Bank of Japan Working Paper Series

How Do Japanese Banks Set Loan Interest Rates?: Estimating Pass-Through Using Bank-Level Data

Tomiyuki Kitamura*
Tomiyuki.Kitamura@bankofengland.co.uk

Ichiro Muto**
ichirou.mutou@boj.or.jp

Ikuo Takei***
ikuo.takei@boj.or.jp

No.15-E-6
July 2015

Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* Financial System and Bank Examination Department
(currently Bank of England)
** Financial System and Bank Examination Department
(currently Monetary Affairs Department)
*** Financial System and Bank Examination Department

How Do Japanese Banks Set Loan Interest Rates?: Estimating Pass-Through Using Bank-Level Data*

Tomiyuki Kitamura†, *Ichiro Muto*‡, *Ikuo Takei*§

Abstract

We estimate interest rate pass-through in the loan market using an individual bank-based panel dataset from Japan. Previous studies using data from European countries have presented a number of common findings, including that banks with a high proportion of relationship lending tend to set lower pass-through. In this respect, we have obtained similar results using a dataset for Japan going back to the early 2000s. We further examine the influence of borrowing firms' balance sheet characteristics on loan interest rate pass-through, and find that these factors are also important determinants for pass-through dispersion. However, we also find that after the recent global financial crisis, even banks with a high proportion of relationship lending have largely lowered loan interest rates by raising pass-through, and that pass-through has not necessarily been determined in accordance with borrowing firms' balance sheet characteristics. These results differ from those of recent studies on European countries. Possible background factors explaining this change are that (i) pressure to lower loan interest rates has risen due to extensive monetary easing and greater lending competition among banks, while Japan's banking system as a whole has maintained its resilience in the post-crisis period; (ii) demand for bank loans has increased substantially due to disruptions in the market for alternative funding sources, such as commercial paper and corporate bonds; and (iii) public measures to increase bank loans have been broadly introduced in Japan.

JEL Classification: E43, E44, G21

Keywords: Loan Interest Rate; Pass-Through; Relationship Lending; Financial Crisis

---

*The authors are grateful to Shuuji Issiki, Seiji Ito, Eiji Kawahara, Arito Ono, Christoffer Kok Sørensen, Iichiro Uesugi, Wako Watanabe, Yoichiro Yamaguchi, and staffs at the Bank of Japan. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan.

†Financial System and Bank Examination Department (currently Bank of England), E-mail: Tomiyuki.Kitamura@bankofengland.co.uk.

‡Corresponding author. Director, Financial System and Bank Examination Department (currently Monetary Affairs Department), Bank of Japan. E-mail: ichirou.mutou@boj.or.jp. Tel: +81-3-3277-2801. 2-1-1 Nihonbashi-Hongokucho Chuo-ku, Tokyo, 103-8660, Japan.

§Financial System and Bank Examination Department, Bank of Japan, E-mail: ikuo.takei@boj.or.jp.

1 Introduction

Banks' loan interest rate setting determines profitability from their core business and ultimately impacts on the stability of their financial basis through their accumulation of capital. Therefore, one of the most important decisions made by individual banks is the loan interest rates they set. In addition, because the bank lending channel plays a central role in a bank-oriented financial system like Japan's, how banks set their loan interest rates is an important determinant of the effectiveness of monetary policy. For these reasons, analyzing banks' loan interest rate setting behavior seems to be of benefit both for monitoring bank operations and for understanding monetary policy transmission channels.

In many existing studies, banks' loan interest rate setting behavior is investigated from the interest rate pass-through perspective, which examines the responsiveness of loan interest rates to market interest rate variations such as changes in banks' funding costs in interbank markets. This reflects the well-known fact that banks' loan interest rates tend to respond gradually to changes in market interest rates, which suggests the presence of a degree of stickiness in loan interest rates. The absence of complete pass-through – at least in the short-run – implies that in the face of increasing market interest rates, banks attempt to limit rises in borrowing firms' funding costs for various reasons, even if such behavior reduces their interest rate spreads on loans.

Most empirical studies that employ individual bank-level data to estimate interest rate pass-through in loan markets have been conducted in European countries. Representative investigations have been carried out by Weth (2002), Graeve, Jonghe, and Vennet (2007), Gambacorta (2008), and Horváth and Podpiera (2009), who respectively use datasets from Germany, Belgium, Italy, and the Czech Republic.[1] These studies share the two following common features. First, they focus on heterogeneity in interest rate pass-through among individual banks, and take account of individual banks' transaction structures (such as relationship banking and monopolistic power in loan markets) and banks' balance sheet characteristics (such as asset size, bank capital, and liquidity).[2] Second, they model and estimate interest rate pass-through as the speed of adjustment in the short-run dynamics of error-correction models (ECM) with which loan interest rates converge to their long-run equilibrium values.

Findings common to the majority of these studies include that (i) banks with a high proportion

[1] Some previous studies estimate loan interest rate pass-through using country-level aggregate data rather than individual bank data. For example, Sørensen and Werner (2006) use a dataset from euro area countries, and Gigineishvili (2011) use a dataset comprising observations from 81 countries.

