Bank of Japan Working Paper Series

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No.20-E-1
February 2020

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Bank Risk Taking and Financial Stability: Evidence from Japan's Loan Market*

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February 2020

Abstract

We examine banks' risk taking in lending to small and medium-sized enterprises under the prolonged low interest rate environment in Japan. Specifically, we identify "low-return borrowers," whose borrowing interest rates are low relative to their financial soundness. Using bank-firm level data for millions of Japanese small and medium-sized enterprises, we find that bank loans to low-return borrowers have increased more than those to other normal firms in recent years and such risk taking by banks has been driven by the low interest rate environment as well as the increase in competition among banks. In addition, we show that highly capitalized banks with low profitability increased loans to such vulnerable borrowers more than lowly capitalized banks. These results suggest riskiness of credit allocation has increased in Japan's loan market, but it does not seem to pose an immediate threat to financial stability.

JEL classification: G21, E52, E44
Keywords: risk-taking channel; bank competition; credit allocation; low interest rate

*The authors are grateful to Silvio Contessi, Yoshihiko Hogen, Yoshitaka Ichise, Daisuke Ikeda, Hirohide Koguchi, Mitsuhiro Osada, and participants at the 12th Annual Workshop of the Asian Research Network for their helpful suggestions. Any remaining errors are ours. The views expressed are those of the authors and do not necessarily reflect those of the Bank.

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1 Introduction

The accommodative monetary policy implemented in both developed and developing economies after the Global Financial Crisis (GFC) has supported the subsequent economic recovery. Japan has also experienced a sustained economic expansion under the Bank of Japan's (BOJ's) aggressive monetary easing.

Accommodative monetary policy, however, can create an intertemporal trade-off between improving current financial conditions and increasing future financial vulnerabilities (Adrian and Liang (2018) and International Monetary Fund (2018)). Although the risk-taking behavior of banks under the accommodative policy facilitates an improvement in firms' financial condition, excessive risk taking by banks could lead to the accumulation of imbalances in the financial sector. These imbalances could result in increasing the financial system's vulnerability to adverse shocks by undermining banks' loss absorbing capacity and their resilience to those shocks. Therefore, examining potential vulnerabilities arising from banks' risk taking under loose financial conditions has become increasingly important from a macroprudential perspective. In addition, Japanese banks have suffered from an underlying decline in their profitability of loan businesses against the background of rapid aging as well as a decrease in population and the number of firms. Not only the prolonged low rate environment but also these structural factors have increased banks' incentive of risk taking in the loan market.

Under these circumstances, this paper examines the risk-taking behavior of banks in terms of the "quality" of loans to small and medium-sized enterprises (SMEs).[1] Specifically, we identify "low-return borrowers" and investigate the mechanism of the recent increase in such loans by focusing on the macroeconomic and financial environments as well as the risk profile of lending banks. Using a large set of bank-firm level data for Japanese SMEs, we define a low return borrower as a firm whose borrowing interest rate is low relative to its credit risk. And we then examine what factors drive credit supply to these firms.

We find that loans outstanding whose interest rates are not commensurate with the credit risks of the borrowing firms increased more than those with relatively high interest rates after 2010. In this period, with the economy recovering from the downturn after the GFC, interest rates continued to decline due to the unconventional monetary policy. In fact, we show that the increase in lending to low-return borrowers has been mainly driven by the low interest rate environment as well as intensified competition among banks. In terms of the risk profile of banks engaged in

[1] In this study, we focus on loans to SMEs for the following reasons. First, Japanese banks—especially regional banks—have actively extended loans to SMEs, which has contributed to a sustained increase in total lending. Second, bank loans play an important role in the credit supply to SMEs while large firms have become increasingly less dependent on the bank loans.

lending to such borrowers, we show that banks with decent capital have been more likely to increase loans to such borrowers. This finding sharply contrasts with one in the zombie lending literature, which found that less capitalized banks increased more loans to the zombie firms for the purpose of avoiding the realization of credit costs in the late Japanese 1990s. Contrary to such evergreening loans, the recent increase in low-return borrowers by highly capitalized banks can be interpreted as an outcome of the risk-taking channel of the accommodative monetary policy. Furthermore, from a macroprudential perspective, it is natural that well-capitalized banks take more credit risks, reflecting their high loss-absorbing capacity. Thus far, risk taking by these well-capitalized banks does not seem to pose an immediate threat to financial stability. However, if such behavior persists, potential vulnerabilities may build up making the financial system more prone to amplifying negative shocks.

The contribution of this paper is threefold. First, we contribute to the literature on the relationship between financial stability and the risk-taking channel of monetary policy. We show that the risky lending to low-return borrowers have been driven by the intensifying competition among financial institutions as well as the low interest rate environment. This finding indicates that severe competition could intensify search-for-yields behavior by banks and lead to deterioration in the credit quality. Therefore, the intertemporal trade-off between stimulating current economic activity and increasing future financial vulnerability can be made more severe by the competition in the loan market.

Second, we investigate the characteristics of banks that increased loans to low-return borrowers in terms of profitability as well as the soundness of their balance sheet. We find that banks with lower profitability and higher capital adequacy ratio are more likely to increase loans to risky firms. This finding implies that banks with sound balance sheets are willing to increase risky loans with the aim of maintaining their current profits. While existing studies show that the capital adequacy ratio significantly affects banks' risk-taking behavior, our paper demonstrates that the profitability and its interaction effect with the capital ratio are also crucial to understand their behavior. These findings provide a new important insight into the risk-taking behavior of banks in an economy with low interest rates and lackluster loan demand.

Third, we extend the identification strategy in the zombie lending literature in order to quantify the extent of misallocation in the loan market by taking into account both firms' financial soundness and the levels of their borrowing interest rates. We argue that an absolute criterion, which is commonly used in the existing studies for identifying distressed firms, is not suitable for examining potential risks in

the current Japanese loan market.[2] We introduce simple but appropriate criteria to identify firms whose borrowing rates are low relative to their credit risks. Specifically, by comparing a firm's borrowing interest rate and financial soundness with those of other firms in the same category (categorized by firm size, industry and fiscal year), we provide an appropriate proxy for credit quality that reflects the risk-taking stance of banks.

The remainder of this paper is organized as follows. In section 2, we provide a brief overview of the literature related to our study. In section 3, we discuss the definition and the methodology for detecting low-return borrowers. Section 4 presents the recent changes in the exposure to such borrowers and introduces our econometric models. In section 5, we analyze what is driving such increase in loans to low-return borrowers from the supply-side. Section 6 provides our conclusion.

2 Related Literature

In this paper, we further develop the identification strategy of credit misallocation that is employed in the zombie lending literature. Previous studies, including Peek and Rosengren (2005), pointed out that Japanese banks continued evergreen lending to low-profit firms to avoid insolvency in the aftermath of the severe banking crises.

This perverse lending attracted a number of studies, which explored the causes and consequences of evergreen lending to inefficient firms. Using microdata, Sekine et al. (2003) show that evergreen lending lowers firms' profitability. Caballero et al. (2008) report that a higher zombie firm ratio is associated with lower productivity growth in the industry. Kwon et al. (2015) conclude that aggregate productivity growth in Japan would have been one percentage point higher without zombie lending.

Prior to the GFC, most studies focused on the experience of Japanese banks in the late 1990s. The increase in non-performing loans (NPLs) in some European countries since the GFC have drawn new attention to the increase in zombie firm lending. Much of the existing literature, including recent studies in European countries, has mainly focused on quantifying the extent of credit misallocation based on an indicator of current financial condition, such as ICRs (Andrews and Petroulakis (2017), Storz et al. (2017), Schivardi et al. (2017), Banerjee and Hofmann (2018)), financial support a la Caballero et al. (2008), or a combination thereof (Acharya et al. (2019), Kwon et al. (2015), Fukuda and Nakamura (2011)).[3] Zombie lending is

[2] See Section 3 for details on the identification strategy.

