer that the bank's financial health would be an important condition for the duration effect to lower the probability of termination.[36]

Figure 12 shows estimation results for AMEs of the duration dummies for lowly and non-lowly capitalized banks. It is observed that the AMEs for non-lowly capitalized banks have significantly negative estimates in the banking crisis periods of the late 1990s and the early 2000s, whereas the AMEs for lowly capitalized banks do not.[37] This implies that the duration effects were preserved during the financial system turmoil for relationships with non-lowly capitalized.

Our analysis in this subsection supports the suggestion that a relatively stable banking system, in particular, based on a bank's financial health would be a prerequisite for the existence of the duration effect.

6.3. **Duration Effect and Firm's Credit Risk** In the previous subsection, we focused on a bank's financial health, thereby demonstrating that when the Japanese banking system was relatively stable, the duration effect was preserved, however when it was fragile, the duration effect was weakened. In this subsection, we focus on firm characteristics that affected the duration effect. In particular, we use firms' asset volatility ($\sigma_{A,it-1}$) as a proxy for their credit risk and the uncertainty of their business to investigate the difference in the duration effect between highly volatile and less volatile firms.

Theoretical models in relationship banking predict that a long-term contract enables banks to maintain a stable loan interest rate through intertemporal transfers in loan pricing even if a firm's credit risk fluctuates (see Boot (2000) for details).[38] Given this positive

[36] We also used the highly leveraged bank indicator, $\text{HBLEV}_{jt-1}$, as a proxy for bank financial health. We found that estimation results obtained using the highly leveraged bank indicator did not qualitatively differ from those obtained using the lowly capitalized bank indicator.

[37] We conducted the Wald test for the equality among the AMEs of the duration dummies and the AMEs of their interaction terms with the lowly capitalized indicator. We found that the equality hypothesis is rejected at the 10% level of significance in 1998, 1999 and 2002.

[38] Jiménez and Saurina (2004) used a Spanish dataset and then demonstrated empirically that a close bank-borrower relationship increased the willingness to take more firm's credit risk.

side of relationship banking, the duration effect is expected to be larger for firms with higher business uncertainty than for firms with lower uncertainty because a bank is more likely to intertemporally smooth loan prices by offsetting short-term losses through long-term rents generated by the firms facing higher uncertainty. To address this point, we include the highly volatile firm dummy variable and its interaction term with duration dummy variables by using firm volatility as a proxy for the firm's uncertainty.[39] The highly volatile firm dummy takes the value one if the firm's volatility is higher than the cross-sectional median value in year $t-1$, and zero otherwise.

The estimation results for AMEs of the duration dummies for highly and less volatile firms are shown in Figure 13. It shows that for relationships with highly volatile firms, a longer duration is associated with a lower probability of terminations, whereas the duration dummy for the second quantile was not significant for the non-highly volatile firms; namely, for the non-highly volatile firms the duration effect is diminished. This result implies that for firms with high volatility, even during the financial turmoil of the late 1990s and early 2000s, the duration effect was preserved; that is, the tight relationships were especially important for firms facing greater business uncertainty, which coincides with the prediction of theoretical models (See Shibata and Yamada (2009)).[40]

To sum, we found that for highly volatile firms, the duration effects were preserved even in a financial crisis, whereas for firms with low volatility, the duration effect was significantly weakened in the late 1990s and the early 2000s. These results indicate that the duration effect depends on the degree to which firms face uncertainty in business.

**7. Conclusion** Using a matched sample of Japanese lending banks and their borrowing firms over 20 years, we examined what factors caused relationships between lending banks and their borrowers to terminate. This paper draws three main substantive conclusions

[39] The premise that banks can intertemporally smooth loan prices in long-relationships is based on the fact that they have access to core deposits, which are interest-inelastic and hence are able to insulate the bank against exogenous economic shocks. See Song and Thakor (2007) for details.

[40] A long-term contract can cause the hold-up and soft budget problems. In the face of these problems, a bank faces uncertainty regarding the exit timing, and the optimal timing is determined by the trade-off between an increase in the firm's credit risk and an opportunity to gain future earnings from the firm. Shibata and Yamada (2009) proposed a theoretical model to investigate a bank's optimal exit timing, and thus demonstrated that the higher the volatility of the firm value, the later a bank exits. Our finding is consistent with this theoretical implication.

about this question.

First, young, highly volatile, and unprofitable firms with a low sales growth are more likely to experience relationship terminations. Furthermore, firms that experience a relationship termination in a previous year are also more likely to face relationship terminations in the current year. In addition to these firm characteristics to explain relationship termination, we include the following: the more a firm depends on bank borrowing and on a particular bank for it, the less likely are its relevant relationships to come to an end.

Second, we find evidence of a capital crunch in the extensive margins of bank loans in the late 1990s and the early 2000s. Furthermore, lowly capitalized banks are more sensitive to firms' profitability than non-lowly ones. In other words, lowly capitalized banks have a tendency to terminate more relationships with lowly profitable firms than non-lowly capitalized banks. This result implies that the flight-to-quality scenario offers a plausible explanation for relationship terminations for distressed banks, rather than the evergreen scenario.

Lastly, when a banking system is relatively stable, a longer duration decreases the likelihood of the relationship between lending banks and their borrowers being terminated. Conversely, when a banking system is fragile, the duration effect is diminished, although this does not hold for relationships with high asset volatility firms even during a financial turmoil. This result implies that long-term contracts in Japanese bank-borrower relationships were aimed at intertemporally smoothing loan prices by offsetting short-term losses through long-term rents generated by firms with higher uncertainty.

**Appendix: Construction of a Loan-level Matched Sample with M&A, Business Transfer, and Divestiture Activity** The Japanese banking sector saw significant M&A, business transfer, and divestiture activity over the late 1990s and early 2000s. To construct our loan-level dataset, we checked whether successor banks took over the merged or eliminated bank's credit claims on its borrowing firms before and after the relevant M&A, business transfer, or divestiture. This appendix explains how we define the termination of a bank-borrower relationship in the case of M&A, business transfer, and divestiture.

**The Case of M&A** Here, we consider the case of an absorption-type merger. If a surviving bank takes over a merged bank's loan lent to a borrowing firm after the absorption merger, we assume that the pre-M&A relationship between the merging bank and the borrowing firm continues in the post-M&A relationship between the surviving bank and the firm. That is, the pre-M&A relationship does not terminate at the time of the absorption merger. In contrast, if no bank takes over the loan of the merging bank, we assume that the pre-M&A relationship terminates at the time of the absorption merger.

**The Case of Business Transfer** Next, we consider the case in which a bank transfers its business to other banks. In this case, we define a relationship termination as the case of M&A. If we find that the transferee bank takes over the loans of the transferor bank, we suppose that the transferor bank also holds over pre-transfer relationships between the transferor bank and its borrowing firms, and that the pre-transfer relationships does not terminate. As long as we find that the transferee banks did not take over loans of the transferor bank, we assume that the pre-transfer relationships between the transferor bank and its borrowing firms are terminated. We adopt the above way of defining a relationship termination, whether the accepting banks enjoyed relationships with those borrowing firms before the business transfer or not.

**The Case of Merger and Divestiture** We consider the case in which banks merge and then divest. In this case, we should identify which banks formed after the merger and divestiture, and whether they took over the loans of the merging banks. If a firm enjoyed relationships with one of the merging banks before the merger and divestiture, and the firm had a relationship with at least one of the surviving banks after the merger and divestiture, we assume that the relationships between the merging banks and the firm were preserved. That is, the relationships did not terminate. If the firm does not have any relationships with the surviving banks after the merger and divestiture, we assume that the relationships between the merged banks and the firm terminated at that time.

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**Table 1: Number of Observations: Average per Year**

| Number of observations | Full Sample | 1990–1999 | 2000–2010 |
|---|---|---|---|
| Firms | 1,992 | 1,792 | 2,174 |
| Banks | 138 | 150 | 127 |
| Relations | 16,528 | 19,760 | 13,411 |

*Notes:* This table shows sample averages of the numbers of observations for borrowing firms, lending banks, and relationships, each calculated per year. "Full Sample" indicates the sample period from fiscal year 1990 to 2010.