[2] Relationship lending is lending conducted under the lender-borrower relationship (relationship banking). Although there is no single definition of relationship banking, Boot (2000) defines it as "the provision of financial services by a financial intermediary that (1) invests in obtaining customer-specific information, that is often proprietary in nature; and that (2) evaluates the profitability of these investments through multiple interactions with the same customer over time and across products." Ongena and Smith (2000) define it as "connection between a bank and customer that goes beyond the execution of simple, anonymous, financial transactions." For surveys of theoretical and empirical studies on relationship lending, see Degryse, Kim, and Ongena (2009) and Ono (2011).

of relationship lending tend to set lower pass-through; and (ii) banks with larger capital buffers or liquidity buffers tend to set lower pass-through. The first result can be interpreted as demonstrating the function of inter-temporal interest rate smoothing typically observed in relationship lending. This means that when future benefits are expected to flow from a bank-firm lending relationship, banks tend to smooth out transaction conditions from a longer-run perspective (providing a kind of insurance function) rather than setting loan interest rates to satisfy short-term payoffs. In this case, loan interest rates are largely unresponsive to variations in market interest rates and, as a result, interest rate pass-through declines. The second result is also basically understandable in the context of relationship lending: banks with larger capital buffers or liquidity buffers are able to provide borrowing firms with transaction conditions which deviate from short-run payoffs. Because banks operating in such circumstances smooth out transaction conditions from a longer-run perspective, interest rate pass-through falls.

Most of these existing studies use bank-side data to examine heterogeneity in interest rate pass-through among individual banks. However, pass-through also depends on the balance sheet characteristics of borrowing firms. For example, if borrowing firms raise a large amount of funds by issuing commercial paper or corporate bonds – which are alternatives to bank lending – banks' loan interest rate setting behavior might be affected by interest rate developments in these alternative markets. In addition, if borrowing firms' financial conditions temporarily deteriorate due to exogenous factors, banks might smooth out loan interest rates from a longer-run perspective if they expect to receive future benefits by maintaining their relationships with customer firms. As a result, interest rate pass-through declines.[3] These considerations suggest that a possible direction to extend existing interest rate pass-through estimation studies is to take account of borrowing firms' balance sheet characteristics.[4]

In this study we estimate loan interest rate pass-through behavior among Japanese banks. The sample period selected for our study is the post-2003 period in order to avoid serious data discontinuity due to mergers and acquisitions in Japan's banking sector. Loan interest rates have followed a moderate declining trend during this period, although it also includes some upward movements such as those that occurred in 2005 and 2007 (Figure 1).

To the best of our knowledge, no previous study has provided empirical analysis of loan interest rate pass-through in Japan using individual bank-level data. In addition, many existing studies investigate relationship lending characteristics (for example, Ono and Uesugi (2009) and others) using Japanese micro data, but no previous research has investigated the connection between relationship lending characteristics and interest rate pass-through. It is against this background that we present

[3] Using a dataset of individual banks' interest rates in the U.S. loan market, Berlin and Mester (1998) present empirical results showing that banks smooth out loan interest rates against an exogenous shock to credit risk for small and medium-sized companies.

[4] Weth (2002) points out the possibility that loan interest rate pass-through depends on borrowers' risk characteristics. However, he remarks that analysis of this possibility is beyond the scope of his study.

loan interest rate pass-through estimation results based on a bank-level dataset. In addition, we also examine the connection between relationship lending characteristics and determinants of loan interest rate pass-through. Our study contributes to the literature by presenting the first estimation results in this respect. However, our contributions are not limited to this point. A further novel feature of our study is that it takes account of borrowing firms' balance sheet characteristics as a possible determinant of pass-though, a factor which has been neglected in previous studies. In designing our empirical methodology, we refer to Gambacorta (2008), who estimates an ECM by applying the generalized method of moments (GMM) to a panel dataset.

This study also focuses on possible changes in loan interest rate pass-through after the recent global financial crisis. Few studies examine the determination of loan interest rates in the post-crisis period. One exception is the investigation of Gambacorta and Mistrulli (2014), who analyze this issue using a dataset drawn from individual Italian banks.[5] They report that (i) pass-through is lower for banks with a higher proportion of relationship lending than for other banks, even in the post-crisis period; and (ii) pass-through is lower for banks with larger capital buffers or liquidity buffers. These results suggest that the mechanism by which loan interest rate pass-through is determined has not changed significantly among Italian banks as a result of the global financial crisis.[6] However, it is still possible that Japanese banks have changed their pass-through setting behavior since the global financial crisis, as pressure to lower loan interest rates has strengthened due to extensive monetary easing and greater lending competition among banks. Meanwhile, Japan's banking system as a whole has maintained its resilience, even in the post-crisis period, and public measures designed to increase bank lending, such as financing facilities for small and medium-sized companies, have been broadly introduced.[7]

The remainder of this paper is organized as follows. Section 2 explains the method employed for estimating loan interest rate pass-through and describes the dataset we use. Section 3 reports the empirical Japanese bank pass-through results. We present the estimation results derived using both full-sample data since the early 2000s and post-crisis data. As a robustness check, we further investigate the existence of asymmetry of pass-through between rising and falling interest rate phases. Section 4 concludes the paper.

---

[5] Although they use individual bank data, their empirical methodology differs from ours and that of Gambacorta (2008) in that it uses cross-section data rather than panel data.

[6] Illes, Lombardi and Mizen (2015) and Paries et al. (2014) examine possible changes in loan interest rate pass-through after the global financial crisis. They report that pass-through estimated at aggregate levels is largely unchanged.

[7] European countries also introduced measures to support financial system stability after the financial crisis. However, most of them were aimed directly at strengthening banks' capital basis rather than at increasing bank lending. In practice, European banks continued deleveraging after the crisis, while NPL problems have become serious.

