Franchise Value Matters: The Drivers of Bank Risk-Taking in the Post-Basel III Era*

Takuji Kawamoto, Taichi Matsuda, Koji Takahashi, and Yoichiro Tamanyu
Bank of Japan

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 findings suggest that under the post-Basel III regulatory framework, *future* franchise value of banks, rather than the *current* capital of banks, is the key driver of banks' risk-taking.

JEL Codes: G21, E52, E44.

*This paper was previously circulated with the title "Bank Risk Taking and Financial Stability: Evidence from Japan's Loan Market." The authors are deeply indebted to the editor, Steven Ongena, and an anonymous referee, whose comments have led to a great improvement of the paper. 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 of Japan. Author e-mails: takuji.kawamoto@boj.or.jp; taichi.matsuda@boj.or.jp; kouji.takahashi-2@boj.or.jp; youichirou.tamanyuu@boj.or.jp.

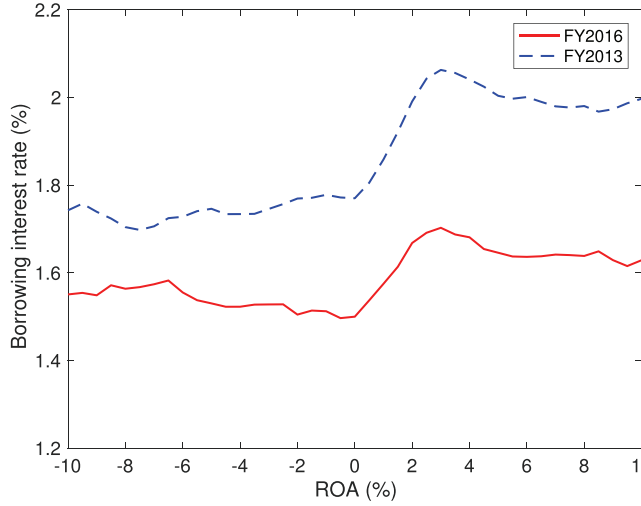
1. Introduction

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 banks' risk-taking behavior under the accommodative policy facilitates an improvement in firms' financial condition, excessive risk-taking 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, banks in developed economies—including Japan—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 interest rate environment but also these structural factors have increased banks' incentive of risk-taking in the loan market.

This paper examines the risk-taking behavior of banks in terms of the "quality" of loans to small and medium-sized enterprises (SMEs) using Japanese bank-firm matched data. Specifically, we identify "low-return borrowers (LRBs)" 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. We define an LRB as a firm whose borrowing interest rate is low relative to its credit risk 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 fact, Figure 1 shows the relationship between firms' return on assets (ROA) and their borrowing interest rates in Japanese SMEs, indicating that firms with ROA of less than 2 percent have lower borrowing rates than those with higher ROA.

Figure 1. Borrowing Interest Rate and Firm ROA

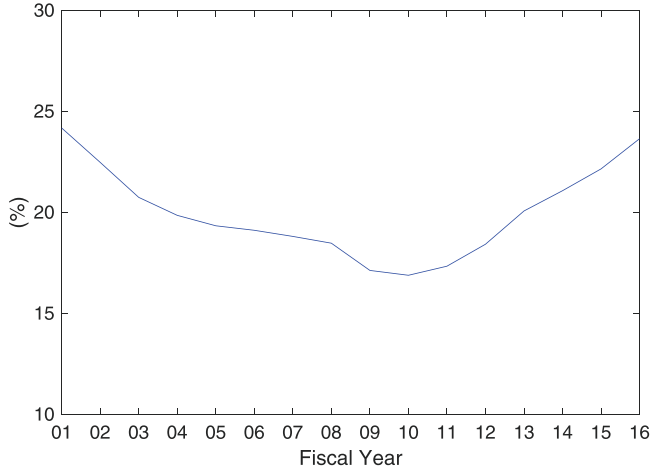


Note: Each line indicates the median borrowing interest rates of firms that are classified by their ROA (represented by the horizontal axis) in each fiscal year. Smoothed using a centered moving average.
Source: Teikoku Databank.