**Table 2: Summary Statistics**

| | Full Sample | | | | 1990–1994 | | 1995–1999 | | 2000–2004 | | 2005–2010 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Dev.** | **Min.** | **Max.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | | | | |
| **Termination** | | | | | | | | | | | | |
| TERM | 0.067 | 0.25 | 0 | 1 | 0.031 | 0.18 | 0.066 | 0.25 | 0.082 | 0.27 | 0.095 | 0.29 |
| **Bank Factors** | | | | | | | | | | | | |
| BLEV | 96.17 | 2.83 | 87.3 | 149.11 | 96.57 | 0.83 | 96.65 | 1.97 | 96.15 | 5.06 | 95.30 | 1.62 |
| LOWCAP | 0.40 | 0.49 | 0 | 1 | 0.88 | 0.33 | 0.64 | 0.48 | 0.054 | 0.23 | 0.007 | 0.081 |
| NPL | 3.93 | 3.25 | 0.13 | 53.73 | 4.21 | 1.19 | 3.07 | 3.22 | 5.31 | 4.06 | 3.38 | 1.75 |
| MAJOR | 0.42 | 0.49 | 0 | 1 | 0.51 | 0.5 | 0.41 | 0.49 | 0.38 | 0.49 | 0.38 | 0.49 |
| BSIZE | 14.64 | 1.34 | 11.68 | 18.85 | 14.57 | 1.41 | 14.63 | 1.35 | 14.64 | 1.31 | 14.73 | 1.28 |
| **Firm Factors** | | | | | | | | | | | | |
| FBLEV | 61.07 | 19.65 | 0.91 | 835.43 | 65.11 | 17.74 | 62.36 | 19.97 | 61.03 | 20.99 | 57.66 | 18.64 |
| Firm $\sigma$ | 19.17 | 15.09 | 0.081 | 520.13 | 20.58 | 9.74 | 17.80 | 10.33 | 18.63 | 15.86 | 19.91 | 19.56 |
| FROA | 0.62 | 7.76 | -372.92 | 157.16 | 1.44 | 4.17 | 0.65 | 5.12 | 0.15 | 8.73 | 0.55 | 9.96 |
| FSIZE | 10.535 | 1.488 | 4.522 | 16.46 | 11.01 | 1.43 | 10.65 | 1.45 | 10.38 | 1.45 | 10.3 | 1.51 |
| FAGE | 3.768 | 0.578 | -0.693 | 4.859 | 3.866 | 0.347 | 3.809 | 0.441 | 3.754 | 0.585 | 3.689 | 0.746 |
| FSALES | 0.011 | 0.254 | -4.681 | 7.299 | 0.034 | 0.199 | 0.005 | 0.159 | 0.013 | 0.244 | 0.001 | 0.341 |
| FMARRY | 0.251 | 0.434 | 0 | 1 | 0.227 | 0.419 | 0.203 | 0.402 | 0.268 | 0.443 | 0.292 | 0.455 |
| FTERM | 0.267 | 0.442 | 0 | 1 | 0.209 | 0.407 | 0.273 | 0.446 | 0.306 | 0.461 | 0.263 | 0.44 |
| **Firm Funding Factors** | | | | | | | | | | | | |
| EQUITY | 0.318 | 0.466 | 0 | 1 | 0.451 | 0.498 | 0.292 | 0.455 | 0.182 | 0.386 | 0.235 | 0.424 |
| CB | -0.137 | 6.331 | -75.407 | 78.431 | 0.779 | 8.517 | -0.634 | 7.628 | -0.453 | 5.764 | -0.191 | 5.64 |
| CP | 0.041 | 1.379 | -32.025 | 33.919 | 0.048 | 0.837 | 0.052 | 1.254 | -0.023 | 1.176 | 0.009 | 1.212 |
| LOAN | -0.08 | 8.595 | -80.89 | 87.22 | 0.069 | 6.907 | 0.893 | 7.363 | -0.955 | 8.478 | -0.184 | 10.284 |
| **Relationship Factors** | | | | | | | | | | | | |
| EXPBORROW | 11.53 | 14.43 | 0 | 100 | 8.159 | 11.035 | 9.785 | 12.655 | 13.224 | 15.392 | 15.982 | 17.395 |
| EXPLEND | 0.712 | 3.033 | 0 | 100 | 0.78 | 3.411 | 0.612 | 2.734 | 0.703 | 2.918 | 0.78 | 3.082 |
| Duration Year | 11.6 | 8.468 | 1 | 33 | 11.148 | 5.284 | 11.689 | 7.907 | 12.023 | 9.452 | 11.544 | 10.732 |
| Duration Dummy 1 | 0.422 | 0.494 | 0 | 1 | 0.214 | 0.41 | 0.388 | 0.487 | 0.532 | 0.499 | 0.587 | 0.492 |
| Duration Dummy 2 | 0.137 | 0.344 | 0 | 1 | 0.128 | 0.334 | 0.132 | 0.338 | 0.117 | 0.321 | 0.177 | 0.381 |
| Duration Dummy 3 | 0.441 | 0.497 | 0 | 1 | 0.658 | 0.474 | 0.48 | 0.5 | 0.35 | 0.477 | 0.236 | 0.425 |

*Notes:* Duration dummy 1 indicates the shortest duration tertile and 3 indicates the longest. The mean and standard variation of all variables are calculated on the basis of relationships.

**Table 3: Wald Test for the Difference of AMEs of the Firm Return on Assets between Lowly and Non-lowly Capitalized Banks**

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| p-value | 0.76 | 0.28 | 0.11 | 0.20 | 0.16 | 0.08* | 0.06* | 0.86 | 0.02** | 0.96 |
| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | | | | |
| p-value | 0.10* | 0.03** | 0.49 | 0.13 | 0.23 | 0.50 | | | | |

*Notes:* Using the estimated AMEs of FROA, we conducted a Wald test for the null hypothesis that the AME for lowly capitalized banks is equal to that for non-lowly capitalized ones. ***, **, * indicate 1%, 5% and 10% levels of significance, respectively.

**Table 4: Wald Test for the Difference of AMEs between Highly and Non-highly Leveraged Banks**

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| p-value | 0.42 | 0.21 | 0.35 | 0.72 | 0.16 | 0.01** | 0.54 | 0.98 | 0.67 | 0.07* | |
| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| p-value | 0.27 | 0.61 | 0.73 | 0.03** | 0.02** | 0.13 | 0.95 | 0.29 | 0.74 | 0.21 | 0.24 |

*Notes:* Using the estimated AMEs of FROA, we conducted a Wald test for the null hypothesis that the AME for highly leveraged banks is equal to that for non-highly leveraged ones. ***, **, * indicate 1%, 5% and 10% levels of significance, respectively.

**Table 5: Estimation Results of AMEs for the Probit Model of Termination Based on Subsamples of Firms Before Bankruptcy**

| | (1) 1995–1997 | (2) 1995–1997 | (3) 1998–2003 | (4) 1998-2003 | (5) 2004–2010 |
|---|---|---|---|---|---|
| Bank Risk Variable | BLEV | LOWCAP | BLEV | LOWCAP | BLEV |
| Bank Variables | | | | | |
| BLEV | -0.000556 | | 0.00896* | | 0.00534 |
| | (-0.07) | | (1.83) | | (0.49) |
| LOWCAP | | .0109 | | 0.0832* | |
| | | (0.61) | | (1.66) | |
| MAJOR | — | — | 0.238*** | 0.242*** | -0.564*** |
| | | | (5.57) | (5.55) | (-5.75) |
| BSIZE | -0.0130 | -0.00849 | -0.00863 | 0.000283 | -0.0150 |
| | (-1.35) | (-1.00) | (-0.71) | (0.02) | (-1.21) |
| Firm Variables | | | | | |
| FLEV | 0.392*** | 0.212*** | -0.00325 | -0.00326 | 0.0721*** |
| | (4.38) | (4.51) | (-1.24) | (-1.30) | (5.74) |
| Firm $\sigma$ | -0.0329 | -0.0106 | -0.000326 | -0.000112 | 0.0215*** |
| | (-0.64) | (-0.74) | (-0.07) | (-0.03) | (4.45) |
| FROA | 1.176*** | 0.698*** | 0.00497 | 0.00439 | 0.235*** |
| | (4.13) | (3.74) | (1.00) | (0.91) | (5.42) |
| Duration Dummy | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year Dummy | ✓ | ✓ | ✓ | ✓ | ✓ |
| $N$ | 290 | 274 | 643 | 614 | 422 |