2 Loan interest rate pass-through estimation method

We first explain the model used for estimating loan interest rate pass-through. As is noted above, we follow the empirical specification of Gambacorta (2008), who estimates an ECM by applying the GMM to a panel dataset. The quarterly model is represented as follows:

$$\begin{aligned}\triangle i_{L,k,t} &= \mu_k + \sum_{j=1}^{2} \kappa_j \triangle i_{L,k,t-j} + \sum_{j=0}^{\Lambda} \left(\beta_j + \sum_m \beta^*_{mj} X_{m,k,t-1} \right) \triangle i_{M,t-1} \\ &\quad + \left(\alpha + \sum_m \alpha^*_m X_{m,k,t-1} \right) (i_{L,k,t-1} - i_{M,t-1}) + \sum_m \lambda_m X_{m,k,t-1} + \phi \overline{Z}_{k,t} + \varepsilon_{k,t}. \quad (1)\end{aligned}$$

In equation (1), $i_{L,k,t}$ is the loan interest rate of bank k at period t ($\triangle$ denotes the difference from the previous period), $i_{M,t}$ is the market interest rate at period t, $X_{m,k,t}$ is the vector of pass-through explanatory variables, which influence the loan interest rate independently from the market interest rate, of bank k at period t, and μ_k is a constant term to capture fixed effects influencing the determination of bank k's loan interest rate. The second term in equation (1) introduces lagged interest rates. Following Gambacorta (2008), the lag length is set at two. Λ in the third term represents the lag length of the difference in market interest rates. It is set at unity for long-term loan interest rates and at zero for short-term loan interest rates.

In the ECM of equation (1), the pass-through of loan interest rates for individual banks to market interest rate variations is assumed to be 100% in the long-run equilibrium.[8] However, pass-through in short-run dynamics depends on each variable ($X_{m,k,t}$), which are possible determinants of pass-through dispersion.[9,10] The control variables ($\overline{Z}_{k,t}$) in equation (1) represent factors influencing loan interest rates independently from market interest rate variations. Most of these factors are determinants of loan interest rate spreads, such as the variables representing the macroeconomic environment and market uncertainty. By controlling for these factors, we can observe how loan interest rates respond to variations in market interest rates, and thereby estimate loan interest rate pass-through.

---

[8] Long-run pass-through can be estimated. However, previous studies (for example, Graeve, Jonghe, and Vennet (2007)) report that long-run pass-through is likely to be underestimated, even if it is actually 100%, when the sample period is too short. It is possible that our sample period, which spans from 2003 to 2014, is not sufficiently long to obtain accurate values of long-run pass-through, because market interest rates in Japan have been stable for much of the period. Therefore, we adopt an approach similar to that of Hofmann (2000) and Mojon (2000) by assuming that long-run pass-through is 100%. However, as a robustness check, we examine the robustness of our findings by assuming that long-run pass-through is 90%, based on the estimation results of Gambacorta (2008). We find little variation in our results, especially in a qualitative sense.

[9] As explained later, each variables included in $X_{m,k,t}$, except for total asset size, is defined in terms of the deviation from its mean value in cross-sectional and historical directions. Total asset size is defined as the deviation from its cross-sectional mean.

[10] Instantaneous pass through for bank k is given as $\beta_0 + \sum_m \beta^*_{m0} X_{m,k,t-1}$. For the calculation of one-year-ahead pass-through, see the Appendix.

2.1 Loan interest rate pass-through determinants

For possible determinants of loan interest rate pass-through ($X_{m,k,t}$), we take account of three factors: (a) banks' transaction structures; (b) banks' balance sheet characteristics; and (c) borrowing firms' balance sheet characteristics (Figure 2). Previous studies using European data have reported that factors (a) and (b) influence loan interest rate pass-through. In addition to these factors, we take into account the influence of factor (c). In what follows, we explain specific variables chosen to represent factors (a), (b), and (c) (see Figure 2 for a conceptual explanation of determining pass-through, Figure 3 for the set of variables, Figure 4 for descriptive statistics, and Figure 5 for the distribution of each variable).

2.1.1 Banks' transaction structures

For the variables representing banks' transaction structures, we consider (i) the share small and medium-sized enterprises represent in banks' loan portfolios (the "SME ratio"); and (ii) share of the regional loan market ("market share").

(i) SME ratio As has already been explained, we expect pass-through to be lower for banks with a high proportion of relationship lending because they typically provide an inter-temporal interest smoothing function to their customer firms. Although there is no consensus on what variables are the appropriate measures to evaluate the proportion of relationship lending, we use the proportion of SME lending in each bank's loan portfolio. It is assumed that loans to small and medium-sized companies typically have relationship lending characteristics because these companies have relatively limited access to market-based funding and their business models and financial conditions are more likely to be subject to the problem of asymmetric information between borrowers and lenders.[11,12] As our data source, we use individual bank observations used for constructing the Bank of Japan's *Loans and Bills Discounted by Sector*.

(ii) Market share Previous studies suggest that market share influences loan interest rate pass-through from two perspectives. First, a bank with a large market share tends to set its loan interest rates at levels significantly higher than market interest rates by utilizing its monopolistic

[11] For example, Elyasiani and Goldberg (2004) point out that it is beneficial to build long-term transaction relationships between lenders and borrowers in order to mitigate various costs arising from informational asymmetry.