Using the matched data set of LRBs and their lending banks, we find that low capital of lending banks is not the key factor driving risky lending by banks after the implementation of Basel III, as banks hold higher levels of bank capital in general. Instead, this paper shows that low profitability, i.e., a decrease in the future franchise value, which ultimately determines a bank's ability to build new capital, is likely to be more important in driving banks' risk-taking. 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 LRBs by highly capitalized banks can be interpreted as an outcome of the risk-taking channel of the accommodative monetary policy.

We also show that not only the low interest rate environment but also the intensified competition among banks is an important

Figure 2. Loan Share of LRBs



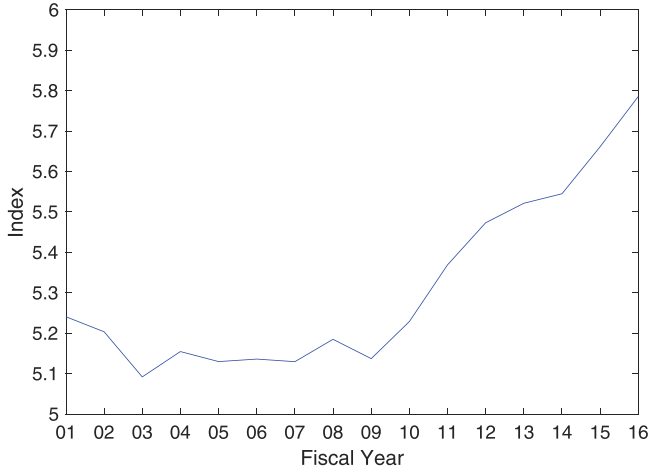
Note: Loan share of LRBs is calculated by dividing the amount of loans outstanding to LRBs by the total SME loans.
Source: Teikoku Databank.

driving factor behind their risk-taking.[1] In fact, Figure 2 shows that the loan share of LRBs—which is calculated by dividing the amount of loans outstanding to LRBs by the total SME loans—has clearly increased from 2010, in tandem with the intensification of the competition among banks in the loan market from 2010, as shown in Figure 3.

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 LRBs has 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

[1] Altunbas, Gambacorta, and Marques-Ibanez (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.

Figure 3. Competition Index



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

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 LRBs 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 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. Furthermore, our data cover long periods of unconventional monetary policies while a growing literature investigates the unconventional policy effects through the risk-taking channel and portfolio rebalancing of financial intermediaries using data for relatively short time periods.[3]

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

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 LRBs. Section 4 introduces our econometric models and possible hypotheses for increasing loans to LRBs. In Section 5, we analyze what is driving such an increase in loans to LRBs from the supply side. Section 6 provides our conclusion.

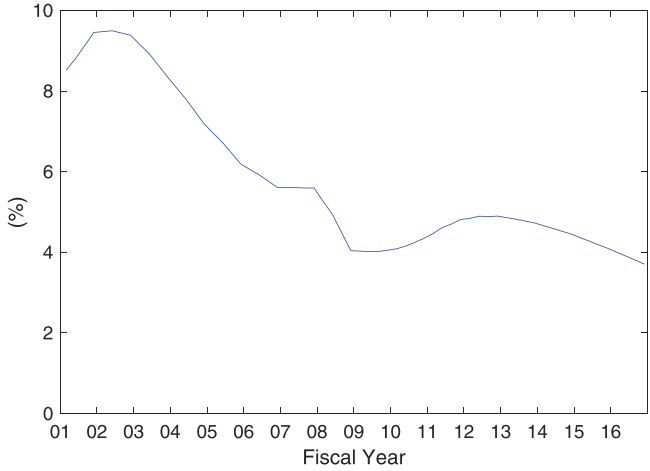
2. Literature Review

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

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

[3]See, for example, Chodorow-Reich (2014), Joyce, Liu, and Tonks (2014), Koijen et al. (2017), Rodnyansky and Darmouni (2017), Albertazzi, Becker, and Boucinha (2021), and Paludkiewicz (2021).

Figure 4. Non-performing Loans Ratio



Note: The figure shows the average non-performing loans ratio of Japanese banks.
Source: Bank of Japan.