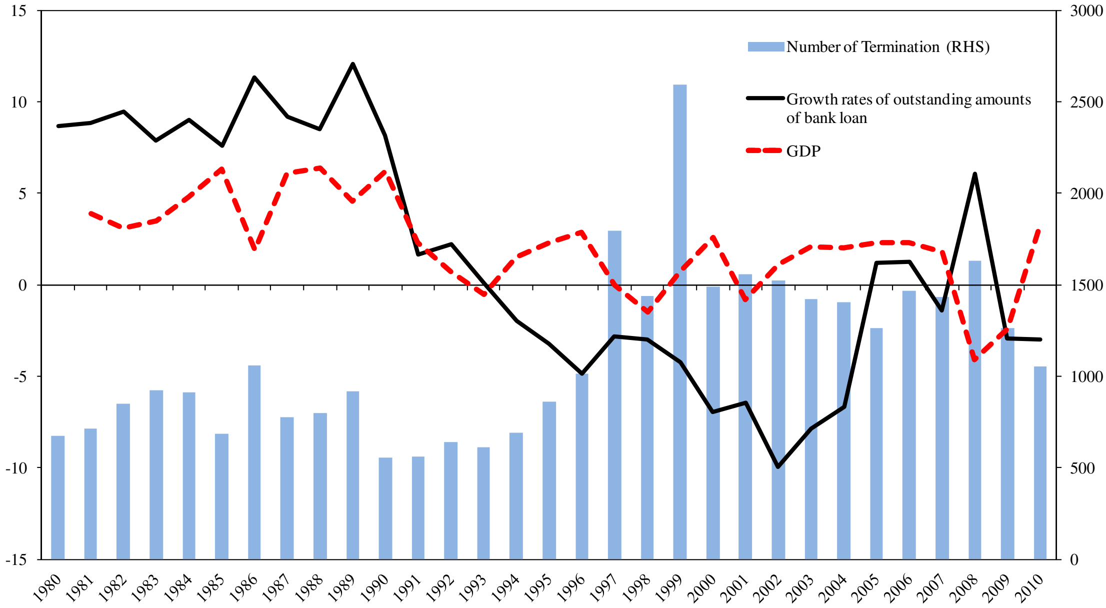
*Notes:* The table shows average marginal effects of covariates based on the estimation results of the probit model for a relationship termination, TERM, obtained by using subsamples consisting of a relationship between a bank and a firm that goes bankruptcy in year $t+1$ or $t+2$. The probit model also includes other control variables; firm factors comprise the 10 characteristics of firm size ($\text{FSIZE}_{it-1}$), firm age ($\text{FAGE}_{it-1}$), sales growth ($\text{FSALE}_{it-1}$), liquid assets ratio ($\text{FLIQUID}_{it-1}$), marry variable ($\text{FMARRY}_{it-1}$), firm termination variable ($\text{FTERM}_{it-1}$), industry dummy variable ($\text{INDUSTRY}_i$); and the four funding variables, equity increase ($\text{EQUITY}_{it-1}$), bank loan ($\text{LOAN}_{it-1}$), corporate bond ($\text{CB}_{it-1}$), and commercial paper ($\text{CP}_{it-1}$). The relationship factors comprise the bank's lending exposure to each borrowing firm ($\text{EXLEND}_{ijt-1}$), firm's borrowing exposure from each lending bank ($\text{EXBORROW}_{ijt-1}$), and the duration dummy variables ($\text{DURATION}_{\mathbf{ijt-1}}$). The estimated coefficients on those variables are not reported in Table 5. The CP and FTERM are dropped from the estimation for 1995–1997 because they take zero values in this subsampe period. $t$ statistics are in parentheses.***, **, * indicate 1%, 5% and 10% levels of significance, respectively.

**Table 6: The Contribution of the Firm, Bank and Relationship Factors to Terminations**

| Sample Period | 1990-1994 | 1995–1999 | 2000–2004 | 2005–2010 |
|---|---|---|---|---|
| Firm Factors | 0.107 | 0.107 | 0.050 | 0.048 |
| Bank Factors | 0.815 | 0.806 | 0.866 | 0.853 |
| Relationship Factors | 0.078 | 0.086 | 0.083 | 0.098 |
| R-squared | 0.338 | 0.340 | 0.376 | 0.428 |

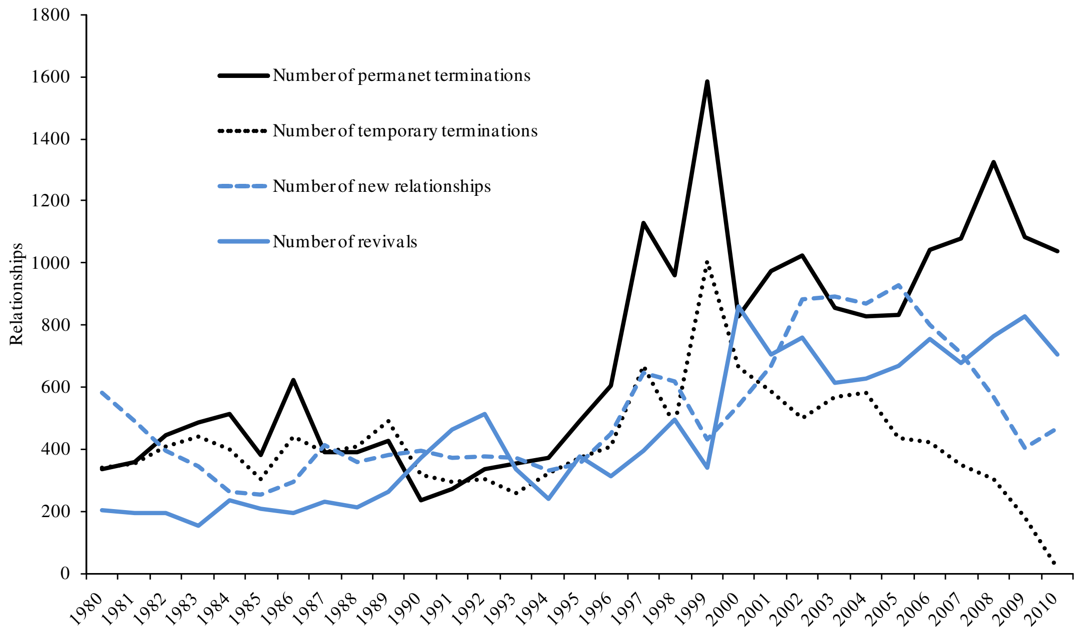
*Notes:* We calculate the contribution of the firm, bank and relationship factors using the linear probability model with fixed effects (14). Each of the contribution is standardized so that three covariances between the termination variable and each of the three factors sum to one.

## Figure 1. The Number of Relatioship Terminations, Bank Loan and GDP




*Notes:* The number of terminations is calculated by summing all terminations over Japanese listed firms for each fiscal year. The growth rate of outstanding amounts of bank loans is calculated as the first log difference of outstanding amounts of loans by private financial institutions to private nonfinancial corporations.

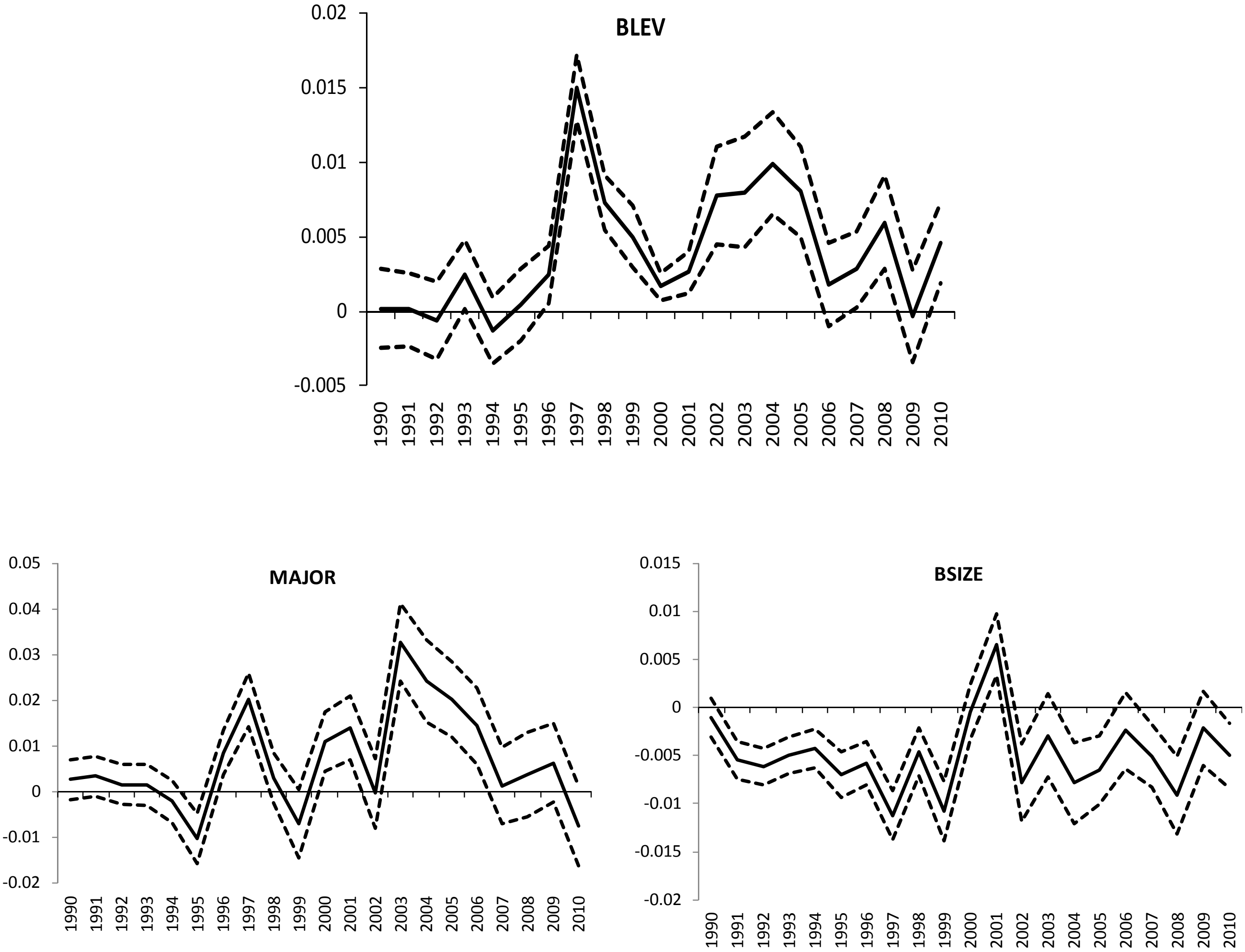
## Figure 2. Termination, New Relation and Revival




*Notes:* The number of terminations and new relationships is calculated by summing all terminations and new relationships over Japanese listed firms.