[3] The identification methodology based on ICRs seems problematic as it conflicts with the notion of excessive financial support through low interest rates, which was originally proposed by Caballero et al. (2008). Given a certain level of profit and leverage, low interest rates imply a higher ICR.

an immediate risk for banks in the sense that banks are likely to incur credit losses if they stop providing loans to those firms.

However, such evergreening incentive is unlikely to be the driving force behind recent risky lending by Japanese banks. Under the bank revival plan, the so-called Program for Financial Revival, led by the government in the early 2000s, Japanese banks reduced NPLs drastically (Figure 1). Partly because of their experiences in the banking crisis in the late 1990s and the early 2000s, Japanese banks suppressed risk taking even during the boom period before the GFC. Indeed, most Japanese financial institutions remained relatively resilient during the financial turmoil that started in 2007 (Bank of Japan (2009)). Furthermore, the prolonged boom periods in Japan and overseas from 2012 helped banks to accumulate capital through low credit costs and capital gains from risky assets including stocks. Against this backdrop, Japan's recent loan market appears to be dominated by a different mechanism from that shown in the literature on forbearance lending, which is based on banks' motivation to avoid the realization of credit losses.

One of the possible hypotheses to explain the increase in loans to low-return borrowers after 2010 is the risk-taking channel of monetary policy and the search-for-yields behavior of banks that face chronic stress from decreases in the population and the number of firms. In the literature, a growing number of studies examine the effects of accommodative monetary policy on risk taking by banks. Among others, using Spanish loan-level data, a seminal paper of Jiménez et al. (2014) find that low policy rates lead to risk taking by highly leveraged banks. On the other hand, based on U.S. loan level rating data, Dell'Ariccia et al. (2017) show that highly capitalized banks are more likely to increase risk taking in credits. Maddaloni and Peydró (2011) also show that low short-term interest rates ease the standard of loans and such tendency is amplified by securitization.[4]

Our paper adds new insights on this strand of literature on the risk-taking channel of banks by focusing on the interaction between banks' profitability and their balance sheet soundness under the low interest rate environment. We also show that not only the low interest rate environment but also the intensified competition among banks is an important driving factor behind their risk taking.[5] Furthermore,

Therefore, identifying firms with a low ICR as zombie firms implicitly assumes that banks' lending behavior is not distorted in terms of loan pricing. On the other hand, the ICR-based studies point out that banks' behavior is distorted in terms of credit allocation measured by loan volume. These opposite views on banks' behavior should be reconciled somehow if we are to rely on ICRs.

[4]For theoretical studies on the risk taking channel, See Dell'Ariccia et al. (2014) and Martinez-Miera and Repullo (2017).

[5]Altunbasa et al. (2014) investigate the effects of prolonged low interest rate periods on banks' risk profiles by using Expected Default Frequency. They control competition among banks when estimating the effects of low interest rates on banks' risk. However, they did not investigate why and how banks' default risk increased.

our data cover periods of unconventional monetary policies while the existing papers mainly used data from periods of conventional policy, which allows us to gain a better understanding on lending behavior under the extremely accommodative financial environment.[6]

Few empirical studies investigated the risk-taking behavior under the low interest rate environment based on bank-firm matched data in Japan. Using bank-firm matched data, Aoki et al. (2016) find that a decrease in long-term interest rates is associated with an increase in lending to risky firms. Using Japanese data for listed firms, Hosono and Miyakawa (2014) investigate the effect of monetary policy easing on risky lending. These papers focused on the effects of low interest rates or monetary policy. On the other hand, our paper investigates not only the effect of low interest rates but also the intensifying competition among banks by including both variables in our econometric specification. If we omit one of the factors, we would fail to identify the effects correctly as those two factors are closely related to each other.[7] Thus, our paper allows us to understand comprehensively the lending behavior of banks that face low interest rates and intensifying competition.

3 Data and definition of low-return borrowers

The first step in our analysis is to quantitatively assess credit allocation to less solvent borrowers by evaluating the quality of credit at the firm level and its relationship with borrowing interest rates. To this end, we identify firms whose borrowing cost is low relative to their credit condition. We define such firms as "low-return borrowers" since the loan interest rate on such firms may not match with their credit risks and therefore are likely to end up being "low-return" ex post from the lender's perspective. In this Section, we explain the definition of low-return borrowers and the firm-bank matched data used in our analysis. Then, we calculate the credit allocation to low-return borrowers and show that the ratio of loans to such firms has increased from 2010.

In this paper, we focus on lending to SMEs. This is because the increase in loans to SMEs is a main driving force behind the recent increase in total loans, and more and more large firms are not relying on bank loans, as discussed in the introduction. Therefore, evaluating banks' risk-taking behavior in SME loans is important in terms of macroprudence and the impacts on macroeconomy.

[6] Chodorow-Reich (2014) investigates the risk-taking channel of unconventional monetary policy using the data for financial institutions such as insurance companies.

[7] A number of papers studied the effect of competition on banks' risk taking empirically (e.g., Jiménez et al. (2013)) and theoretically (e.g., Boyd and De Nicolo (2005), Martinez-Miera and Repullo (2010)).

3.1 Data

We make use of two distinct data sets in our analysis: firm-level data with lender information provided by Teikoku Databank (TDB) and bank-level data compiled by the Bank of Japan. The firm-level data cover major financial statements and some basic information such as the number of employees. The data also include information on lender-borrower relationships, which enables us to identify the amount of loans provided to low-return borrowers. The bank-level data collected by the Bank of Japan covers comprehensive financial data for all major, regional and small local banks, the so-called *shinkin* banks, in Japan. Our data cover fiscal years 1999 to 2016.

3.2 Identifying low-return borrowers

"Low-return borrower" are identified in light of firms' performance as measured by profitability and leverage as well as their interest rate expenses. Specifically, we define low-return borrowers as firms who satisfy both interest rate and financial soundness criteria.

- Interest rate criterion: The firm's borrowing interest rate is below the median rate of the most creditworthy firms. We use the median borrowing interest rate of creditworthy firms as a benchmark (quasi-prime rate), in order to judge whether the firm's borrowing interest rate is too low relative to the borrower's credit risk. More concretely, in each year, creditworthy firms are defined as those with a return on assets (ROA) within the top 10th percentile or with a leverage ratio lower than the median in each firm group categorized by the firm's industry. We use the ROA and leverage ratio as a measure of firms' creditworthiness as they are strongly associated with firms' defaults.

- Financial soundness criterion: A firm is classified as a risky firm if the firm's ROA is lower than the median or its leverage is higher than the median of each firm group categorized by industry.

We label a firm as a low-return borrower if the firm satisfies both interest rate and financial soundness criteria for two consecutive years. If we defined borrowers using information from a single fiscal year, we might label a firm whose profit happened to be struck by a transitory idiosyncratic shock as a low-return borrower.

Our first criterion follows the literature indicating that zombies are receiving subsidized credit (Caballero et al. (2008)). If the interest rate on loans to firms with relatively poor economic performance is lower than the quasi-prime rate, such loans would not be appropriately priced. In particular, such loans are likely to be provided

on the excessively optimistic premise that the favorable macroeconomic conditions and the low interest rate environment will continue in the future.

The second criterion rests on the notion that firms with low profitability and/or high leverage are more likely to experience default. Previous studies on firm defaults (e.g., Jacobson et al. (2013)) found that major financial indicators such as ROA and leverage significantly affect the probability of default. Therefore, firms with poor performance are more likely to default and hence are required to pay a higher credit premium.

Rather than defining low-return borrowers as those with both a low ROA and high leverage, we label a firm as a low-return borrower if *either* (i) has a low ROA and satisfies interest rate criteria or (ii) has high leverage and satisfies interest rate criteria. This allows us to identify vulnerable firms in a conservative manner. Further details on the definition and identification method of low-return borrowers are provided in the Appendix.