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 the consequences of evergreen lending to inefficient firms. Sekine, Kobayashi, and Saita (2003) show that evergreen lending lowers firms' profitability using microdata. Caballero, Hoshi, and Kashyap (2008) report that a higher zombie firm ratio is associated with lower productivity growth in the industry. Kwon, Narita, and Narita (2015) conclude that aggregate productivity growth in Japan would have been 1 percentage point higher without zombie lending.

However, such an 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 non-performing loans (NPLs) drastically, as shown in Figure 4. 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, recent loan market in Japan 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 LRBs 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) finds 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, Laeven, and Suarez (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]

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

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

to each other.[5] Thus, our paper allows us to understand comprehensively the lending behavior of banks that face low interest rates and intensifying competition.

This paper also contributes to the measurement issue of zombie 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 interest coverage ratios (ICRs) (Andrews and Petroulakis 2017; Storz et al. 2017; Banerjee and Hofmann 2018; Schivardi, Sette, and Tabellini 2021), financial support à la Caballero, Hoshi, and Kashyap (2008), or a combination thereof (Fukuda and Nakamura 2011; Kwon, Narita, and Narita 2015; Acharya et al. 2019). However, 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, Hoshi, and Kashyap (2008). Given a certain level of profit and leverage, low interest rates imply a higher ICR. 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. In this paper, we propose a new measure to identify the distortional lending behavior emerged in a low interest rate environment in Japan.

3. Data and Definition of Low-Return Borrowers

In this section, we explain the definition of LRBs and the firm-bank matched data used in our analysis.

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)

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

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. In order to analyze the credit allocation to LRBs from the loan supply-side perspective, we calculated the lending exposure of each bank to LRBs using the lender-borrower relationships. The details of the calculation of the bank-level exposure to LRBs are provided in the appendix. 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 borrowers" are identified in light of firms' performance as measured by profitability and leverage as well as their interest rate expenses. Specifically, we define LRBs as firms that 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 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 an LRB 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 an LRB.

Our first criterion follows the literature indicating that zombies are receiving subsidized credit (Caballero, Hoshi, and Kashyap 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. Existing studies on firm defaults (e.g., Jacobson, Lindé, and Roszbach 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.[6]

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

[6]Low interest rates relative to an LRBs' credit risk might reflect private information that lending banks have and the information could justify the low interest rate. However, it would not be the case for the following two reasons. First, as shown in Bank of Japan (2018a), we do not find evidence for such information even though we comprehensively examine different LRBs' characteristics. Second, firms with low credit scores borrow with lower interest rates when the credit score is less than some level. For example, the average interest rate for firms with credit score of 25–30 is 1.8 percent while that of firms with 45–50 is 2.2 percent. The credit score of a firm is determined by a credit investigator by considering even soft information including its CEO's personality, and the firm's transaction history. This shows that even if we take into account private information to some extent, the interest rates are still low relative to their credit risks for some firms with high credit risk, which include LRBs. We thank an anonymous referee for pointing out this issue.

3.3 Differences in the Definition of Low-Return Firms from Previous Studies

The seminal paper of Caballero, Hoshi, and Kashyap (2008) in the credit misallocation literature used the interest rate criterion solely 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, Narita, and Narita (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 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" in recent years. For example, with a criterion based on an absolute level of ROA, more firms could be categorized as LRBs 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.[7]

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 LRBs 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, LRBs have a larger amount of loans, which is also reflected in high leverage ratios. In addition, the ICR of LRBs is significantly lower than one. This indicates that LRBs will be left with losses after paying interest expenses.

Despite the fact that LRBs are vulnerable in terms of financial indicators, lending interest rates to such borrowers are in fact lower than those to other borrowers: the interest rate gap between LRBs and other borrowers is larger than 1 percentage point. This fact strongly supports our hypothesis that LRBs 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 (2018b). Bank of Japan (2018b) shows that banks with a high share of loans to low-return borrowers are more concerned about the

[7] In a booming period, our definition of LRBs 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 a 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 (2018a), this is not the case: the level of profitability of LRBs 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.