[12] For the proxy of the proportion of relationship lending, various indicators other than the SME ratio – such as geographical distance between banks and firms and the ratio of long-term lending – can be considered, and there is no consensus on which is the most appropriate measure for relationship lending. Gambacorta and Mistrulli (2014) use multiple indicators to examine Italian banks' loan interest rate setting behavior after the global financial crisis, such as the distance between firm and bank headquarters, the number of banks lending to a given firm, and credit history between banks and firms. They find that regardless of the choice of these indicators, variations in loan spreads are small for banks with a high proportion of relationship lending. Ono and Uesugi (2009) estimate the proportion of relationship lending using small enterprise data for Japan, such as credit history between banks and borrowing firms and the number of banks lending to a given borrowing firm. They report that strong relationship lending characteristics increase the likelihood of the borrowing firm pledging collateral to banks.

power. The large markup arising from the bank's monopolistic power then acts as a buffer against market interest rate variations, and as a result, pass-through is expected to decline.[13] Second, if a bank has a large market share, its customer relationships are likely to be close and relationship lending naturally arises.[14] A bank in this situation is expected to have lower pass-through because it provides an inter-temporal interest rate smoothing function. For the data representing market share, we calculate the Herfindahl index by using individual bank data for the Bank of Japan's *Deposits, Vault Cash, and Loans and Bills Discounted by Prefecture*.[15]

2.1.2 Banks' balance sheet characteristics

For the variables representing banks' balance sheet characteristics, we consider (i) total asset size; (ii) capital adequacy ratio; and (iii) liquidity ratio.

(i) Total asset size Total asset size is used as the most fundamental variable representing banks' balance sheet characteristics.[16] Previous studies show a lack of consensus on the relationship between total asset size and loan interest rate pass-through. Weth (2002) reports that pass-through is higher for banks with large asset sizes. In contrast, Gambacorta (2008) and Horváth and Podpiera (2009) show that asset size is not an important determinant of pass-through.[17]

(ii) Capital adequacy ratio The capital adequacy ratio is used to measure banks' ability to absorb losses. As noted above, previous studies using European data have reported that pass-through is lower for banks with larger capital buffers (Gambacorta (2008)). This finding can be interpreted to mean that banks with a high capital buffer do not significantly change loan interest rates in response to market interest rate movements because they have sufficient capacity to supply funds at stable interest rates in order to maintain their firm relationships. In this study, we measure the size of the capital buffer by calculating the difference between the bank's capital adequacy ratio and the regulatory level.[18]

---

[13] Berger (1995) theoretically points to this possibility. Graeve, Jonghe, and Vennet (2007) demonstrate that this hypothesis is supported by their empirical study using Belgian bank data.

[14] Ono (2007) uses Japanese data to examine the linkage between market share and relationship lending. He reports that the proportion of relationship lending tends to be large for a bank with a high market share.

[15] The Herfindahl index for each region is calculated as the sum of squared regional loans outstanding for each bank divided by the square of the sum of regional loans outstanding across banks.

[16] Total asset size can be interpreted as a proxy of relationship lending. For example, Uchida, Udell and Watanabe (2008) present results showing that borrowing firm relationships tend to be strong for banks with small total assets.

[17] Weth (2002) explains that small banks set loan interest rates without taking much account of market interest rate variations because borrowing firms are typically small and face some constraints regarding market-based funding.

[18] As capital adequacy ratio data, we use total capital adequacy ratios for internationally active banks and capital adequacy ratios for domestic banks (core capital ratios are from fiscal 2013). The regulatory levels are 8% for the former and 4% for the latter.

(iii) Liquidity ratio The liquidity ratio is used as the measure of banks' liquidity buffer. Banks with a high liquidity ratio are assumed to have a high capacity to absorb shocks to market conditions. Therefore, as in the case of the capital adequacy ratio, we expect such banks to leave their loan interest rates largely unchanged in response to market interest rate movements because they have sufficient capacity to smooth out transaction conditions.[19] Previous studies using European data have reported that pass-through is lower for banks with a higher liquidity ratio (Gambacorta (2008), Graeve, Jonghe, and Vennet (2007)). In this study, we calculate the liquidity ratio as the sum of securities, cash, and the current account balance at the Bank of Japan divided by total assets, using individual bank data from the Bank of Japan's *Financial Institutions Accounts*.

2.1.3 Borrowing firms' balance sheet characteristics

Previous studies have not taken explicit account of borrowing firms' balance sheet characteristics as a determinant of heterogeneity in loan interest rate pass-through. Although several measures can be considered as borrowing firms' balance sheet characteristics, we choose (i) the market funding ratio; (ii) the debt to equity ratio; and (iii) the interest coverage ratio (ICR) as possible determinants of pass-through.[20]

(i) Market funding ratio It is possible that borrowing firms' funding structures influence loan interest rate pass-through. For example, if a borrowing firm raises a large proportion of its funds through market-based funding instruments such as commercial paper or corporate bonds, arbitrage between market interest rates and loan interest rates – which is the cost of an alternative funding source for these firms – is likely to arise. As a result, we expect loan interest rate pass-through to be higher for such a firm. Therefore, in this study, we take into account borrowing firms' market funding ratios as a possible determinant of pass-through.[21]

(ii) Debt to equity ratio Borrowing firms' debt to equity ratio is considered to influence the determination of pass-through from multiple perspectives. One viewpoint is that the debt to equity ratio measures firms' debt burden. For example, when a borrowing firm's debt burden rises temporarily due to exogenous factors, a bank having a close relationship with the firm is expected to smooth out transaction conditions if a future benefit is expected. Pass-through then declines. Another viewpoint is that the debt to equity ratio represents the firm's funding structure. Because firms with a higher debt to equity ratio are more dependent on bank lending, the relationships between such firms and banks tend to be strong. In this situation, banks smooth out transaction

[19] A presumption made for this interpretation is the existence of relationship lending between bank and firm.

[20] We also examine the impact of firms' return on assets (ROA) on loan interest rate pass-through. However, we find that the impact is not significantly different from zero.