3.3 Differences in the definition of low-return firms from previous studies

The seminal paper of Caballero et al. (2008) in the credit misallocation literature used solely the interest rate criterion to define zombie firms. Furthermore, they defined hypothetical prime rates using market interest rates and "prime rates" in the Bank of Japan survey. However, as Fukuda and Nakamura (2011) pointed out, such single criteria do not take into account the fact that a well-performing firm could obtain loans with low borrowing interest rates simply because its credit risk is substantially low. In fact, recent papers such as Kwon et al. (2015) have used criteria similar to ours to define zombie firms. In this paper, the second financial soundness criterion enables us to avoid misspecifying a well-performing firm as a low-return firm. Furthermore, as the first criterion is based on the observed borrowing interest rates for well-performing firms, we can address the mismeasurement problem of prime rates.

Recent studies measure the distortion in the credit allocation to insolvent firms based on the interest payment ability of the borrowers. For example, Andrews and Petroulakis (2017) identify zombie firms using the interest coverage ratio (ICR). Although the ICR allows us to identify firms that are already in trouble, credit risks in loans may be underestimated. For example, banks might lower interest rates because otherwise a firm would become insolvent. In that case, the firm's ICR would improve although it is distressed; in other words, the ICR is contaminated by the endogenous response of banks lowering their lending rate to insolvent firms.

However, the Japanese economy has seen secular downward trends in economic

growth and interest rates during the sample period including several severe recessions. Therefore, identification of low-return firms that relies on an absolute measure would lead to labeling a large portion of firms as "low-return" borrowers in recent years. For example, with a criterion based on an absolute level of return on assets (ROA), more firms could be categorized as low-return borrowers due to the deterioration of firms' performance when the economy is in recession. In addition, with a downward trend in potential growth rates, firms' profitability is likely to decline. Therefore, in a case where a threshold is defined as an absolute level of firms' profitability, more and more firms could fall under the threshold simply reflecting the lower potential growth rates. To tackle this misidentification problem, we opt to use relative measures by comparing interest rates and performance among firms of the same industry categories in each year.[8]

3.4 Credit allocation to low-return borrowers

We apply the identification strategy described in the previous section and examine the development of the credit allocation to low-return borrowers from the early 2000s.

Table 1 summarizes the major indicators for different types of borrowers. Low-return borrowers have lower labor productivity as their profitability is lower than the rest of the borrowers. However, low-return borrowers have a larger amount of loans, which is also reflected in high leverage ratios. In addition, the interest coverage ratio (ICR) of low-return borrowers is significantly lower than one. This indicates that low-return borrowers will be left with losses after paying interest expenses.

Despite the fact that low-return borrowers are vulnerable in terms of financial indicators, lending interest rates to such borrowers are in fact lower than other borrowers: the interest rate gap between low-return borrowers and other borrowers is larger than one percentage point. This fact strongly supports our hypothesis that low-return borrowers are not paying a sufficient credit premium in spite of their financial vulnerability. In addition, the hypothesis is confirmed by a survey conducted by the Bank of Japan on regional financial institutions as discussed in Bank of Japan (2018). Bank of Japan (2018) shows that banks with a high share

[8]In a booming period, our definition of low-return borrowers based on the relative criterion theoretically could lead to overestimation of loans whose interest rates are not commensurate with credit risks. For example, suppose that all firms become highly profitable and even a relatively low profitable firm generates high return in an absolute measure, and then their lower borrowing rates can be justified. However, as shown in Table 1 and pointed out by Bank of Japan (2018), this is not the case: the level of profitability of low-return borrowers has remained low even in the prolonged macroeconomic expansion and no substantial upward shift in the distribution of firms' profitability has been observed. Therefore, our criterion does not suffer from the overestimation problem due to an upward shift in profitability for all firms.

of loans to low return borrowers are more concerned about the possibility that their loan interest rates do not match the average credit costs. This suggests that our identification strategy successfully captures loans whose interest rates are not commensurate with the risks involved.[9]

To analyze the credit allocation to low-return borrowers, we should take into account the fact that such borrowers tend to be highly leveraged. In fact, Figure 2 shows that the loan share of low-return borrowers—which is calculated by dividing the amount of loans outstanding to low-return borrowers by the total SME loans—has clearly increased from 2010.

We split the sample period into two separate phases before and after 2010, and analyze the share of low-return borrowers for each phase. In the early 2000s, the share of low-return borrowers steadily decreased from the highest level in 2001. In the 1990s, banks were still able to maintain loans to distressed firms with relatively low interest rates partly because the pressure from regulatory authorities to write-off bad loans was not strong (see Hosono and Sakuragawa (2005) for example).

However, as we discussed in Section 2, the restructuring plan led by the government forced banks to decrease loans to low-return borrowers. In addition, the sustained economic recovery until the GFC allowed banks to reduce such loans through an increase in interest rates (i.e., a switch to non-low interest rate loans) or improvements in firms' performance (i.e., a switch to non-distressed firms).

In the severe recession after the GFC, the loan share of low-return borrowers hit the bottom in 2010. Such a decline in the share of low-return borrowers had emerged due partly to the re-shuffling effect; the unprecedented adverse shocks struck not only low-return firms but also normal (non-low-return) firms and some normal firms' ROA temporarily dropped more than that of low-return borrowers. This led to the re-shuffling of the ROA order among those firms. Thus, some previous low-return firms came to no longer satisfy the relative low-performance criterion because firms must satisfy the low ROA criterion for two consecutive years in order to be categorized as low-return borrowers.

On the other hand, from 2010, the share increased persistently and marked close to 25% in 2016. The increase in the credit allocation to low-performing firms is not explained in the same manner as the increase observed in Europe after the GFC. As Figure 1 indicates, the NPL ratio among Japan's banks in recent years is very low

[9]In order to identify low-return borrowers, we do not rely on the calculation of lending costs, which include a wide range of expenses such as personnel expenses and office rental fee. This is partly because it is difficult to obtain a precise measure of lending costs and partly because our focus is on potential costs that could entail under a stress event rather than observed costs. In addition, we include bank fixed effects in our estimation as explained in Section 4, to take into account the possibility that some banks can offer lower interest rates due to high efficiency in their lending business.

and the capital ratio has been well above the regulatory requirement. Given these facts, we need different explanations from those used in the previous literature on zombie lending. In the following sections, we propose our explanation for the recent increase in the credit allocation to low-return firms by focusing on the effects of the low-interest rate environment, the competition among banks, and the prolonged expansion of the economy.

4 Empirical results for banks' risk taking

In the previous section, we showed the fact that the loan share of low-return borrowers has increased since 2010. In the following analysis, we link these borrowers with banks and investigate factors that have contributed to the increase in lending to low-return borrowers. To this end, we illustrate briefly the construction of the bank-firm matched data and the econometric model. Then, we propose possible explanations for the increase in lending to low-return borrowers.

4.1 Bank-firm matched data

In order to analyze the credit allocation to low-return borrowers from the loan-supply side perspective, first we match the borrowing firms with their lending banks. Then, we calculated the lending exposure of each bank to low-return borrowers. The details of the calculation of the bank-level exposure to low-return borrowers are provided in the Appendix.

Summary statistics for the data on the linkage between low-return borrowers and their banks are provided in Table 2. In the table, banks are divided into two groups according to the size of their exposure to low-return borrowers: the high-exposure group consists of banks whose exposure to low-return borrowers falls in the upper fourth quartile, while others are classified as the low-exposure group.

Two distinct features are worth mentioning in Table 2. First, banks in the high-exposure group have higher capital ratios. This sharply contrasts with the past finding in the literature that evergreen lending is undertaken mainly by lowly capitalized banks. Second, banks with higher exposure have a lower ROA although they have higher capital asset ratios. These two facts imply that the window-dressing motivation cannot explain banks' risk-taking behavior in lending to low-return borrowers. Rather, we show that chronic stresses such as the low interest rate environment and decreasing loan demand play an important role in the risk-taking behavior of banks.

4.2 Econometric model

To investigate the driving forces behind movements in loans to low-return borrowers, we introduce a simple econometric model. In addition, we construct the banks' lending competition indicator by exploiting the bank-firm matched data.