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 (Thous. Yen/Person)	9,064	6,185	10,200	6,816
	(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	

Note: 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 Section A.3 of the appendix. For the definition of each firm variable, see Section A.1 of the appendix.
Source: Teikoku Databank.

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.[8]

[8]In order to identify LRBs, 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 3, to take into account the possibility that some banks can offer lower interest rates due to high efficiency in their lending business.

Using the identification of LRBs, we calculate the loan share of LRBs, which is defined as follows:

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

where $LowReturnLoan_{i,j,t}$ 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, $J_{i,t}$ indicates a set of LRBs to whom bank i makes loans at time t. Figure 2 shows the development of the average loan share of LRBs. We split the sample period into two separate phases before and after 2010, and analyze the share of LRBs for each phase.

In the early 2000s, the share of LRBs 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 discussed above, the restructuring plan led by the government forced banks to decrease loans to LRBs. 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).

From 2010, the share increased persistently and marked close to 25 percent 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 4 indicates, the NPL ratio among Japanese banks in recent years is very low, 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 credit allocation to LRBs by focusing on the effects of the low interest rate environment, the competition among banks, and the prolonged expansion of the economy.

Summary statistics for the data on the linkage between LRBs and their banks are provided in Table 2. In the table, banks are

Table 2. Summary Statistics of Bank Variables (Mean)

	High Exposure	**Low Exposure**
Loan Share of LRBs (%)	26.5	15.9
	(0.16)	(0.10)
Core ROA (%)	0.405	0.424
	(0.007)	(0.005)
Capital Adequacy 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

Note: Standard deviations are in parentheses. This high-exposure group consists of banks whose exposure to LRBs falls in the upper fourth quartile, while others are classified as a low-exposure group. For the definition of each bank variable, see Section A.1 of the appendix. "Loan Share of LRBs" indicates the ratio of loans to LRBs to the total amount of SME loans for each bank.
Source: Teikoku Databank; Bank of Japan.

divided into two groups according to the size of their exposure to LRBs: the high-exposure group consists of banks whose exposure to LRBs 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 in the high-exposure group have lower ROAs, although they have higher capital ratio. These two facts imply that the window-dressing motivation cannot explain banks' risk-taking behavior in lending to LRBs. 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.

In the following analysis, 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 LRBs 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.

4. Econometric Model and Hypotheses

In the previous section, we showed the fact that the loan share of LRBs has increased since 2010. In the following analysis, we explain an econometric model to investigate factors that have contributed to the increase in lending to LRBs. Then, we propose possible explanations for the increase in lending to LRBs.

4.1 Econometric Model

To investigate the driving forces behind movements in loans to LRBs, we introduce a simple econometric model. Our focus is on the credit allocation between normal borrowers and LRBs. Therefore, a dependent variable in our baseline model is the share of loans to LRBs in bank i's total loans. We should note that the variable of our interest, namely the outstanding amount of loans to LRBs, 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 LRBs with bank fixed effects as follows:

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

where $LSHARE_{i,t}$ indicates the share of loans to LRBs in bank i's total loans, and $X_{i,t-1}$ denotes a vector of bank i's variables. As $X_{i,t-1}$, we use competition indicator, bank capital, bank profitability, and their interaction effects. As we discuss below, we focus on effects of these variables to investigate the background mechanism of loans to LRBs. We take a one-year lag for the variables to avoid the

endogeneity problem. $YIELDS_{t-1}$ and GAP_{t-1} indicate the five-year government bond yield and the 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 the error term.

In addition, to check whether our results depend on the assumption of dynamic panel models, 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 Equations (3) and (4), we conduct system GMM estimation following Blundell and Bond (1998) using lagged dependent and explanatory variables as instrumental variables. Including bank fixed effects allows us to mitigate the omitted-variable problem. However, as Blundell and Bond (1998) pointed out, the endogeneity problem arises when we extract bank fixed effects by taking the first difference of the equation or subtracting the average. Thus, our system GMM estimation is most suitable to deal with predetermined variables and fixed effects.