[21] In this study, the market funding ratio is defined as the sum of commercial paper and corporate bonds divided by the sum of discounts, short-term loans, long-term loans, commercial paper and corporate bonds.

conditions. As a result, pass-through becomes low. Therefore, from either viewpoint, borrowing firms with a higher debt to equity ratio are expected to have lower pass-through.

(iii) Interest coverage ratio (ICR) The ICR is defined as the sum of operating profits, interest received, and dividends received divided by interest payments. While the debt to equity ratio is the measure of firms' debt burden, the ICR represents firms' ability to make interest payments, which indicates to what extent firms can cover interest payments in each period from revenue earned in the same period. This means that a low ICR signifies a low ability to make interest payments. The ICR influences pass-through behavior in a similar way to the debt to equity ratio. For example, if a firm's ICR temporarily declines due to deteriorating business conditions, a bank having a close relationship with the firm is expected to smooth out their transaction conditions if a future benefit is expected. Pass-through then declines. Another possibility is that firms with a lower ICR tend to be highly dependent on bank lending. If so, pass-through is likely to be low because the relationships between such firms and banks are strong. From either viewpoint, pass-through is expected to be low if the ICR is low.

For observations of these variables representing individual firms' financial data, we use the SPECIA database provided by Teikoku Databank. We use this database, which includes observations for approximately 150,000 companies, to calculate the market funding ratio, the debt to equity ratio, and the ICR for individual firms.[22,23] However, because it is difficult to identify individual transactions between banks and firms directly from this database,[24] balance sheet data for firms with which banks conduct transactions are not available. Because of this problem, we calculate a proxy of borrowing firms' balance sheet data for each bank by averaging out firms' balance sheet data aggregated at prefecture level with the weight of each bank's loans outstanding in each prefecture. In Figure 6, which presents each variable aggregated at prefecture level, we find considerable dispersion among regions.

2.2 Control variables

The control variables ($\overline{Z}_{k,t}$) in equation (1) represent factors influencing loan interest rates independently from market interest rate variations. These factors include determinants of loan interest spreads, such as the variables representing the macroeconomic environment and market uncertainty.

[22] For the treatment of outliers, we exclude (i) firms lacking sales data; and (ii) firms with the top 0.1% of current profits in each prefecture.

[23] We confirm that the time series of financial variables aggregated by using individual data are mostly consistent with macro-level statistics such as "*Financial statements statistics of corporations by industry*" published by the Ministry of Finance.

[24] SPECIA does not provide data on the transactions between individual banks and individual firms before 2007. In addition, even after 2007, it does not provide us with information on all transactions between banks and firms.

For example, it is possible that changes in loan demand, increased market uncertainty, and deteriorating loan portfolio quality exert pressure to increase loan spreads independently from market interest rate variations. In this study, we use potential economic growth as a structural factor, changes in the GDP gap as a cyclical factor, market volatility as an uncertainty factor, and changes in the non-performing loan (NPL) ratio as a factor representing changes in the quality of portfolios.[25] We also introduce fixed effects (μ_k), which represent other determinants of individual banks' loan spreads, in the first term of equation (1).

2.3 Interest rate data

As loan interest rate data, we use individual bank observations reported for the Bank of Japan's *Average Contract Interest Rates on Loans and Discounts*. These statistics bring together loan interest rates for various types of loans and discounts (long-term loans, short-term loans, discounts, and overdrafts). In this study, we define long-term interest rates as the interest rates for loans maturing in more than one year (long-term loans) and short-term interest rates as the interest rates for loans maturing strictly in less than one year (the sum of short-term loans, discounts, and overdrafts). We then estimate the pass-through of long-term interest rates and short-term interest rates separately.[26] The reason for this separate estimation is that pass-through can naturally differ between long-term loans, which are mainly used for long-term fixed investments, and short-term loans, most of which are used for routine business operations. Based on the fact that long-term loans as a share of Japanese banks' loans outstanding were 78.6% as of September 2014, we mainly focus on the pass-through of long-term interest rates.

As data on market interest rates, which represent banks' funding costs, we use three year swap rates and three month LIBOR for estimating the pass-through of long-term interest rates and short-term interest rates, respectively. These data are obtained from Bloomberg. The length of the market interest rate is chosen so that the correlation between the market interest rate and the (long- or short-term) loan interest rate is maximized.

2.4 Estimation method and samples

In estimating a dynamic panel model including fixed effects and a lagged-term like equation (1), ordinary least squares (OLS) does not satisfy the consistency of parameters as the error term has serial correlations through the lagged term. Therefore, we apply the dynamic GMM approach

[25] Potential economic growth and the GDP gap are estimated by de-trending real GDP with HP filtering (λ=1600). As the market volatility variable, we use the historical volatility of three month LIBOR (the observation period is one year).

[26] Variable interest rate loans represent 64.7% of total loans outstanding. In order to estimate the pass-through of interest rates on both new loans and existing loans, we use stock-based data for loan interest rates. In carrying out this study, we also conduct an estimation which controls for heterogeneity in the ratio of variable interest rate loans among banks. The results are not qualitatively different from those presented in Section 3.

developed by Arrellano and Bond (1991).[27] The bank samples employed are major banks and regional banks, comprising 10 and 105 banks as of September 2014. The sample period chosen is from March 2003 to September 2014 to avoid serious discontinuity due to bank mergers and acquisitions.[28]

3 Estimation results

In this section, we present estimation results on loan interest rate pass-through. First, we provide the results obtained using the full sample since the early 2000s. Next, we present the results derived using the post-global financial crisis sub-sample and compare it with those obtained for the full sample period. Finally, as a robustness check, we estimate pass-through by taking account of possible asymmetry between rising and declining interest rates.