4.2.1 Model for the share of loans to low-return borrowers

Our focus is on the credit allocation between normal firms and low-return firms. Therefore, a dependent variable in our baseline model is the share of loans to low-return borrowers in bank i's total loans. Specifically, the share is defined as follows:

$$LSHARE_{i,t} = \frac{\sum_{j \in J_{i,t}} LowReturnLoan_{ijt}}{Loan_{i,t}}, \tag{1}$$

where $LowReturnLoan_{ijt}$ indicates the amount of loans to low-return firm j at time t from bank i and $Loan_{i,t}$ indicates the total SME loans of bank i. In addition, J_{it} indicates a set of low-return borrowers to whom bank i makes loans at time t. We should note that the variable of our interest, namely the outstanding amount of loans to low-return borrowers, changes gradually because the data include loans with a maturity of more than a year. Therefore, we use a dynamic panel model of loans to low-return borrowers with bank fixed effects as follows:

$$LSHARE_{i,t} = \alpha_i + \beta_1 LSHARE_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 YIELDS_{t-1} + \beta_4 GAP_{t-1} + \epsilon_{i,t}, \tag{2}$$

where $LSHARE_{i,t}$ indicates the share of loans to low-return borrowers in bank i's total loans, $X_{i,t-1}$ denotes a vector of bank i's variables. $YIELDS_{t-1}$ and GAP_{t-1} indicate the 5-year government bond yield and output gap, respectively. These two macroeconomic variables are included to capture the effects of the low interest rate environment and prolonged economic expansion. α_i denotes bank i's fixed effect, and ϵ_{it} indicates error term.

In addition, to check the robustness of the results, we also use the following simple fixed effects model without lagged dependent variables,

$$LSHARE_{i,t} = \gamma_i + \delta_1 X_{i,t-1} + \delta_2 YIELDS_{t-1} + \delta_3 GAP_{t-1} + \epsilon_{it}. \tag{3}$$

To prevent an endogeneity problem from arising due to the inclusion of the lagged dependent variable in Equation (2) and predetermined variables $X_{i,t-1}$ in Equation (3), we conduct system GMM estimation following Blundell and Bond (1998) using lagged dependent and explanatory variables as instrumental variables.

4.2.2 Low interest rates and macroeconomic conditions

As discussed in Section 2, under the accommodative monetary conditions, banks would intensify reach for yields behavior in order to attain their target of profits. If such a risk-taking channel exists, the coefficient on the 5-year bond yield should be negative in the estimated equations. As short-term rates in Japan remained almost unchanged at a very low level for more than a decade, we use medium-term interest rates rather than policy rates to capture the accommodative financial environment. We also include the interaction term between the 5-year bond yield and banks' capital adequacy ratios to investigate whether the risk-taking channel is more pronounced for highly capitalized banks.

In addition, the prolonged economic expansion after the GFC would affect the risk-taking behavior of banks by changing their perception of borrowing firms' credit risks. If the economic expansion promotes banks' risk taking in loans to low-return borrowers, the coefficient on the output gap is expected to be positive. On the other hand, if a lending bank kept a borrowing firm solvent through forbearance lending with extremely low interest rates during the economic downturn, the improvement of the firm's financial soundness due to the subsequent economic recovery would enable the bank to halt forbearance lending by increasing loan interest rates to the borrower. In this case, the coefficient can be negative. In order to investigate such a business cycle effect on loans to low-return borrowers, we use the output gap estimated by the BOJ.

4.2.3 Intensifying competition among banks

Along with the prolonged low interest rate environment, intensifying competition among banks is also a possible driving force behind the increase in loans to low-return borrowers. In Japan, the competition among financial institutions in loan markets has steadily intensified. One of the reasons for the intensified competition is that banks have not drastically reduced the loan supply capacity even though banks have faced a persistent decline in loan demand. In fact, as pointed out by Bank of Japan (2017), Japanese banks have maintained a large capacity, such as the number of branches despite the long-lasting declines in the population and the loan demand from firms. Furthermore, Japanese banks rely heavily on traditional loan business and have not diversified the sources of their income, which would lead to an increase in the competition in loan markets.[10] The mechanism of the intensification of the competition itself is an important research topic, but it is beyond the scope of this paper. We focus on investigating the effects of the competition on the credit allocation to low-return borrowers.

[10]See Bank of Japan (2017) for details.

The intensified competition is likely to change the lending behavior of banks. If the competition reaches an excessive level, the price, i.e., the interest rate, could become extremely low as a result of "mispricing". In particular, amid the prolonged economic expansion period, banks are tempted to decrease interest rates in order to capture the loan demand because the low loan rates could be justified by the low default probability in such an environment.

To analyze such banks' lending behavior, we construct a proxy for competition among banks by using bank-firm matched data. We calculate the ratio of the number of financial institutions' branches to the number of existing firms in each bank's business area. A bank's business area is defined based on the location of the headquarters of client firms with whom the bank has a transaction relationship. Specifically, we calculate the competition index as follows. First, we calculate the ratio of the total number of banks' branches to the number of firms in each prefecture. We use the number of branches compiled by the Japan Financial News and the number of firms from the Economic Census for Business Activity conducted by the Ministry of Internal Affairs and Communications. Once we obtain the branch-to-firm ratio of prefectures, for each bank, we take a weighted average of the ratios in prefectures by using the bank's loan exposure to each firm as a weight. Thus, we can calculate the competition index for each bank. In the Appendix, we illustrated the details of the method to construct the index. Note that an increase in the index indicates that the number of branches increases relative to the number of firms, which may result in an excess supply of financial services.

Figure 3 shows the development of the competition index. While the index was relatively stable during the 2000s, it started to rise from 2010. The total number of firms in Japan has been declining steadily, while the number of banks' branches continued to decline until 2010 but has remained almost unchanged thereafter. Figure 3 indicates that banks have been put under pressure from increasing competition as loan demand persistently have declined.

In the baseline model, we include the competition index to disentangle the effects of intensified competition from the effects of low interest rates on banks' risk-taking behavior. If the increase in competition encourages the risk-taking behavior of banks, the coefficient on the index is expected to be positive in the estimated equation.

4.2.4 Bank financial condition and performance

Finally, the third possible hypothesis is that banks' financial condition affects their risk taking in loans to low-return borrowers. A strand of literature on bank lending behavior reported that the soundness of banks' balance sheets matter for banks'

risk-taking behavior, as discussed in Section 2. Specifically, Japanese banks suffered from non-performing loans and resultant low capital ratios after the collapse of the bubble economy at the beginning of the 1990s. The previous literature found forbearance lending or capital crunch of Japanese banks from the late 1990s to the early 2000s. To investigate the effects of the capital ratio on lending behavior, we include the capital adequacy ratio based on the Basel Accord as a bank variable in the regression.

We should note that the sign of the coefficient on the capital ratio could be positive or negative in our estimated equation. If window-dressing behavior is prevalent, the capital ratio has a negative coefficient. On the other hand, if the capital ratio works as a constraint, the coefficient should be positive as an increase in capital mitigates the constraint.

In addition to the capital ratio, we include a bank's profit ratio to capture the banks' current performance. The profit ratio is also expected to serve as a proxy for the future capital ratio. By definition, profits are a main determinant of the future capital ratio and therefore current low profits could be associated with relatively low capital in the future. Even though Japanese banks generally maintain capital ratios well above the regulatory level, continuing declines in profits would affect their risk-taking behavior by changing banks' expected capital ratio in the future. In particular, if the banks continue to suffer from low profits, they would strengthen risk taking to increase profits to prevent the capital constraint from binding in the future. To examine this hypothesis, we use a profit ratio, which is defined as the ratio of pre-provision net revenue (PPNR) excluding trading income to total assets (core ROA). If banks tend to intensify risk-taking behavior in order to prevent the occurrence of low capital in the future, the coefficient of the profit ratio would be negative in the estimated equation.