4.2 Factors of Increasing Loans to Low-Return Borrowers

We focus on three driving factors of increasing loans to LRBs: low interest rates, competition among banks, and bank performance.

4.2.1 Low Interest Rates and Macroeconomic Conditions

As discussed in Section 2, under the accommodative monetary conditions, banks would intensify their search-for-yields behavior in order to attain their target of profits. If such a risk-taking channel exists, the coefficient on the five-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 five-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 LRBs, 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 LRBs, we use the output gap estimated by the BOJ.

4.2.2 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 LRBs. 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.[9] 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 LRBs.

[9]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.

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.

4.2.3 Bank Financial Condition and Performance

Finally, the third possible hypothesis is that banks' financial condition affects their risk-taking in loans to LRBs. A strand of literature on bank lending behavior reported that the soundness of banks' balance sheets matters 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 a value of one if the capital ratio is below 9 percent. To set the threshold for the dummy variable, we choose 1 percentage point above the regulatory level of 8 percent for internationally active banks because banks could start to alter their lending behavior before the capital adequacy ratio actually hits the regulatory level.[10] Although the regulatory level for domestic banks is set at 4 percent, the level of 8 percent 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 2018a).

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, first, as the supply-side variable, we use either the bank competition index or the bank financial variables. Then, we show the robustness of the estimation results by including simultaneously those supply-side variables. We include the output gap and five-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).

[10]For example, Peek and Rosengren (2005) defined a low capital dummy as a variable that takes a value of one if the capital ratio is less than 2 percentage points above the regulatory level.

Table 3. Estimation Results with the Competition Index

	(1)	(2)
Lagged Dependent Variable	—	0.460***
		(0.051)
Five-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	2,382	2,382
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

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent 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.

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 percent 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 five-year government bond yield increases the share of loans to LRBs. By considering the fact that bank loans increased on average in this period, the increase in the share of loans to LRBs implies that loans to LRBs increased

more rapidly than those to normal borrowers. Furthermore, as the BOJ has implemented an 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 LRBs.

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 LRBs. 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.

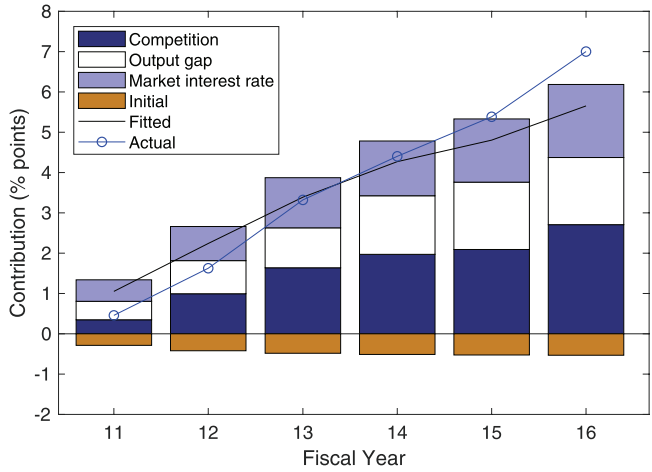
The estimated coefficients for the two macroeconomic variables imply that the favorable economic conditions along with the expansionary policy stimulated banks' risk-taking behaviors in the loan market.

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 LRBs 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 LRBs. Furthermore, the degree of 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 LRBs.

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.

Figure 5. Decomposition of the Increase in Loan Share of LRBs



Note: The figure shows the decomposition of cumulative changes in the share of loans to LRBs 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 LRBs from fiscal 2009 to 2010).

In fact, Figure 5 indicates that the contribution of the competition index to the increase in the share of LRBs is of nearly the same magnitude as that of five-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 LRBs more. This implies that a sound balance sheet encourages risk-taking, and window-dressing behavior seen in the 1990s

Table 4. Estimation Results with Bank Capital and Profit Ratio

	(1)	(2)
Lagged Dependent Variable	—	0.622***
		(0.037)
Five-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	2,382	2,382
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

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Robust standard errors are in parentheses. The first column shows the estimation result for the fixed-effect model with the lagged dependent variable as an explanatory variable, and the second column shows that for the model without the lagged dependent 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.