3.1 Full sample results

We now present the pass-through estimation results based on the full sample period from March 2003 to September 2014. Figure 7 shows the estimation results on long-term loan interest rates. We employ four specifications. In equation (i), we introduce only factors which have already been examined by previous studies: (a) the variables related to banks' transaction structures (SME ratio and market share); and (b) those related to banks' balance sheet characteristics (total asset size, capital adequacy ratio, and liquidity ratio). In the other equations ((ii), (iii), and (iv)), we introduce (c) variables related to borrowing firms' balance sheet characteristics (market funding ratio, debt to equity ratio, and ICR). We display median values for one-year and three-year-ahead pass-through, which are defined as the pass-through in each term assuming that all explanatory variables take median values among banks. Given the median values, in order to identify the impact of each variable on the dispersion of pass-through, we present pass-through values based on the assumption that a particular variable (for example the SME ratio) takes the values of 75% and 25% among banks. In addition, we show the statistical significance of the estimated pass-through value from its median value in accordance with three significance levels (1% significance represented by ***,

[27] The estimation method of Arellano and Bond (1991) provides consistent estimates by applying the GMM and transforming the model into first-differences to remove the fixed effects. Their method requires that errors are not serially correlated for second-order estimation. We test the null hypothesis that models are not subject to serial correlation of order two, and the null hypothesis is not rejected. In addition, while the dynamic GMM uses instrumental variables, it is necessary to verify that the moment conditions are valid under different combinations of instrument variables when the number of instrumental variables exceeds the number of estimated parameters. The over-identifying restrictions test (Sargan test) is performed, and the null hypothesis that the over-identifying restrictions are valid is not rejected. Moreover, the null hypothesis that the over-identifying restrictions are valid is not rejected for results obtained using the post-global financial crisis sub-sample.

[28] In Japan, the decrease in the number of banks reached its peak in the early 2000s due to bankruptcies and mergers among banks. This data discontinuity might become significant when we include observations before the early 2000s.

5% by **, and 10% by *).[29] The middle of the figure also presents coefficients on control variables and the error-correction term.

The estimation results obtained with equation (i) indicate that the median value of one-year-ahead pass-through is 0.18.[30] As for the factors influencing pass-through heterogeneity, the SME ratio and market share are statistically significant at the 1% level. Pass-through is lower for banks with a higher SME ratio, being estimated at 0.16 at the 75^{th} percentile and 0.19 at the 25^{th} percentile. Similarly, pass-through is lower for banks with a larger market share, being 0.15 at the 75^{th} percentile and 0.20 at the 25^{th} percentile. As has already been explained, the SME ratio and market share can together be viewed as a proxy of the proportion of relationship lending. From this perspective, the results showing lower pass-through for banks with a higher proportion of relationship lending can be regarded as qualitatively the same as those of previous studies using European data. This evidence is consistent with the view that pass-through tends to be low for relationship lending because of the inter-temporal smoothing of transaction conditions.

For the variables related to banks' balance sheet characteristics, total asset size and the capital adequacy ratio do not yield substantial pass-through dispersion, although these variables are statistically significant. In contrast, the liquidity ratio is statistically significant at 0.15 at the 75^{th} percentile and 0.20 at the 25^{th} percentile, values which indicate that this factor yields some pass-through dispersion. Many previous studies using European data demonstrate that pass-through tends to be low for banks with a high capital adequacy ratio or a high liquidity ratio. Therefore, our liquidity ratio results are consistent with those of previous studies. In contrast, a possible reason the capital adequacy ratio does not yield significant pass-through variation is that Japanese banks have accumulated their capital, reflecting their improved financial conditions, and capital adequacy ratios for many Japanese banks have recently far exceeded regulatory levels. This situation is confirmed by Figure 4, which indicates that the average capital adequacy ratio buffer – calculated as the difference between the capital adequacy ratio and its regulatory level – exceeds 6%, and by Figure 5, which also indicates that some banks have a capital adequacy ratio buffer of more than 10%. It is reasonable to conclude that there is no clear link between pass-through and the capital adequacy ratio among banks with sufficiently large capital adequacy ratio buffers.

Next, we examine the influence of borrowing firms' balance sheet characteristics on pass-through. Equations (ii), (iii), and (iv) indicate that in explaining loan interest rate variations, the market funding ratio, the debt-to-equity ratio, and the ICR are all statistically significant at the 1% level.

[29] We check the statistical significance of our results on the heterogeneity of interest rate pass-through by testing whether the difference between one-year-ahead pass-through$_{25\%\text{ point or }75\%\text{ point}}$ and one-year-ahead pass-through$_{50\%\text{ point}}$ is statistically different from zero. In previous studies, Gambacorta (2008) and Weth (2002) calculate the p-value using the approximation of "delta method (first order approximation)". In contrast, our tests use Monte Carlo calculations. The sample size (500,000) is large enough to ensure the p-value converges to a stable value.

[30] It is difficult to compare our long-term loan rate pass-through estimates directly with those presented by previous studies because long-term loan rate pass-through depends on banks' maturity structures. For instance, Donnay and Degryse (2001) and Mojon (2000) report one-quarter-ahead pass-through values ranging from 0.2 to 0.5.

Equation (ii) shows that pass-through tends to be higher for banks with a higher market funding ratio, as it is 0.28 at the 75^{th} percentile and 0.23 at the 25^{th} percentile. Equation (iii) indicates that pass-through is somewhat lower for banks with a higher debt-to-equity ratio, as it is 0.23 at the 75^{th} percentile and 0.25 at the 25^{th} percentile. Equation (iv) indicates that pass-through is lower for banks with a lower ICR, as it is 0.47 at the 75^{th} percentile and 0.40 at the 25^{th} percentile. These results are consistent with the relationship assumed in the previous section.