Furthermore, current profits could have interaction effects with the capital ratio. For example, if a bank's current profit is low and its capital is also low, the bank may not increase risk taking on the concern that its capital level will hit the regulatory threshold immediately under a stress event. The opposite case also could be true, if such a bank with low profits and low capital bets its remaining lending capacity on risky lending, hoping that an increase in its loan volume to risky firms would raise its profits somehow.

Specifically, as an explanatory variable, we include the interaction term of the profit ratio and the low capital adequacy ratio dummy. The low capital ratio dummy takes one if the capital ratio is below 9%. To set the threshold for the dummy variable, we choose one percentage point above the regulatory level of 8% for internationally active banks because banks could start to alter their lending behavior

before the capital adequacy ratio actually hits the regulatory level.[11] Although the regulatory level for domestic banks is set at 4%, the level of 8% is often referred to as a reference level for the capital adequacy ratio even for domestic banks with sound balance sheets (See, for example, Bank of Japan (2018)).

As discussed above, the coefficient of the interaction term can be either positive or negative in the estimated equation. If we assume that low profit induces the bank's risk-taking behavior and a low capital ratio mitigates the effect of low profits on risk taking, the coefficient could be positive. On the other hand, if the bank's low capital accelerates the risk-taking behavior of low-profit banks, the coefficient on the interaction term should be negative.

5 Estimation result

As the baseline models, we estimate two different specifications. In each of the regressions, as the supply-side variable, we use either the bank competition index or the bank financial variables as those variables are expected to be correlated with each other.[12] We include the output gap and 5-year yields in both of the specifications. In addition, we estimate two fixed effect models: a dynamic panel model with a lagged dependent variable and a simple model without the lagged variable. As the regressions include predetermined variables in both of Equations (2) and (3), we used the lagged variables as instrumental variables following Blundell and Bond (1998).

We exclude the samples in the post-bubble crisis period toward the early 2000s, in which Japanese banks suffered from non-performing loan problems and focus on the sample from 2005 and 2016. The TDB data include information for large banks as well as *Shinkin* banks. To construct banks' lending exposure to low-return borrowers with a sufficient sample size of the borrowing firms for each bank, we omit observations of banks for which we cannot identify transaction relationships with more than 300 firms in the year. This procedure produces unbalanced panel data with around 200 observations of banks per year.

[11] For example, Peek and Rosengren (2005) defined a low capital dummy as a variable that takes one if the capital ratio is less than two percentage points above the regulatory level.

[12] As shown by Bank of Japan (2017), more intensified competition in Japanese bank loan markets is associated with a lower markup of banks, which indicates that those two variables are highly correlated. To avoid the multicollinearity problem, we did not include simultaneously a bank variable and the competition index in our estimation.

5.1 Effects of low interest rates and economic expansion

First, we report the estimation results with the competition index in Table 3. The first and second columns in Table 3 indicate the estimation result for the simple fixed effect and the dynamic panel model, respectively. In both models, all coefficients are significant at a 1% significance level. However, in the estimation without the lagged dependent variable in the first column, the Hansen test for the validity of instrumental variables is rejected. In addition, the Arellano-Bond test for the autocorrelation of error terms shows that error terms may be correlated, which means that the estimation does not satisfy the required assumption.

The result shows that a decrease in the 5-year government bond yield increases the share of loans to low-return borrowers. By considering the fact that bank loans increased on average in this period, the increase in the share of loans to low-return borrowers implies that loans to low-return borrowers increased more rapidly than those to normal borrowers. Furthermore, as the BOJ has implemented expansionary monetary policy for most of this period, the result also indicates that the BOJ's monetary easing has worked through a risk-taking channel by increasing risky loans to low-return borrowers.

The coefficient on the output gap is estimated to be positive in the specifications with and without the lagged dependent variable, which suggests that the favorable macroeconomic conditions induce banks' risk-taking behavior in loans to low-return borrowers. In particular, this means that the current economic expansion facilitates banks to offer low interest rates relative to firms' credit risks as it causes banks to underestimate firms' potential default risks.

The estimated coefficients for the two macroeconomic variables imply that the favorable economic conditions along with the expansionary policy stimulated banks' risk-taking behaviors in the loan market.

5.2 Intensifying competition and loans to low-return borrowers

Table 3 also shows that the increase in the competition index raises the share of loans to low-return borrowers and the effect is economically significant: a one-point increase in the index means about a 3-4 percentage point increase in the share of loans to low-return borrowers. Furthermore, the degree of the competition that each bank faces substantially differs across banks. In particular, banks that experienced a sharp decline in the number of firms in their business areas are likely to increase credit allocation to low-return borrowers.

The coefficient is economically significant even though we control for the low

interest rate environment. This means that competition itself is also an important driving force behind the increase in risky lending. This result sheds light on a new aspect of risky lending as it shows that chronic stress such as intensified competition could increase the distortion in credit allocations, thereby leading to the accumulation of potential vulnerabilities in the financial system. In particular, Japanese banks more or less suffer from intensified competition that arises from persistent decreasing demand in loan markets in tandem with the shrinkage of the local economy.

In fact, Figure 4 indicates that the contribution of the competition index to the increase in the share of low-return borrowers is of nearly the same magnitude as that of 5-year yields in recent years. This shows that the banks' risk taking increases more in an environment with low interest rate policies and an underlying decline in loan demand.

5.3 Effects of banks' capital and profits

Table 4 indicates the estimation result for the specification with banks' capital and profit ratio. We make four points. First, the impacts of the two macroeconomic variables are comparable to those shown in Table 3. Second, the positive coefficient on the capital ratios indicates that banks with higher capital adequacy ratios increase loans to low-return borrowers more. This implies that a sound balance sheet encourages risk taking and window-dressing behavior seen in the 1990s has not been prevalent in our sample period. This positive coefficient shows a sharp contrast to what the extant literature found in the early 2000s in Japan and the periods after the GFC in European countries; i.e., risk taking in loans to low-return borrowers in Japan is mainly driven by banks with adequate capital rather than those with low capital.

Third, banks with a lower core ROA increase loans to low-return borrowers more. This suggests that banks suffering from low profitability take credit risks aggressively by offering low interest rates to low-performing firms in order to raise profits by increasing their loan volume. We need to pay attention to this tendency from a macroprudential perspective, because banks with low profitability could disproportionately incur a large loss when an adverse shock strikes the economy and such losses of specific banks could then impair the resilience of the financial system.

On the other hand, the interaction effects of low capital dummy and core ROA indicate that the effect of core ROA on risk taking is mitigated for banks with low capital. In other words, even if their core ROA is low, banks that have low capital ratios do not increase risk-taking behavior in the loan market. This means that the capital constraints matter more for loans to low-return borrowers than current

profitability. As banks with low capital are concerned that they may not be able to absorb credit costs in the case where risky loans become non-performing under negative shocks, they tend to suppress their risk taking. This result has an important macro-prudential policy implication; if the banks' balance sheet deteriorates, banks whose capital ratios approach the regulatory minimum requirement may not continue to lend to low-return borrowers. In turn, the reduction in the credit supply could entail the sudden deleveraging of low-return firms, which puts downward pressure on the real economy.

To examine the interaction effects of capital and profitability quantitatively, Table 5 compares the sensitivity of the share of low-return borrowers to the core ROA for lowly and non-lowly capitalized banks. The table shows that the core ROA has a significant effect only for non-lowly capitalized banks while the effect for lowly capitalized banks is not significant.

5.4 Interaction effects of low interest rates and banks' balance sheet soundness

We also investigate the interaction effect between low interest rates and financial soundness on risk taking in loans to low-return borrowers. Although we do not focus on monetary policy shocks in this paper, the heterogeneous effect of the low interest environment on risk taking is an important issue for the financial system. Therefore, we include the interaction terms of the capital ratio and 5-year government bond yields to take into accounts the possibility that the effect of low interest rate on banks' risk taking could differ depending on their capital ratios. In addition, we also include the interaction term between the capital ratio and output gap as a control variable.