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 LRBs 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 LRBs 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

Table 5. Sensitivity of the Loan Share of LRBs to Core ROA

	Lowly Capitalized Banks	Non-lowly Capitalized Banks
Sensitivity to Core ROA	–0.383 (1.010)	–2.677*** (0.885)

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent 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. For example, the sensitivity for a lowly capitalized bank is calculated by adding the coefficient on the interaction effect to that on the core ROA (i.e., –0.383 = 2.293 – 2.677).

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.

Fourth, on the other hand, the interaction effects of the 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 LRBs 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 macroprudential policy implication; if the banks' balance sheet deteriorates, banks whose capital ratios approach the minimum regulatory requirement may not continue to lend to LRBs. In turn, the reduction in the credit supply could entail the sudden deleveraging of LRBs, 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 LRBs 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 LRBs. 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 five-year government bond yields to take into account 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 five-year yields and capital is significantly negative. This suggests that banks with more capital increase loans to LRBs 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 LRBs are relatively more highly capitalized. This result is consistent with the finding of Dell'Ariccia, Laeven, and Suarez (2017) although our measure of risky lending is different from theirs.

5.5 Robustness Check

In this subsection, as a robustness check, we focus solely on bank characteristic variables and control for time-varying elements by year fixed effects as follows:[11]

$$LSHARE_{i,t} = \gamma_i + \delta_1 X_{i,t-1} + \sum_{j=1}^{T} \phi_j Time_t^j + \epsilon_{it}. \qquad (4)$$

[11]We thank an anonymous referee for suggesting to conduct the robustness check with year fixed effects.

Table 6. Interaction Effects of Low Interest Rates and Bank Capital Ratio

	Dynamic
Lagged Dependent Variable	0.651***
	(0.039)
Five-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 × Five-Year Yields	–0.078*
	(0.045)
Capital Adequacy Ratio × Output Gap	–0.038***
	(0.012)
Bank Fixed Effect	√
Sample Period	2005–2016
Observations	2,382
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

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent 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.

We should note that by including time fixed effects, we cannot identify the effect of the macroeconomic variables, although we extensively control for unobserved macroeconomic effects.

Columns 1 and 2 in Table 7 correspond to the specifications in Tables 3 and 4, respectively. Column 1 indicates that the competition index has a statistically significant estimate. In addition, as shown in column 2 in Table 7, the coefficients on core ROA, capital adequacy ratio, and their interaction term have qualitatively similar estimates to those in Table 4.

Furthermore, we investigate the effect of each variable by including all of the variables simultaneously as well as year fixed effects in

Table 7. Robustness Check with Year Fixed Effects

	(1)	(2)	(3)
Lagged Dependent Variable	0.420***	0.534***	0.604***
	(0.0574)	(0.0566)	(0.0500)
Competition Index	5.802***	—	1.173***
	(0.872)		(0.444)
Core ROA	—	–7.544***	–3.482***
		(1.390)	(1.166)
Capital Adequacy Ratio	—	0.238***	0.165**
		(0.0922)	(0.0718)
Low Capital Dummy × Core ROA	—	2.227*	1.372
		(1.237)	(1.148)
Bank Fixed Effect	√	√	√
Year Fixed Effect	√	√	√
Sample Period	2005–2016	2005–2016	2005–2016
Observations	2,382	2,382	2,382
Hansen Test (p-value)	0.193	0.100	0.141
Arellano-Bond Test for AR(1) (p-value)	0.000	0.000	0.000
Arellano-Bond Test for AR(2) (p-value)	0.887	0.435	0.356

Note: *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Robust standard errors are in parentheses. The table indicates the estimation result for the dynamic panel model with bank variables and year 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.

column 3. The estimation result indicates that the competition index and bank variables have qualitatively similar estimated coefficients to the baseline estimations in Table 3 and 4.[12]

6. Conclusion

In this paper, we investigate the driving factors behind the increase in loans to risky firms, i.e., "LRBs," by exploiting bank-firm matched