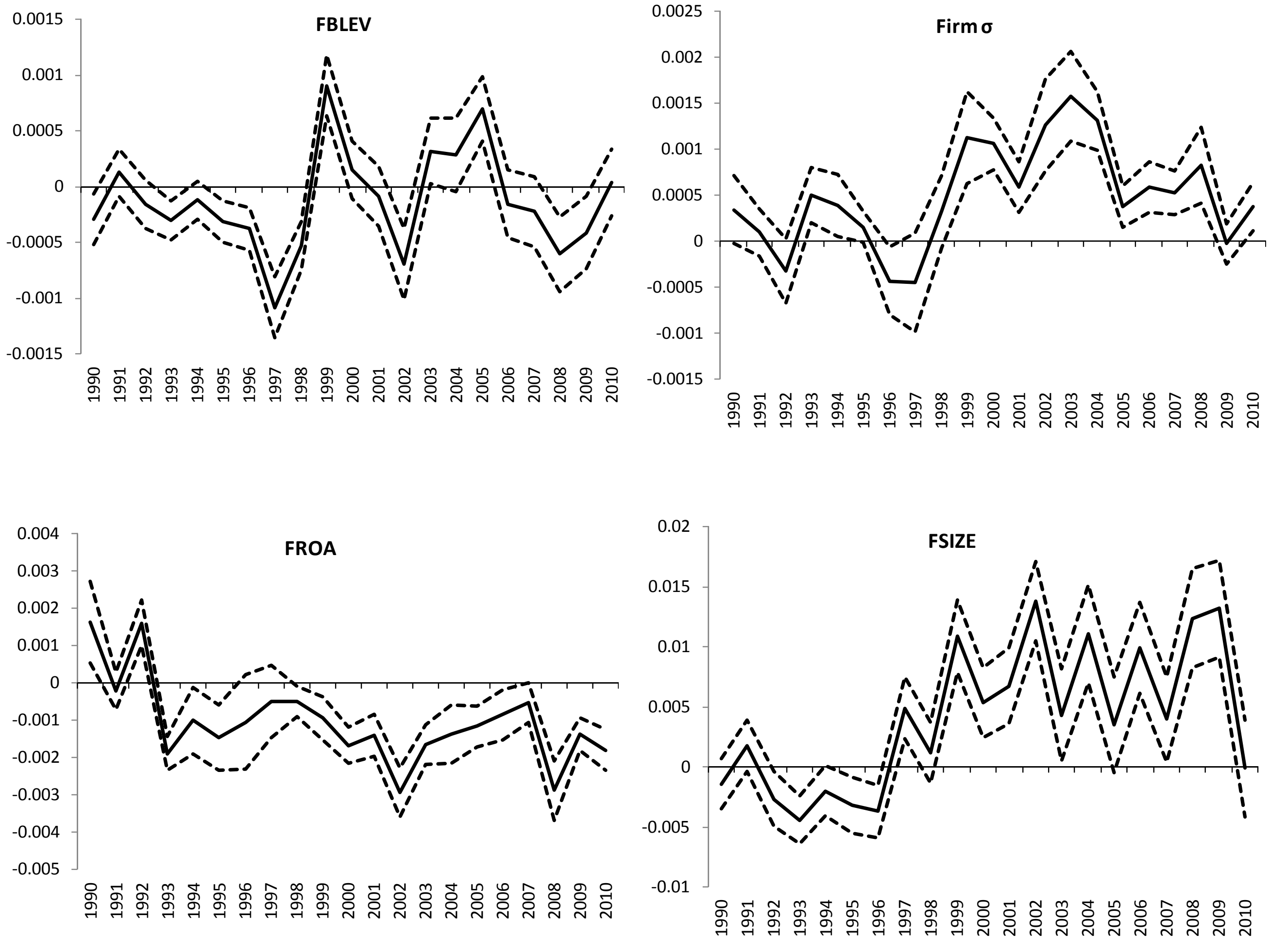
## Figure 3. Estimation Results for the Baseline Termination Model

### Figure 3-1. Bank Factors



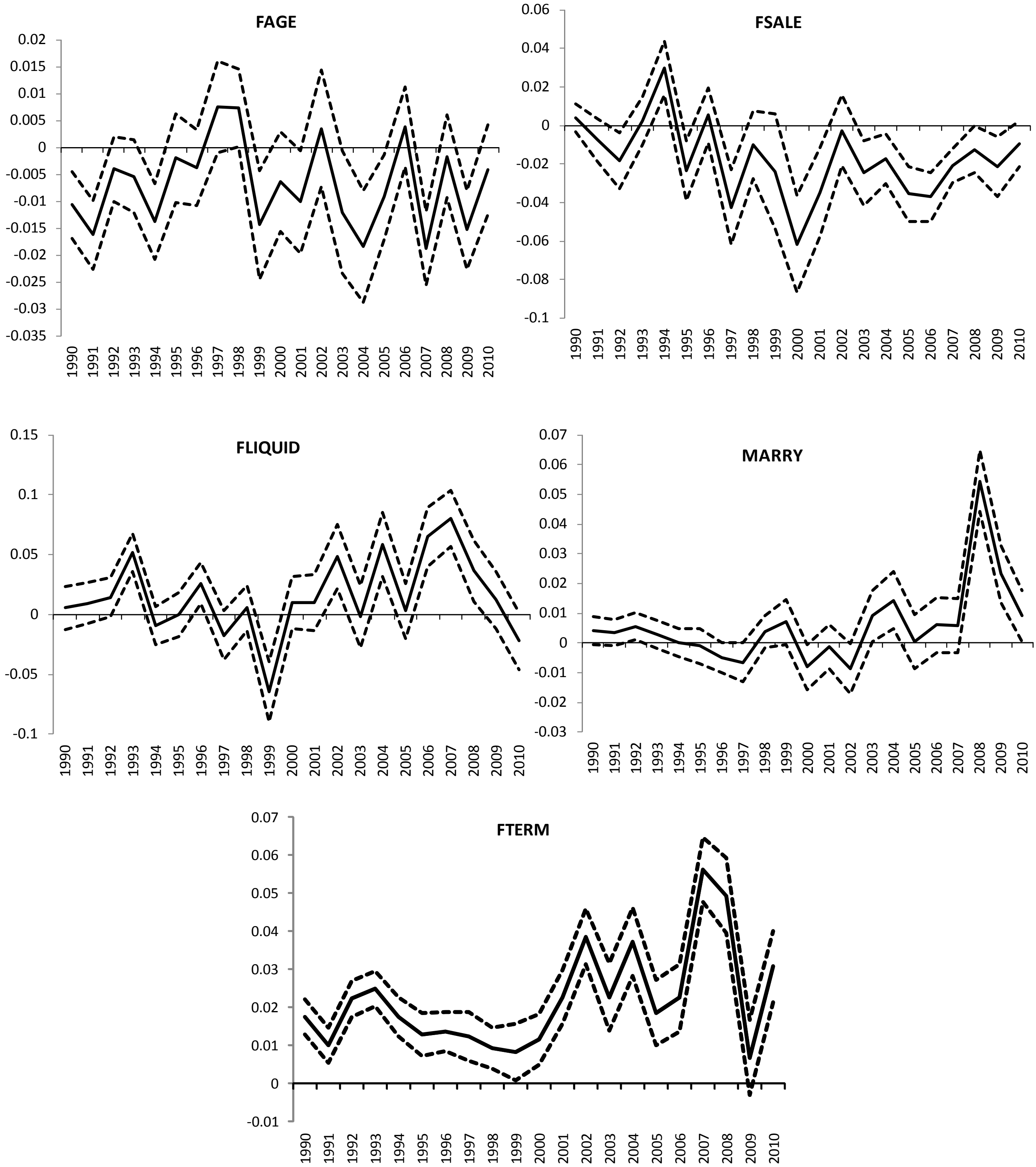

*Notes:* BLEV, MAJOR and BSIZE indicate the bank book leverage ratio, the dummy variable of a major bank, and the bank size variable, reslpectively. The solid line indicates a point estimate of AMEs for each covariate and the shaded area shows the 90% confidence interval of the estimate based on the rolling estimations of the baseline probit model.