Table 6 shows the estimation result for the dynamic panel model with the interaction terms. The coefficient on the interaction effect between 5-year yields and capital is significantly negative. This suggests that banks with more capital increase loans to low-return borrowers more aggressively in response to a decline in interest rates than banks with less capital. In other words, the risk-taking effect of the low interest rate environment is more pronounced for highly capitalized banks. Therefore, the recent risk-taking behavior by banks does not pose an immediate threat to financial stability because banks that are more involved in loans to low-return borrowers are relatively more highly capitalized. This result is consistent with the finding of Dell'Ariccia et al. (2017) although our measure of risky lending is different from theirs.

6 Conclusion

In this paper, we investigate the driving factors behind the increase in loans to risky firms, i.e., "low-return borrowers," by exploiting bank-firm matched data in Japan. We show the three main findings for the mechanism of banks' risk-taking in such loans. First, we find that the low interest rate environment encourages risk-taking by banks and the effect of low-interest rates is more pronounced for banks with a higher capital adequacy ratio. Second, our estimation result provides evidence that highly capitalized but low-profit banks are likely to increase loans to low-return borrowers. In addition, banks with low capital do not increase loans to low-return borrowers even if their profits are low. Third, the intensified competition among banks in loan markets, which is captured by the decrease in the loan demand from local firms relative to the number of banks' branches, contributed to the increase in loans to low-return borrowers. Furthermore, the contribution of the intensified competition to the increase in low-return loans from 2010 is comparable to that of low interest rates in terms of magnitude. The result suggests that loose financial conditions combined with the intensified competition among banks could exacerbate the quality of credit by stimulating banks' risk-taking and lead to an accumulation of future vulnerabilities that make the system more prone to amplifying negative shocks. These findings add new insights on the understanding of banks' behavior in the low interest rate environment with low economic growth rates, which is prevalent even in other developed economies.

In this paper, we do not investigate the detailed reasons why banks offer lower interest rates relative to the riskiness of firms. However, we can point out possible hypotheses for the mechanism. Under the prolonged favorable economic conditions, banks' expectation about the future financial condition of firms has turned too myopic. Additionally, bank managers may be under pressure to achieve a certain level of profits because banks need to pay fixed costs even under the low interest environment. Institutionally, this constraint seems to be more binding and may force bank managers to discount future credit costs somehow. Thus, they aim to increase net interest income by increasing loan volumes with relatively low interest rates. We will study this issue as a future research topic.

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Table 1: Summary statistics of firm variables

	Low-return borrowers		Other borrowers	
	mean	median	mean	median
ROA (%)	-2.8	0.2	1.3	2.1
	(0.0)		(0.0)	
ICR (ratio)	-5.8	0.4	21.2	1.7
	(0.2)		(3.7)	
Leverage (%)	103.9	89.5	86.5	80.8
	(0.1)		(0.0)	
Borrowing interest rate (%)	1.3	1.4	2.9	2.4
	(0.0)		(0.0)	
Total sales (mil. Yen)	932	235	838	266
	(4.2)		(2.1)	
Total borrowings (mil. Yen)	337	83	241	66
	(1.6)		(0.6)	
Labor productivity	9,064	6,185	10,200	6,816
(thous.Yen/person)	(43.1)		(15.0)	
Employees (persons)	22	9	21	9
	(0.0)		(0.0)	
Sample period	2001 - 2016		2001 - 2016	
Number of observations	396,916		2,224,053	

Source: Teikoku Databank.

Notes: Standard errors are in parentheses. Low-return borrowers are defined based on their borrowing interest rates and financial soundness. For the details of the definition, see Section 3 and Appendix C. For the definition of each firm variable, see Appendix A.

Table 2: Summary statistics of bank variables (mean)

	High exposure	Low exposure
Loan share of low-return borowers (%)	26.5	15.9
	(0.16)	(0.10)
Core ROA(%)	0.405	0.424
	(0.007)	(0.005)
Capital ratio	12.6	11.6
	(0.15)	(0.09)
Non-performing loans (%)	4.16	4.26
	(0.09)	(0.05)
Total assets (bil. Yen)	3,049	5,022
	(171)	(473)
Total loans (bil. Yen)	1,863	2,558
	(101)	(206)
Sample period	2005 - 2016	2005 - 2016
Observations	631	1,877

Sources: Teikoku Databank; Bank of Japan.

Notes: Standard deviations are in parentheses. This high-exposure group consists of banks whose exposure to low-return borrowers falls in the upper fourth quartile, while others are classified as a low-exposure group. For the definition of each bank variable, see Appendix A. Loan share of low-return borrowers indicates the ratio of loans to low-return borrowers to the total amount of SME loans for each bank.

Table 3: Estimation results with the competition index

	Fixed-effect	Dynamic
Lagged dependent variable	-	0.460^{***}
		(0.051)
5-year government bond yield	-1.393^{***}	-1.382^{***}
	(0.469)	(0.366)
Output gap	0.485^{***}	0.315^{***}
	(0.064)	(0.055)
Competition index	5.781^{***}	3.853^{***}
	(1.188)	(0.890)
Bank fixed effect	✓	✓
Sample period	2005-2016	2005-2016
Observations	2382	2382
Hansen test (p-value)	0.001	0.140
Arellano-Bond test for AR(1) (p-value)	0.000	0.000
Arellano-Bond test for AR(2) (p-value)	0.016	0.964

Notes: $*, **, ***$ denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are in parentheses. The table indicates the estimation result for the fixed effect models with and without the lagged dependent variable as an explanatory variable. The explanatory variables are lagged by one year to mitigate the endogeneity problem. We employed the system GMM, following Blundell and Bond (1998) by using lagged variables of dependent and explanatory variables as instrumental variables.

Table 4: Estimation results with bank capital and profit ratio

	Fixed-effect	Dynamic
Lagged dependent variable	-	0.622^{***}
		(0.037)
5-year government bond yield	-3.057^{***}	-1.906^{***}
	(0.140)	(0.275)
Output gap	0.708^{***}	0.391^{***}
	(0.020)	(0.044)
Core ROA	-1.920^{***}	-2.677^{***}
	(0.480)	(0.941)
Capital adequacy ratio	0.263^{***}	0.201^{***}
	(0.037)	(0.066)
Low capital dummy × Core ROA	3.287^{***}	2.293^{**}
	(0.332)	(0.982)
Bank fixed effect	✓	✓
Sample period	2005-2016	2005-2016
Observations	2382	2382
Hansen test	0.006	0.137
Arellano-Bond test for AR(1) (p-value)	0.000	0.000
Arellano-Bond test for AR(2) (p-value)	0.003	0.396

Notes: $*, **, ***$ denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are in parentheses. The table shows the estimation result for the fixed effect models with and without the lagged dependent variable as an explanatory variable. The explanatory variables are lagged by one year to mitigate the endogeneity problem. We employed the system GMM, following Blundell and Bond (1998) by using lagged variables of dependent and explanatory variables as instrumental variables.

Table 5: Sensitivity of the loan share of low-return borrowers to core ROA

	Lowly capitalized banks	Non-lowly capitalized banks
Sensitivity to core ROA	-0.383	-2.677^{***}
	(1.010)	(0.885)

Notes: $*, **, ***$ denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are in parentheses. The sensitivity is calculated by using the estimation result shown in the second column of Table 4.

Table 6: Interaction effects of low interest rates and bank capital ratio

	Dynamic
Lagged dependent variable	0.651^{***}
	(0.039)
5-year government bond yield	-1.676^{***}
	(0.340)
Output gap	0.510^{***}
	(0.058)
Core ROA	-1.981^{***}
	(0.794)
Capital adequacy ratio	0.117^{**}
	(0.046)
Capital adequacy ratio × 5-year yields	-0.078^{*}
	(0.045)
Capital adequacy ratio × Output gap	-0.038^{***}
	(0.012)
Bank fixed effect	✓
Sample period	2005-2016
Observations	2382
Hansen test (p-value)	0.267
Arellano-Bond test for AR(1) (p-value)	0.000
Arellano-Bond test for AR(2) (p-value)	0.331

Notes: $*, **, ***$ denote significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are in parentheses. The table indicates the estimation result for the dynamic panel model with bank fixed effects. The explanatory variables are lagged by one year to mitigate the endogeneity problem. We employed the system GMM, following Blundell and Bond (1998) by using lagged variables of dependent and explanatory variables as instrumental variables.