With respect to the control variables, the coefficients on potential economic growth and the NPL ratio are statistically significant and positive for all specifications, and those on the GDP gap and market volatility are statistically significant and positive for some specifications. These results can be interpreted as follows. First, a rise in potential economic growth or the GDP gap raises loan interest rates by increasing loan demand. Second, greater market volatility raises loan interest rates by increasing risk premiums. Third, banks with a high NPL ratio set higher credit spreads because borrowing firms' financial conditions are relatively poor.[31]

The short-term loan interest rate pass-through estimation results are presented in Figure 8. The median value of one-year-ahead pass-through ranges from 0.5 to 0.8 depending on the specification.[32] Looking at the impact of possible determinants on pass-through dispersion, the SME ratio is statistically significant and pass-through is lower for banks with a higher SME ratio, results that are similar to those on long-term interest rates. In contrast, although market share is statistically significant, pass-through is higher for banks with a higher market share, a result opposite to those on long-term interest rates. A possible explanation is that banks with a large market share – which allows for lower pass-through on long-term loans – reflect much of the market interest rate variation on short-term loan interest rates to compensate for small spreads on long-term interest rates. In the case of short-term lending, it is assumed that monopolistic banks can adjust their loan interest rates significantly in response to market interest rate movements given they have less need to foster long-term relationships. For the variables related to banks' balance sheet characteristics, the capital adequacy ratio and the liquidity ratio are not statistically significant in explaining pass-through dispersion. These results also suggest that in short-term lending, banks do not absorb market interest rate variations by using their capital or liquidity buffers to take account of firm relationships. The variables related to borrowing firms' balance sheet characteristics are generally weak in explaining pass-through. This result also suggests that relationship lending is weak in guiding short-term lending rates.

[31] It is also possible that banks with deteriorating financial conditions need to raise loan interest rates because of their higher funding rates.

[32] Gambacorta (2008) reports that one-quarter-ahead pass-through of short-term loan interest rate estimates range from 0.82 to 0.88.

3.2 Post-crisis results

We next examine how loan interest rate pass-through behavior among Japanese banks has changed since the global financial crisis began in 2008. Specifically, we estimate pass-through based on the above specification using data for the sub-sample period from September 2008 to September 2014.

Figure 9 reports the estimation results for pass-through on long-term loan interest rates in the post-crisis period. For the variables related to banks' transaction structures, we cannot find the negative relationship between the SME ratio and pass-through observed in the full sample results, although the SME ratio is statistically significant in explaining pass-through. In addition, we find that the relationship between market share and pass-through depends on the specification (positive for (i) and (ii) and negative for (iii) and (iv)), although it is statistically significant. These results suggest that the relationship between banks' transaction structures and pass-through has changed since the global financial crisis. The upper panels of Figure 10 compare the estimated pass-through values between the full sample and the post-crisis data. These results indicate that pass-through on long-term loan interest rates has increased for banks with a high SME ratio since the global financial crisis. This means that even banks with a high proportion of relationship lending have lowered their loan interest rates significantly by increasing their pass-through.

Figure 9 shows that among the variables related to banks' balance sheet characteristics, total asset size is statistically significant and has a positive relationship with pass-through, which differs from the results obtained using the full sample data. This result can be interpreted as showing that large banks – which have been relatively significantly influenced by global financial market developments in the wake of the financial crisis – have since lowered their loan interest rates because their funding costs have declined to a large extent as the influence of the financial crisis has diminished and market interest rates have declined. In fact, the data on individual banks' market funding spreads – which are calculated by subtracting market-wide funding costs (market interest rates) from individual banks' market-based funding costs – show that spreads have declined by a relatively large amount for banks with large total assets (Figure 11). Turning to the capital adequacy ratio, pass-through in the post-crisis period is higher for banks with small capital adequacy ratio buffers. This is also confirmed by Figure 11, which shows that market funding spreads have declined relatively significantly for banks with smaller capital buffers. This suggests that these banks have lowered their loan interest rates because their funding costs have declined to a large extent as the influence of the financial crisis has diminished and market interest rates have declined. The relationship between the liquidity ratio and pass-through has become unclear since the financial crisis. A possible reason for this result is that each bank's liquidity ratio has reached a sufficiently high level against the background of recent extensive monetary easing, and that differences among high liquidity ratios have not been an important determinant of pass-through dispersion among banks. As these results suggest, the overall relationship between banks' balance sheet characteristics and

pass-through has changed in the wake of the global financial crisis.

Finally, for the variables related to borrowing firms' balance sheet characteristics, each variable has lost its statistical explanatory power for pass-through in the post-crisis sample period. The lower panels of Figure 10 suggest that with respect to the market funding ratio or the debt-to-equity ratio, long-term loan interest rates are almost the same across individual banks since the financial crisis. The positive relationship found between the ICR and pass-through in the full sample period qualitatively holds in the post-crisis period. However, quantitatively, the pass-through difference between firms with lower and higher ICRs becomes small in the post-crisis period. These results suggest that pass-through policies have not necessarily been determined in accordance with borrowing firms' balance sheet characteristics since the global financial crisis.