**Figure 3-2. Firm Factors**



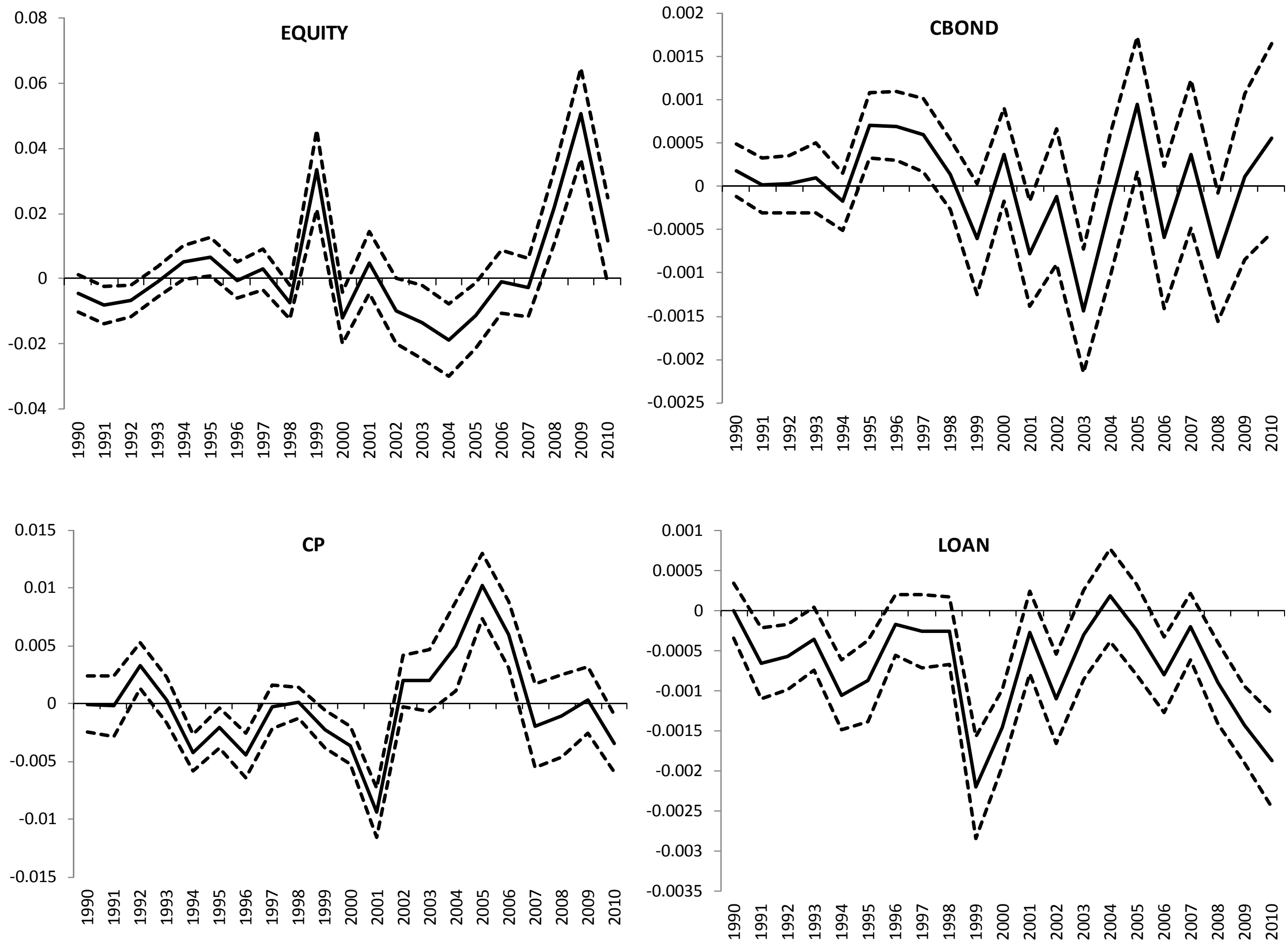

*Notes:* FLEV, Firm σ, FROA and FSIZE indicate the firm book leverage ratio, the firm volatility, the firm return on assets, and the firm size variable, respectively. The solid line indicates a point estimate of AMEs for each covariate and the shaded area shows the 90% confidence intervals of the estimates based on the rolling estimations of the baseline probit model.

## Figure 3-2. Firm Factors (continued)



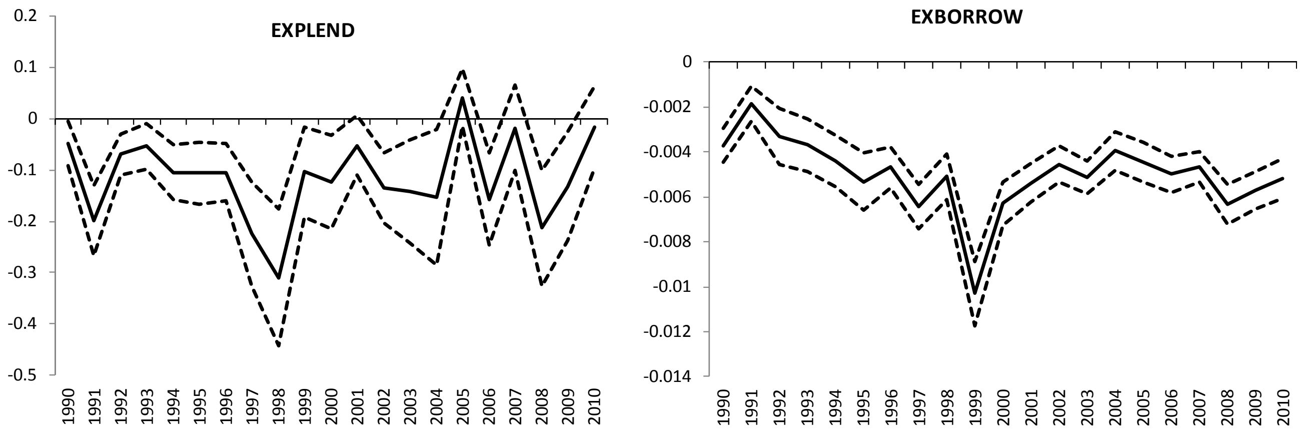

*Notes:* FAGE, FSALE, FLIQUID, MARRY and FTERM indicate the firm age, the firm sales growths, the firm liquid asset ratio, the firm marry indicator, and the firm terminatio indicator, respectively. The solid line indicates a point estimate of AMEs for each covariate and the shaded area shows the 90% confidence interval of the estimate based on the rolling estimations of the baseline probit model.

**Figure 3-3. Firm Funding Factors**



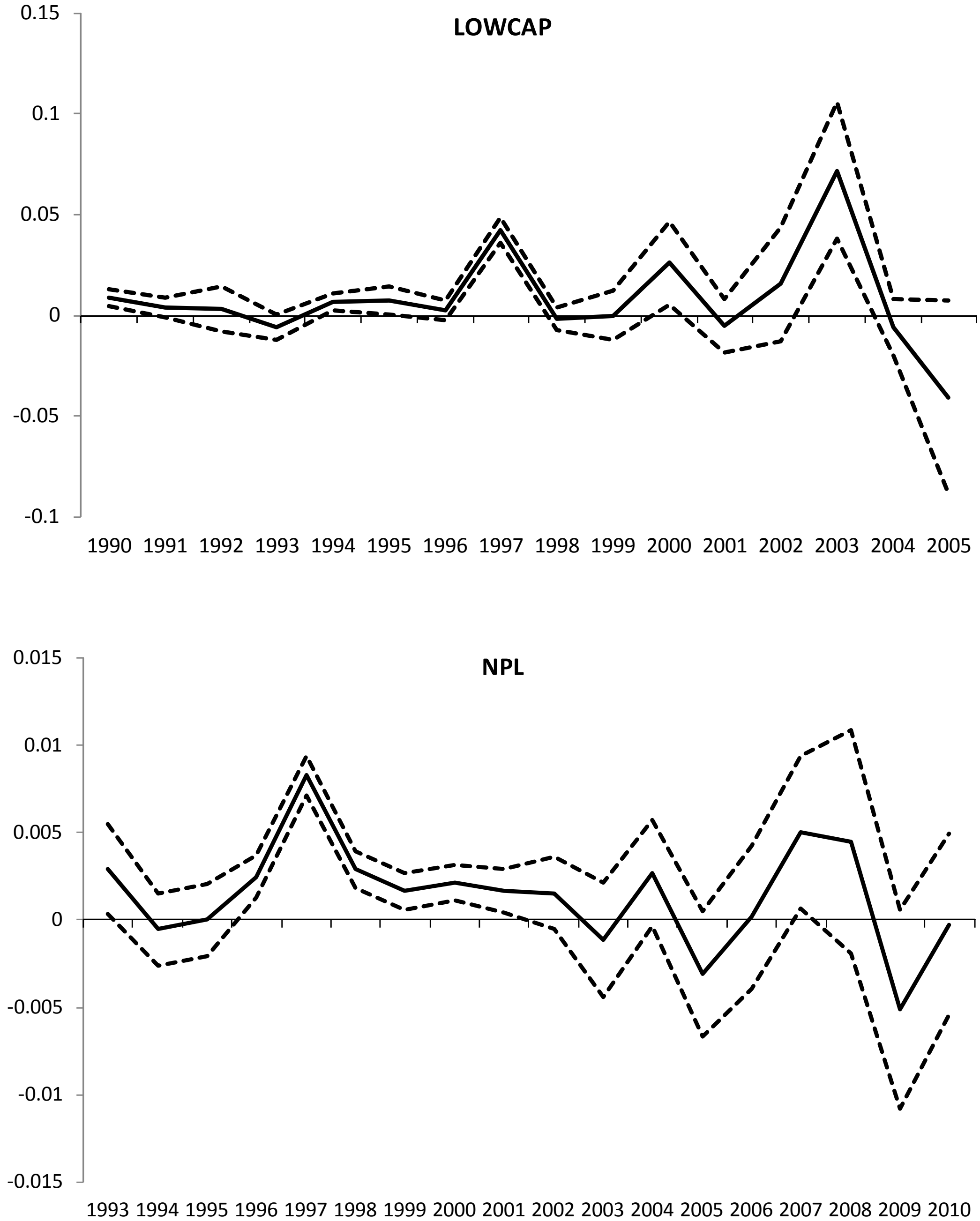

*Notes:* EQUITY, CBOND, CP and LOAN indicate the equity increase indicator, the corporate bond, the commercial paper, and the bank loan dependence variables, respectively. The solid line indicates a point estimate of AMEs for each covariate and the shaded area shows the 90% confidence interval of the estimate based on the rolling estimations of the baseline probit model.