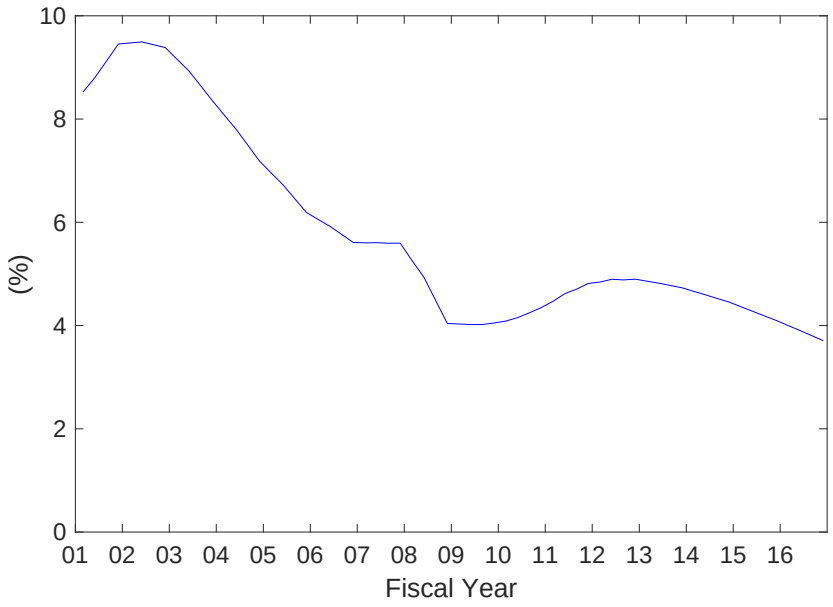

Figure 1: Non-performing loans ratio

Source: Bank of Japan.

Notes: The figure shows the average non-performing loans ratio of Japanese banks.

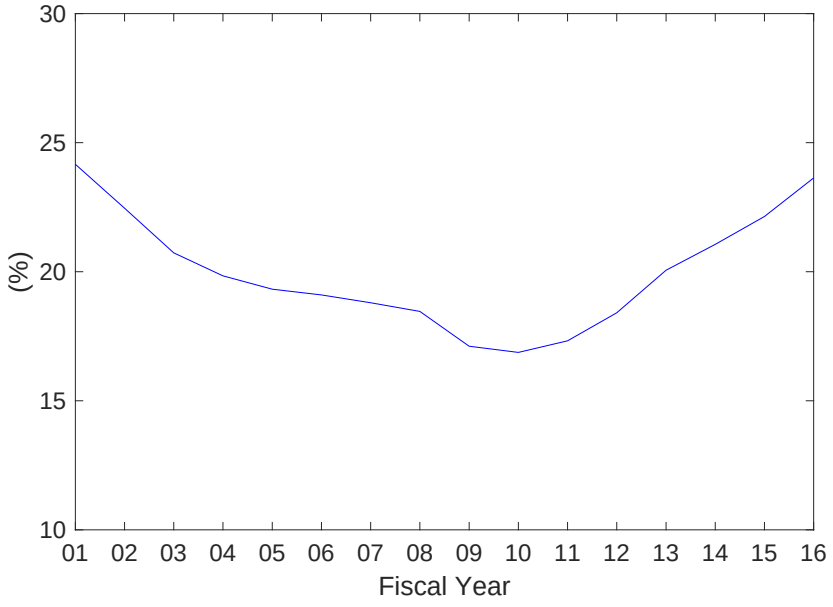

Figure 2: Loan share of low-return borrowers

Source: Teikoku Databank.

Notes: Loan share of low-return borrowers is calculated by dividing the amount of loans outstanding to low-return borrowers by the total SME loans.

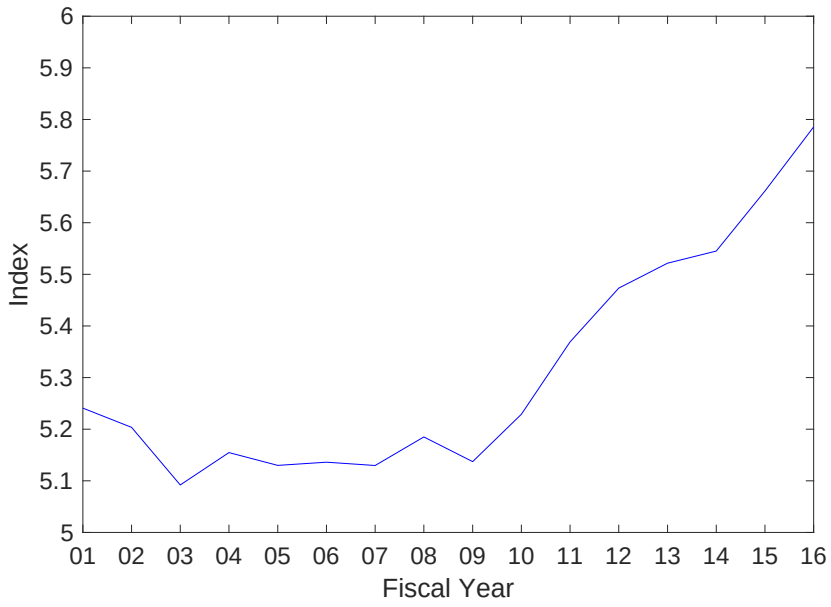

Figure 3: Competition Index

Sources: The Japan Financial News; Ministry of Internal Affairs and Communications; Teikoku Databank.

Notes: The figure indicates the median value of the degree of branch competition calculated by dividing the number of total branches by the number of firms in a bank's business area.

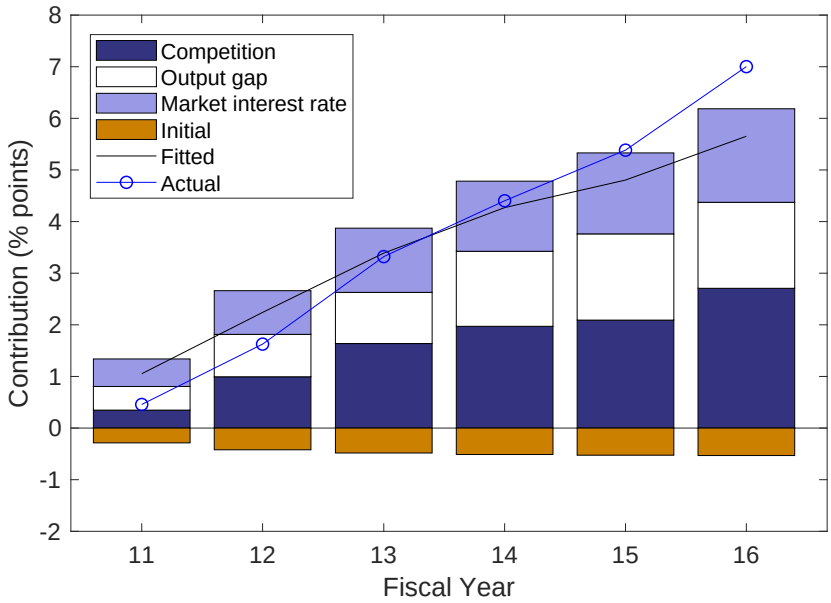

Figure 4: Decomposition of the increase in loan share of low-return borrowers

Notes: The figure shows the decomposition of cumulative changes in the share of loans to low-return borrowers since 2010 based on the estimation result for the dynamic model in Table 3. The contribution of the lagged dependent variable is decomposed into that of each explanatory variable by using recursive substitution. "Initial" indicates the contribution of the initial value (the actual change in the loan share of low-return borrowers from fiscal 2009 to 2010).