[12]We should note that the impact of each variable becomes slightly smaller than the impact in the baseline model. This is because the competition index, return on assets, and capital ratio are weakly correlated with each other. This result is reasonable if we consider that the competition among banks would be intensified when they face low profitability and such competition erodes profits further, impairing the capital ratio. To investigate the driving factors of intensifying competition is an interesting topic. However, it is out of the scope of this paper and is a topic for future research.

data in Japan. We show 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 LRBs. In addition, banks with low capital do not increase loans to LRBs 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 LRBs. 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' risk-taking behavior in the post-Basel III regulatory framework, where banks have sufficient capital in general, as well as in the low interest rate environment with low economic growth rates, which is prevalent 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 rate 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.

Appendix

A.1 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

A.2 Detailed Information on the Data

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

- COSMOS1 includes detailed information on profit/loss 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 fewer firms than COSMOS1 and COSMOS2 and covers only from 2008 to 2016.

A.3 Definition of Low-Return Borrowers

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

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

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 creditworthy 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, LRBs are defined as follows:

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

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

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:

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

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

A.4 Aggregation by Banks

In this section, 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 data set, 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 Table A.1.

The fifth to the ninth 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 10 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 $\Sigma_{i=1}^n \; w_i^n = 1$. We estimate w_m^n using the auxiliary data set, 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 Table A.2.

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 LRBs ($LSHARE_{i,t}$) for bank i as follows:

$$LSHARE_{i,t} = \frac{\sum_{j \in N_{i,t}} LowReturn_{j,t} \times LOAN_{i,j,t}}{LOAN_{i,t}}, \qquad \text{(A.1)}$$

where $N_{i,t}$ indicates a set of firms who have a relationship with bank i and $LowReturn_{j,t}$ is an LRB dummy variable. $LOAN_{i,j,t}$ is

Table A.1. Bank-Firm Matched Data from COSMOS1 and COSMOS2 Combined

	Low Return	**Total Loans**	**No. 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
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
$firm_{J-2}$	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	

Table A.2. Amount of Loans from Each Bank, Calculated Using Auxiliary Data Set

	Low Return	**Total Loans**	**No. of Bank Transactions**	$\boldsymbol{bank_1}$	$\boldsymbol{bank_2}$	$\boldsymbol{bank_3}$	$\boldsymbol{bank_4}$	$\boldsymbol{bank_5}$
$firm_1$	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

the estimated amount of loans from bank i to firm j in the above procedure.

A.5 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.

References

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. 2019. "Whatever It Takes: The Real Effects of Unconventional Monetary Policy." *Review of Financial Studies* 32 (9): 3366–3411.

Adrian, T., and N. Liang. 2018. "Monetary Policy, Financial Conditions, and Financial Stability." *International Journal of Central Banking* 14 (1): 73–131.

Albertazzi, U., B. Becker, and M. Boucinha. 2021. "Portfolio Rebalancing and the Transmission of Large-Scale Asset Purchase Programs: Evidence from the Euro Area." *Journal of Financial Intermediation* 48 (October): Article 100896.

Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez. 2014. "Does Monetary Policy Affect Bank Risk?" *International Journal of Central Banking* 10 (1, March): 95–136.

Andrews, D., and F. Petroulakis. 2017. "Breaking the Shackles: Zombie Firms, Weak Banks and Depressed Restructuring in Europe." OECD Economics Department Working Paper No. 1433 (November).

Aoki, K., A. Ono, S. Nishioka, K. Shintani, and Y. Yasui. 2016. "Long-Term Interest Rates and Bank Loan Supply." Working Paper No. 16-E-2, Bank of Japan (March).

Banerjee, R., and B. Hofmann. 2018. "The Rise of Zombie Firms: Causes and Consequences." *BIS Quarterly Review* (September): 67–78.

Bank of Japan. 2009. "Financial System Report, March 2009."

———. 2017. "Financial System Report, October 2017."