**Figure 3-4. Relationship Factors**



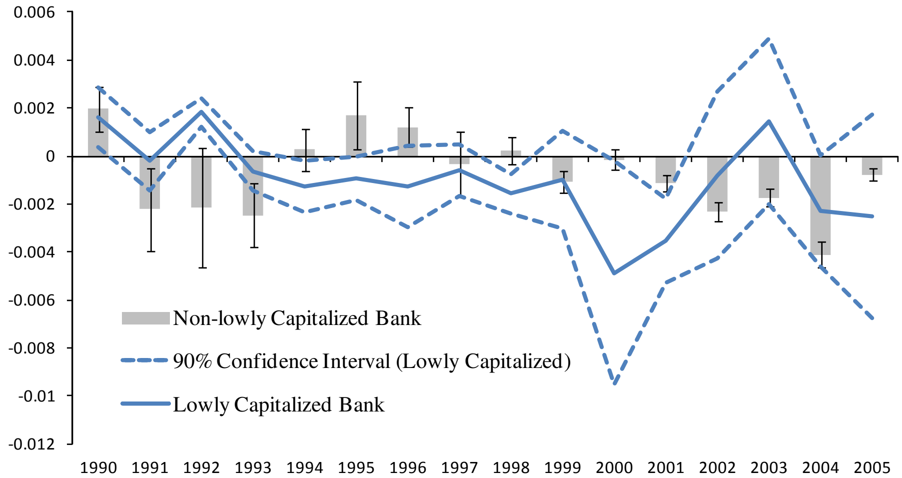

*Notes:* EXBORROW and EXLEND indicate the borrowing exposure of firms, and the lending exposure of banks, respectively. The solid line indicates a point estimate of AMEs for each covariate and the shaded area shows the 90% confidence interval of the estimate based on the rolling estimations of the baseline probit model.

**Figure 4. Estimated AMEs of the Lowly Capitalized Bank Dummy and the Nonperforming Loan Ratio**



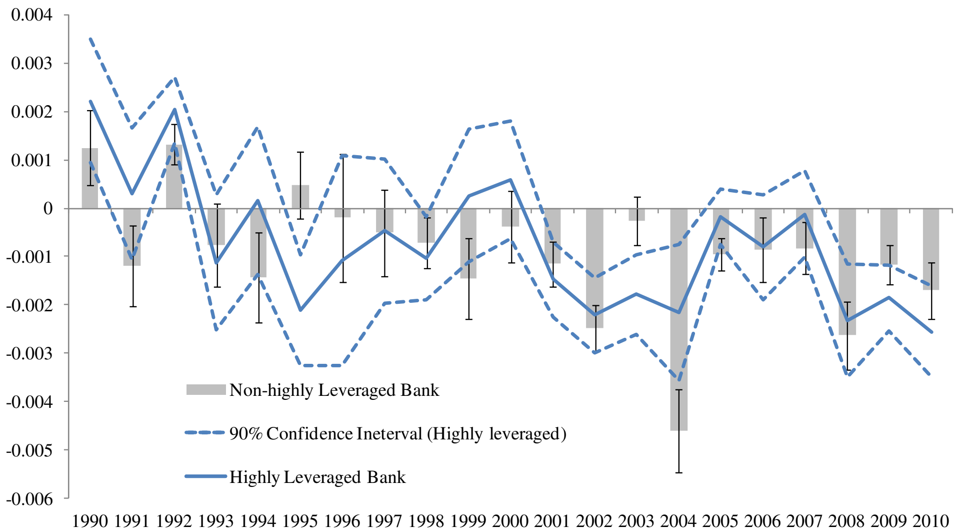

*Notes:* LOWCAP and NPL indicate the lowly capitalized bank indicator and the nonperforming loan ratio variable, respectively. The solid line indicates point estimates of AMEs for each bank variable and the dotted line indicates the 90% confidence interval of the estimates based on the rolling estimations of alternative models where the bank book leverage ratio is replaced with the lowly capitalized bank indicator (LOWCAP) or the nonperforming loan ratio variable (NPL). Since after 2006, almost all banks have zero values for the lowly capitalized bank variable, the estimation results after 2006 are not shown in this figure.

## Figure 5. Estimated AMEs of FROA for Lowly and Non-lowly Capitalized Banks



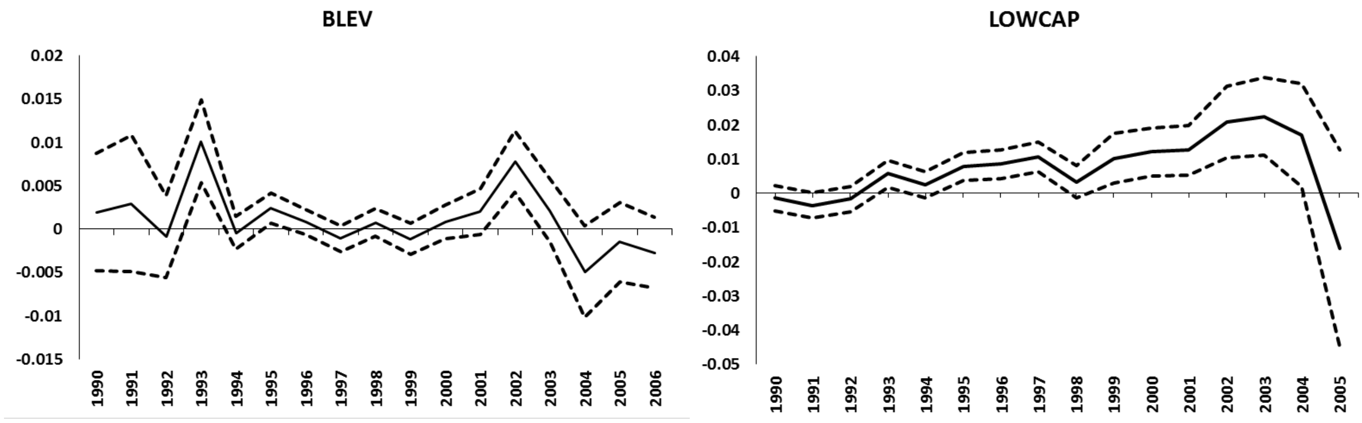

*Notes:* The solid line indicates point estimates of AMEs of the firm return on assets (FROA) for lowly capitalized banks and the dotted line indicates the 90% confidence intervals of the estimates. The gray bar indicates point estimates of AMEs of the firm ROA for non-lowly capitalized banks with error bars for the 90% confidence intervals. Since after 2006, almost all banks have zero values for the lowly capitalized bank variable, the estimation results after 2006 are not shown in this figure. The results are obtained by the rolling estimations of alternative models where the bank book leverage ratio is replaced with the lowly capitalized bank indicator and the interaction variable between the lowly capitalized dummy and the firm ROA is included.

## Figure 6. Estimated AME of FROA for Highly and Non-highly Leveraged Banks



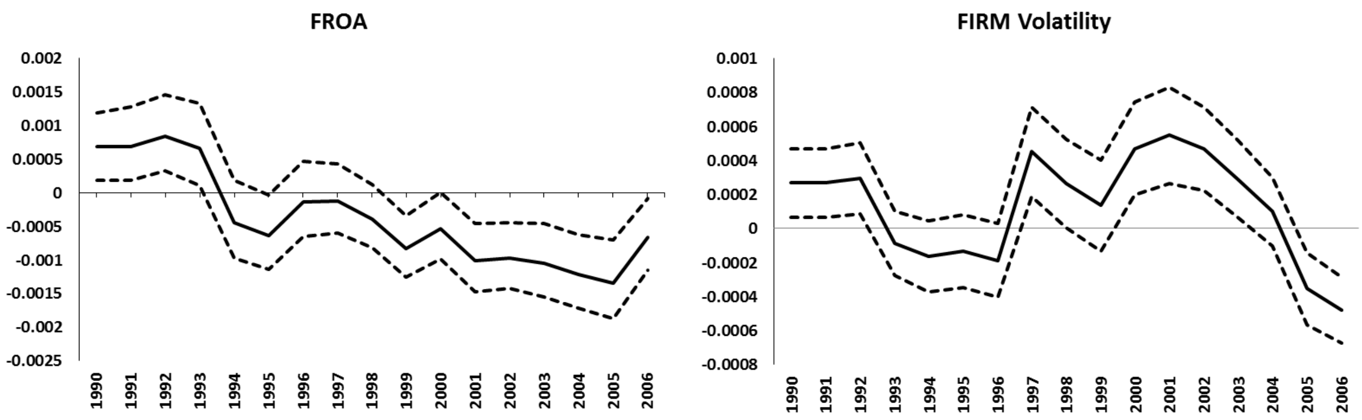

*Notes:* The solid line indicates point estimates of AMEs of the firm return on assets (FROA) for highly leveraged banks and the dotted line indicates the 90% confidence intervals of the estimates. The gray bar indicates point estimates of the AMEs for non-highly leveraged banks with error bars for the 90% confidence intervals.