Appendices

A. Definitions of bank and firm indicators

The definition of each indicator used in this paper is as follows.
Borrowing interest rate (%) = Interest expenses / Total borrowing × 100
Interest Coverage Ratio (ICR) = (Operating income + Interest revenue) / Interest expenses
Return on Assets (ROA, %) = Operating income / Total assets × 100
Leverage ratio = Total debt / Total assets × 100
Labor productivity = (Total sales - Sales cost)/employee
Banks core operating income (Core ROA, %) = PPNR (pre-provision net revenue) excluding trading income / Total assets × 100

B. Detailed information on the data

The bank-firm matched data compiled by Teikoku Databank comprises the following three different datasets: COSMOS1, COSMOS2 and the AUX (auxiliary) datasets. By combining the datasets, we construct bank-firm matched data with banks' and firms' financial data for the analysis.

- COSMOS1 includes detailed information on P/L and balance sheets and covers from 1999 to 2016.
- COSMOS2 includes each firm's transaction information with banks and covers from 1976 to 2016.
- AUX includes detailed information on loans between firms and banks. But it covers less firms than COSMOS1 and 2 and covers only from 2008 to 2016.

C. Definition of low-return firms

We provide detailed descriptions on how low-return firms are defined. The first key indicator is the benchmark interest rate $PrimeRate_t^{LEV}$ and $PrimeRate_t^{ROA}$, which are defined as follows:

$$
\begin{aligned}
PrimeRate_t^{ROA} &= \text{median}(BorrowingRate_{j,t} \mid \\
&\qquad j \in \{\text{Firms within the top 10th percentile for ROA in } t-1\ \}) \\
PrimeRate_t^{LEV} &= \text{median}(BorrowingRate_{j,t} \mid \\
&\qquad j \in \{\text{Firms within the lower 50th percentile for leverage in } t-1\ \})
\end{aligned}
$$

Note that one lag is taken when we extract the most creditworthy firms to mitigate the endogeneity problem as firms' financial indicators and their borrowing interest rate generally are determined simultaneously. For the prime rate based on firm leverage, we define the lower 50th percentile as the most credit worthy group. This is because if we define the lowest 10th percentile as such group instead, since most firms have a small amount of borrowings from the bank, it would make the borrowing rate less informative.

Given the benchmark interest rate, low-return borrowers are defined as follows

$$LowReturn_{j,t}^{ROA} = \begin{cases} 1 \;\; \text{if} \;\; j \in \{k | BorrowingRate_{k,t} \; < PrimeRate_t^{ROA} \;\; \wedge \\ \qquad\qquad\qquad ROA_{k,t} < \text{median}(ROA_{h,t}, \;\; \forall \; h)\} \\ 0 \;\; otherwise \end{cases}$$

$$LowReturn_{j,t}^{LEV} = \begin{cases} 1 \;\; \text{if} \;\; j \in \{k | BorrowingRate_{k,t} \; < PrimeRate_t^{LEV} \;\; \wedge \\ \qquad\qquad\qquad Leverage_{k,t} > \text{median}(Leverage_{h,t}, \;\; \forall \; h)\} \\ 0 \;\; otherwise \end{cases}$$

Finally, we identify firms whose $LowReturn_{j,t}^{ROA}$ is one in two consecutive years or $LowReturn_{j,t}^{LEV}$ is one in two consecutive years and label them as "low-return" borrowers as follows:

$$LowReturn_{j,t} = \begin{cases} 1 \;\; \text{if} \;\; j \in \{k | LowReturn_{k,t}^{LEV} = LowReturn_{k,t-1}^{LEV} = 1 \vee \\ \qquad\qquad\qquad LowReturn_{k,t}^{ROA} = LowReturn_{k,t-1}^{ROA} = 1\} \\ 0 \;\; otherwise \end{cases}$$

We split the entire sample into 6 industry groups: construction, manufacturing, wholesale, retail, real estate, and services. Then, we apply the above exercise to each industry group to define low-return borrowers.

D. Aggregation by banks

In this Appendix, we illustrate how to construct bank-level data from the bank-firm matched data. As we do not have complete data on exactly how much a firm borrows from a particular bank, we take a two-step approach to estimate the volume of bank loans.

The main dataset, COSMOS1, contains the total amount of loans and COSMOS2 contains the list of banks that the firm has transactions with and the order of the

banks as ranked by the firm according to the closeness of its relationships with the banks. We can combine them and make a bank-firm matched data summarized in the following table:

	Low-return	Total loans	# of bank transactions	$bank_1$	$bank_2$	$bank_3$	$bank_4$	$bank_5$
$firm_1$	1	L_1	2	2				1
$firm_2$	0	L_2	3		1	3	2	
$firm_3$	0	L_3	5	4	1	5	3	2
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
$firm_{J-2}$	1	L_{J-2}	3			2	1	3
$firm_{J-1}$	0	L_{J-1}	4	3	4	2		1
$firm_J$	1	L_J	1				1	

The fifth to the tenth columns indicate banks that each firm has transactions with. The number in the cell indicates the order of the banks for each firm as ranked by the firm for up to ten banks according to the closeness of its relationships with the banks. For example, the table shows that $firm_1$ ranked $bank_5$ as the first bank in terms of relationship closeness. For illustration, we list only five banks although the data include about 200 banks per year.

Next, let us define the share of loans from mth bank to the total amount of loans when the total number of transacting banks is n as w_m^n. Note that $\sum_{i=1}^n w_i^n = 1$. We estimate w_m^n using the auxiliary dataset, which includes detailed information on transactions and loans. Then, we apply $\hat{w}_m^n$ to calculate the amount of loans from each bank and construct the table shown below.

	Low-return	Total loans	# of bank transaction	$bank_1$	$bank_2$	$bank_3$	$bank_4$	$bank_5$
$firm_1$	1	L_1	2	$\hat{w}_2^2 L_1$	0	0	0	$\hat{w}_1^2 L_1$
$firm_2$	0	L_2	3	0	$\hat{w}_1^3 L_2$	$\hat{w}_3^3 L_2$	$\hat{w}_2^3 L_2$	0
$firm_3$	0	L_3	5	$\hat{w}_4^5 L_3$	$\hat{w}_1^5 L_3$	$\hat{w}_5^5 L_3$	$\hat{w}_3^5 L_3$	$\hat{w}_2^5 L_3$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
$firm_{J-2}$	1	L_{J-2}	3	0	0	$\hat{w}_2^3 L_{J-2}$	$\hat{w}_1^3 L_{J-2}$	$\hat{w}_3^3 L_{J-2}$
$firm_{J-1}$	0	L_{J-1}	4	$\hat{w}_3^4 L_{J-1}$	$\hat{w}_4^4 L_{J-1}$	$\hat{w}_2^4 L_{J-1}$	0	$\hat{w}_1^4 L_{J-1}$
$firm_J$	1	L_J	1	0	0	0	L_J	0

Thus, we can calculate the estimated amount of loans that firm j borrows from bank i. Then, by aggregating all loans by bank i, we calculate the loan share of

low-return borrowers ($LSHARE_{i,t}$) for bank i as follows:

$$LSHARE_{i,t} = \frac{\sum_{j \in N_{i,t}} LowReturn_{j,t} \times LOAN_{i,j,t}}{LOAN_{i,t}} \tag{4}$$

where $N_{i,t}$ indicates a set of firms who have a relationship with bank i and $LowReturn_{j,t}$ is a low-return borrower dummy variable. $LOAN_{i,j,t}$ is the estimated amount of loans from bank i to firm j in the above procedure.

E. Construction of the bank competition index

The competition among bank branches is calculated as follows. First, the number of total bank branches per firm is calculated for each prefecture. Second, each bank's client firms are grouped based on the prefecture where such firms' headquarters are located. Third, the competition index is calculated as the weighted average of the overcapacity index by using the share of each loan to the bank's total loans as the weight.