———. 2018a. "Financial System Report, April 2018."
———. 2018b. "Financial System Report, October 2018."
Blundell, R., and S. Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87 (1): 115–43.
Boyd, J. H., and G. De Nicolo. 2005. "The Theory of Bank Risk Taking and Competition Revisited." *Journal of Finance* 60 (3): 1329–43.
Caballero, R. J., T. Hoshi, and A. K. Kashyap. 2008. "Zombie Lending and Depressed Restructuring in Japan." *American Economic Review* 98 (5): 1943–77.
Chodorow-Reich, G. 2014. "Effects of Unconventional Monetary Policy on Financial Institutions." *Brookings Papers on Economic Activity* 45 (1, Spring): 155–227.
Dell'Ariccia, G., L. Laeven, and G. A. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States." *Journal of Finance* 72 (2): 613–54.
Dell'Ariccia, G., L. Laeven, and R. Marquez. 2014. "Monetary Policy, Leverage, and Bank Risk-taking." *Journal of Economic Theory* 149 (January): 65–99.
Fukuda, S., and J. Nakamura. 2011. "Why Did 'Zombie' Firms Recover in Japan?" *World Economy* 34 (7): 1124–37.
Hosono, K., and D. Miyakawa. 2014. "Business Cycles, Monetary Policy, and Bank Lending: Identifying the Bank Balance Sheet Channel with Firm-Bank Match-level Loan Data." RIETI Discussion Paper No. 14026.
Hosono, K., and M. Sakuragawa. 2005. "Bad Loans and Accounting Discretion." Manuscript.
International Monetary Fund. 2018. "Global Financial System Report, April 2018."
Jacobson, T., J. Lindé, and K. Roszbach. 2013. "Firm Default and Aggregate Fluctuations." *Journal of the European Economic Association* 11 (4): 945–72.
Jiménez, G., J. A. Lopez, and J. Saurina. 2013. "How Does Competition Affect Bank Risk-Taking?" *Journal of Financial Stability* 9 (2): 185–95.
Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica* 82 (2): 463–505.

Joyce, M. A. S., Z. Liu, and I. Tonks. 2014. "Institutional Investor Portfolio Allocation, Quantitative Easing and the Global Financial Crisis." Working Paper No. 510, Bank of England.

Koijen, R. S. J., F. Koulischer, B. Nguyen, and M. Yogo. 2017. "Euro-area Quantitative Easing and Portfolio Rebalancing." *American Economic Review* 107 (5): 621–27.

Kwon, H. U., F. Narita, and M. Narita. 2015. "Resource Reallocation and Zombie Lending in Japan in the 1990s." *Review of Economic Dynamics* 18 (4): 709–32.

Maddaloni, A., and J.-L. Peydró. 2011. "Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards." *Review of Financial Studies* 24 (6): 2121–65.

Martinez-Miera, D., and R. Repullo. 2010. "Does Competition Reduce the Risk of Bank Failure?" *Review of Financial Studies* 23 (10): 3638–64.

———. 2017. "Search for Yield." *Econometrica* 85 (2): 351–78.

Paludkiewicz, K. 2021. "Unconventional Monetary Policy, Bank Lending, and Security Holdings: The Yield-Induced Portfolio Rebalancing Channel." *Journal of Financial and Quantitative Analysis* 56 (2): 531–68.

Peek, J., and E. S. Rosengren. 2005. "Unnatural Selection: Perverse Incentives and the Misallocation of Credit in Japan." *American Economic Review* 95 (4): 1144–66.

Rodnyansky, A., and O. M. Darmouni. 2017. "The Effects of Quantitative Easing on Bank Lending Behavior." *Review of Financial Studies* 30 (11): 3858–87.

Schivardi, F., E. Sette, and G. Tabellini. 2021. "Credit Misallocation During the European Financial Crisis." *Economic Journal* 132 (641): 391–423.

Sekine, T., K. Kobayashi, and Y. Saita. 2003. "Forbearance Lending: The Case of Japanese Firms." *Monetary and Economic Studies* 21 (2): 69–92.

Storz, M., M. Koetter, R. Setzer, and A. Westphal. 2017. "Do We Want These Two to Tango? On Zombie Firms and Stressed Banks in Europe." IWH Discussion Paper No. 13/2017, Halle Institute for Economic Research (IWH).