**Figure 7. Estimated Effects of the Bank Leverage Ratio and the Lowly Capitalized Bank Indicator in the Linear Probability Model with FEs**



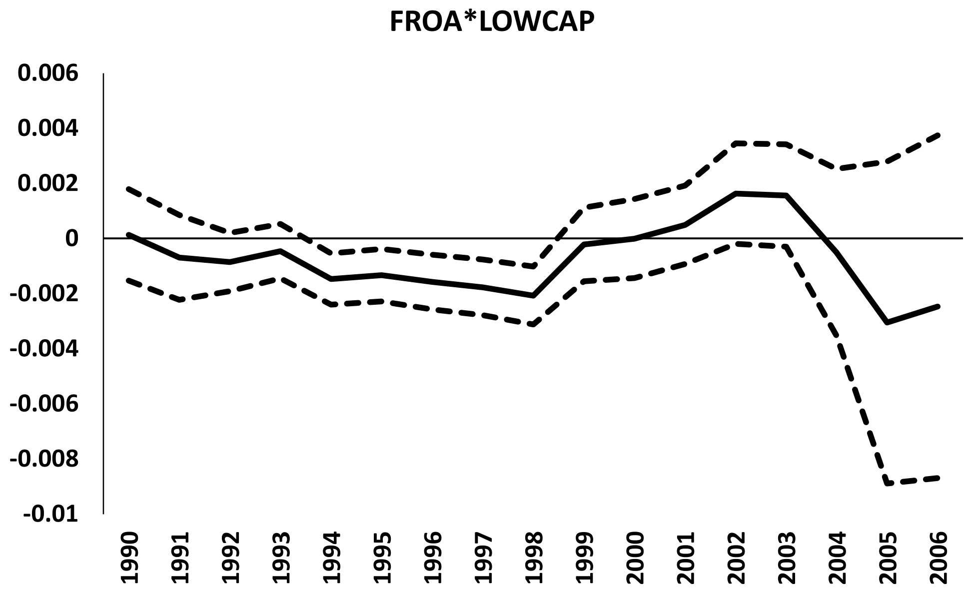

*Notes:* The solid line indicates a point estimate for the bank leverage ratio (BLEV) and the lowly capitalied bank indicator (LOWCAP) and the dashed line shows the 90% confidence intervals of the estimates based on the rolling estimations of the liner probability model (11). The X-axis indicates a starting year of each subsample period: A plot in year t shows an estimate based on the subsample period from year t through t+4.

**Figure 8. Estimated Effects of the Firm ROA and the Volatility of Firm Assets in the Linear Probability Model with FEs**



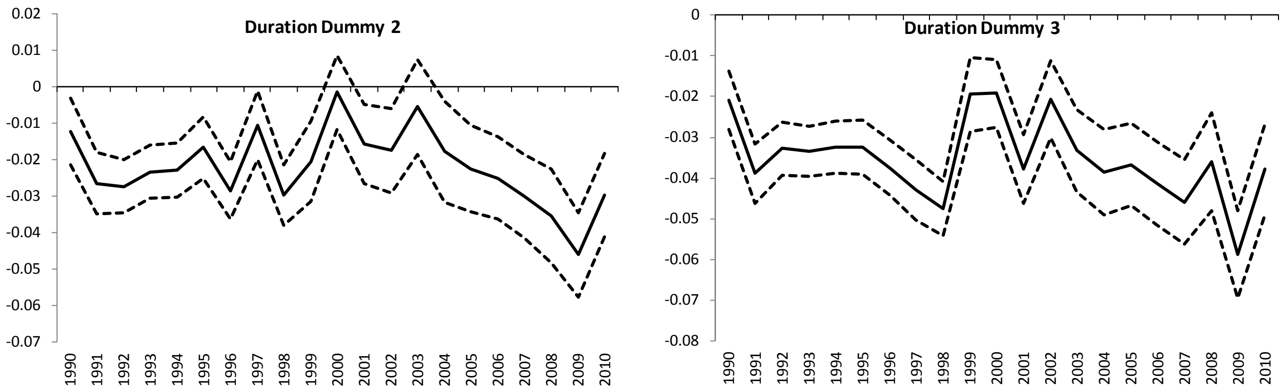

*Notes:* The solid line indicates a point estimate for the firm ROA (FROA) and the volatility of firm assets (Firm Volatility) and the dashed line shows the 90% confidence intervals of the estimates based on the rolling estimations of the liner probability model (12). The X-axis indicates a starting year of each subsample period: A plot in year t shows an estimate based on the subsample period from year t through t+4.

**Figure 9. Estimated Interaction Effects in the Linear Probability Model with FEs**



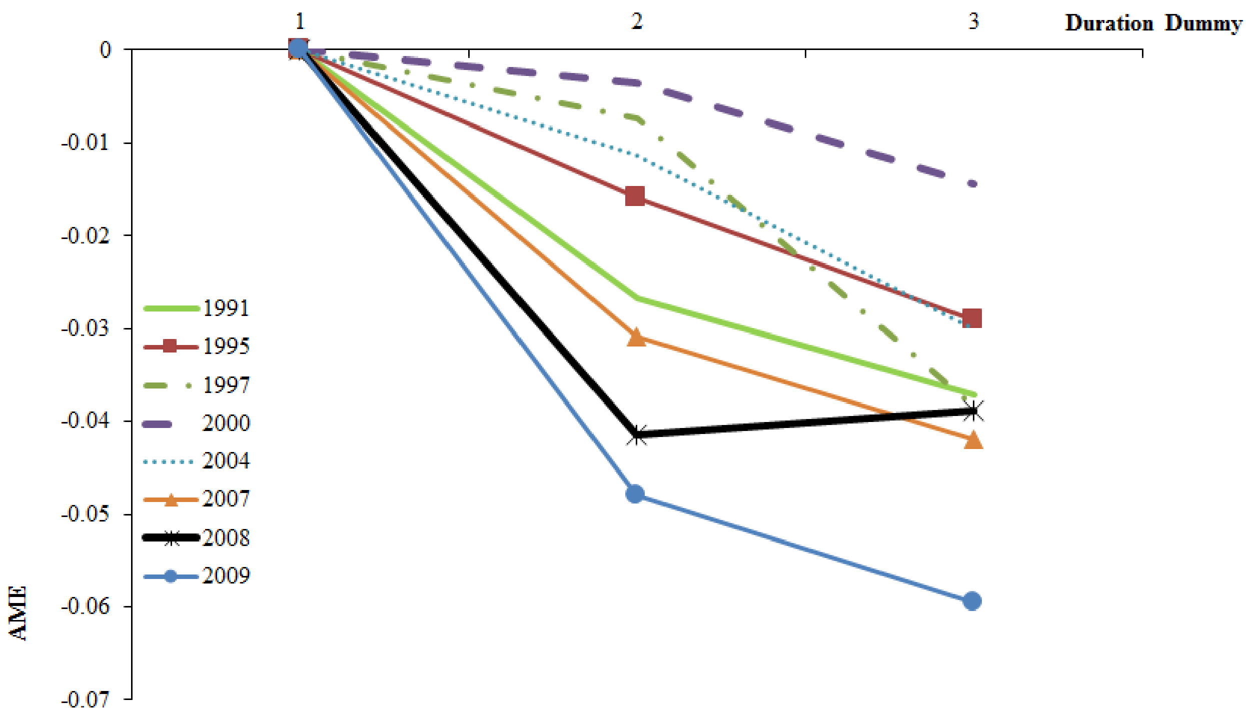

*Notes:* The solid line indicates a point estimate for the bank leverage ratio (BLEV) and the lowly capitalied bank indicator (LOWCAP) and the dashed line shows the 90% confidence intervals of the estimates based on the rolling estimations of the liner probability model (13). The X-axis indicates a starting year of each subsample period: A plot in year t shows an estimate based on the subsample period from year t through t+4.

## Figure 10. Estimated Duration Effects



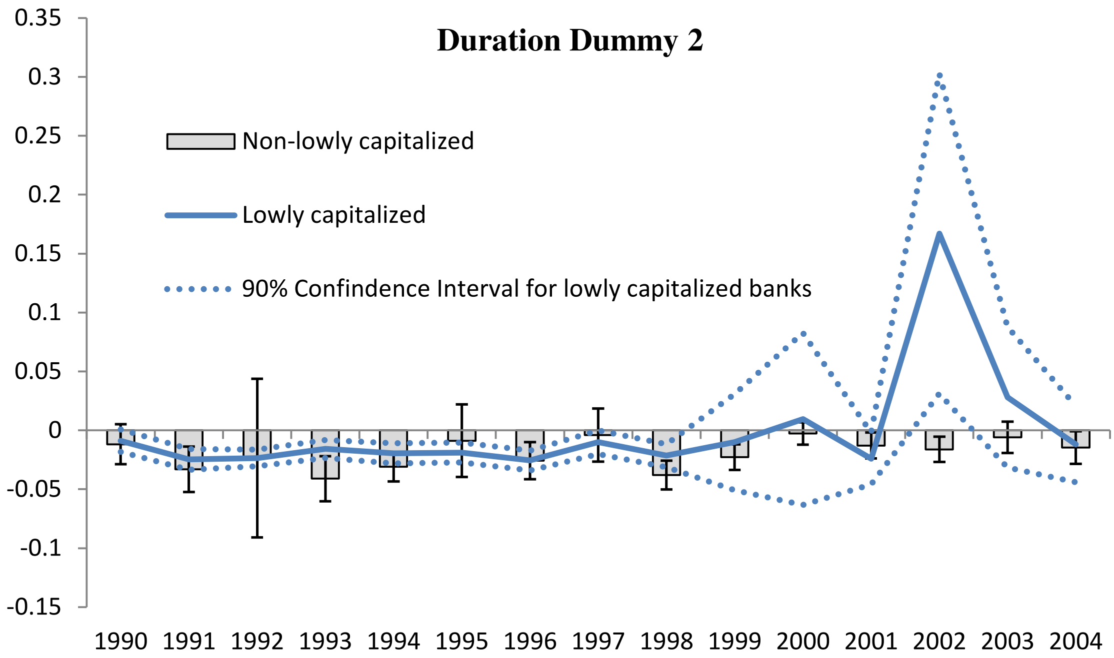

*Notes:* The solid line indicates point estimates of AMEs for duration dummy variables from the rolling estimations based on the baseline probit model and the dotted line indicates the 90% confidence intervals of the estimates. To calculate the AMEs, we used the shortest duration group as the reference.

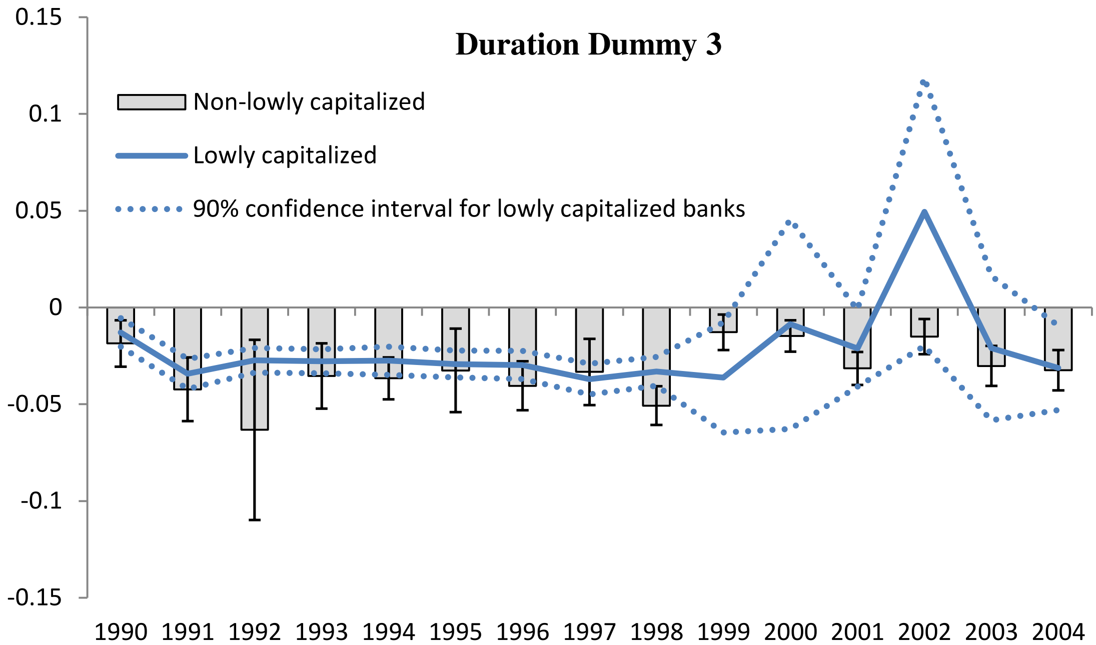
## Figure 11. Term Structure of Duration Effects for Selected Period




*Notes:* Each line indicates the point estimates of AMEs of the duration dummy variable for a specific fiscal year from the rolling estimations based on the baseline probit model.

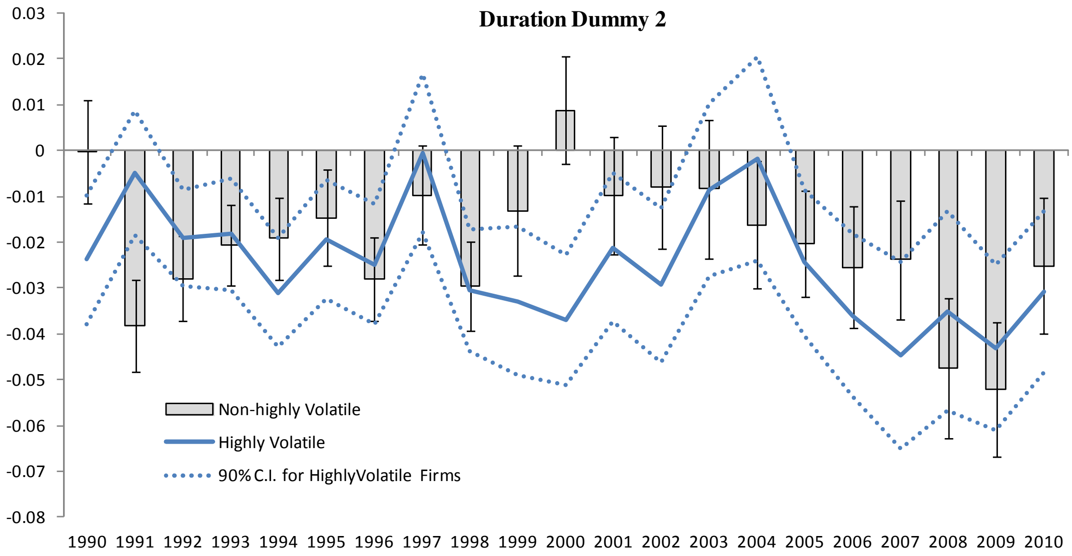
**Figure 12. Estimated Duration Effects by Bank Capitalization**

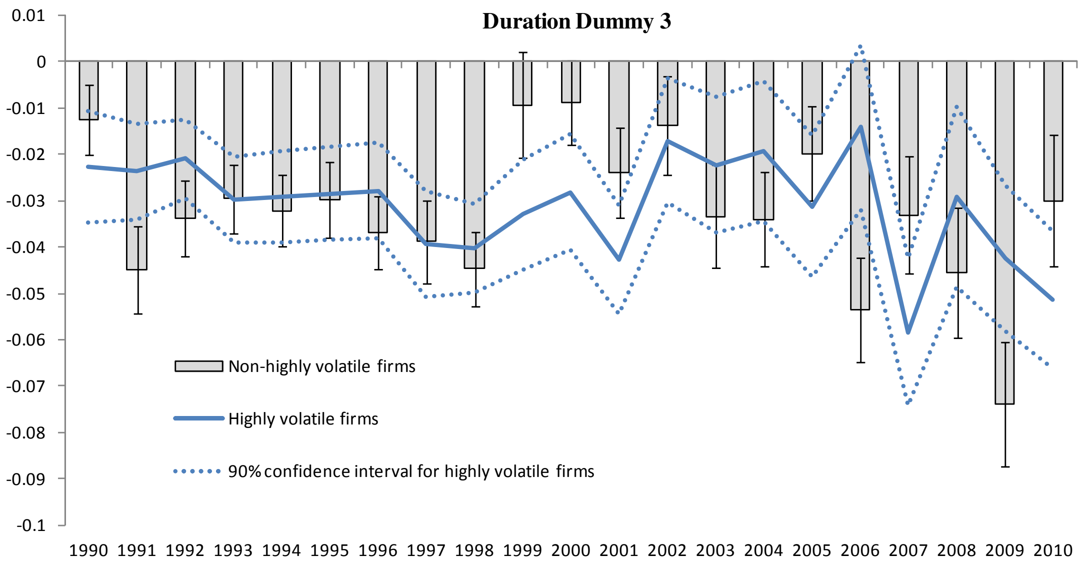



*Notes:* The solid line indicates point estimates of AMEs of the duration dummy variables for lowly capitalized banks and the dotted line indicates the 90% confidence intervals of the estimates. The gray bar indicates point estimates of AMEs for non-lowly capitalized banks with error bars for the 90% confidence intervals. The resutls are obtained by the rolling estimations of alternative models where the lowly capitalized bank dummy and the interaction variables between it and the duration dummy variables are included.

## Figure 13. Estimated Duration Effects by Firm Volatility




*Notes:* The solid line indicates point estimates of AMEs of the duration dummy variables for firms with higher volatility and and the dotted line indicates the 90% confidence intervals of the estimates. The gray bar indicates point estimates of AMEs for firms with lower volatility with error bars for the 90% confidence intervals. The results are obtained by the rolling estimations of alternative models where the firm volatility variable is replaced with the highly volatile firm indicator and the interaction variables between it and the duration dummy variables are included.