The above findings tell us that Japanese banks have altered how they determine pass-through on long-term loan interest rates in the post-crisis period. Among these changes, the finding that pass-through has increased for banks with a high proportion of relationship lending differs from the results obtained in some previous studies using European country data, which report that pass-through behavior remains largely unchanged even after the financial crisis (see, for example, Gambacorta and Mistrulli (2014) and Illes, Lombardi, and Mizen (2015)). A basic background factor explaining our results is that pressure to cut loan interest rates has been strengthened due to extensive monetary easing and more intense lending competition among banks, while Japan's banking system as a whole has maintained its resilience in the post-crisis period. Due to the strong pressure to reduce loan interest rates, banks with a high proportion of relationship lending – which tended to smooth out loan interest rates before the crisis period – have become more aggressive in lowering loan interest rates in response to declining market interest rates since the financial crisis.

Turning to the variables related to borrowing firms' balance sheet characteristics, one possible reason for the declining importance of market funding rates is the inability to access market-based funding sources, such as commercial paper and corporate bonds, since the financial crisis. In normal times, firms with a high market funding ratio tend to demand lower interest rates from banks because these firms have alternative funding sources. However, because funding spreads on commercial paper and corporate bonds (the difference between funding rates on these instruments from LIBOR rates or swap rates) rapidly expanded, funding among these firms quickly shifted to bank lending, and loan interest rates were set at higher levels, reflecting increased loan demand. In this respect, loan surveys indicate that loan demand among Japanese firms increased after the onset of the financial crisis, in clear contrast to developments in the US and Europe (Figure 12).

A possible reason the influence of the debt-to-equity ratio and the ICR on pass-through has declined is that public measures designed to increase bank loans have been broadly introduced in Japan.[33] One example of these initiatives is the Act Concerning Temporary Measures to Facilitate

[33] One important background factor for the public sector's active introduction of measures promoting bank lending is Japan's experience that the disruption of banks' financial intermediation functions, which were triggered by

Financing for Small and Medium-Sized Enterprises (SMEs), etc. (the SME Financing Facilitation Act), which was implemented in December 2009. This act aimed at promoting SME financing required financial institutions to accept firms' demands to restructure existing loans (through, for example, forbearance and interest payment reductions) as far as possible. In practice, the loan conditions restructuring acceptance ratio from December 2009 to September 2012 was 97.4%, which means that financial institutions have virtually accepted almost all firms' demands to restructure their loan conditions (Figure 13). Another important public measure to promote bank lending is the Emergency Guarantee Program introduced by the Credit Guarantee Corporation (CGC). In this program, CGC provides 100% guarantees in principle for private bank lending to SMEs provided certain conditions, such as declining sales, are satisfied.[34] Because credit risk has been restrained under this program, even if firms' balance sheet conditions have deteriorated, banks have rarely needed to set loan interest rates in accordance with firms' balance sheet conditions. These public measures aimed at promoting bank lending are considered to have influenced the determination of banks' loan interest rates, and to have changed the traditional relationship between variables related to firms' ability to make debt repayments (or interest repayments), such as the debt-to-equity ratio or the ICR, and pass-through on loan interest rates.

The above analysis has focused on long-term loan interest rates. The short-term loan interest rate pass-through estimation results presented in Figures 14 and 15 show that pass-through has generally increased since the financial crisis. Figure 16 shows that the overall distribution of pass-through on short-term loans for individual banks has shifted to the right-hand side since the financial crisis, although that of long-term loans has not shifted greatly. This suggests that pressure to reduce short-term loan interest rates has generally strengthened against the background of extensive monetary easing and more intense lending competition among banks, irrespective of the proportion of relationship banking.

For short-term loans, the relationships between pass-through dispersion among individual banks and the variables related to banks' transaction structures or banks' balance sheet characteristics remain largely unchanged since the financial crisis. Looking at the variables related to borrowing firms' balance sheet characteristics, the market funding ratio is statistically significant and has a relatively large influence on pass-through dispersion. This result suggests that after the financial crisis, firms with a high market funding ratio faced difficulty in raising funds in the commercial paper and corporate bond markets, and banks did not significantly lower their loan interest rates to these firms because of the latter group's increased demand for short-term bank lending. The debt-to-equity ratio and the ICR are statistically significant at the 1% and 10% levels, respectively,

---

heightened concern over financial system stability in the late 1990s, brought about a long period of stagnation in the real economy.

[34] Ono, Uesugi, and Yasuda (2013) report that the Emergency Guarantee Program actually improved credit availability for firms using the program. These public measures designed to increase bank lending, as mentioned above, are considered to have changed the traditional relationship between banks' transaction structures and pass-through.

in explaining pass-through. However, these variables do not yield large pass-through dispersion among individual banks.

3.3 Asymmetry between the rise and fall of interest rates

Our analysis so far has assumed that each explanatory variable has a symmetrical influence on pass-through irrespective of whether interest rates are rising or falling. However, in reality, it is probable that banks set loan interest rates asymmetrically in these two phases. In this respect, previous studies report different results on the quantitative importance of asymmetry, depending on the country, the period, and the empirical methodology employed.[35] However, in examining the robustness of our empirical results, we consider it necessary to estimate pass-through by incorporating asymmetry. We conduct such a regression here.

Specifically, we introduce dummies ($D_{up,t}$, $D_{down,t}$) into the coefficients on explanatory variables of pass-through in equation (1).

$$\begin{aligned}\triangle i_{L,k,t} &= \mu_k + \sum_{j=1}^{2} \kappa_j \triangle i_{L,k,t-j} + \sum_{j=0}^{\Lambda} \left(\beta_j + \sum_m \left(\beta^*_{up,mj} D_{up,t} + \beta^*_{down,mj} D_{down,t} \right) X_{m,k,t-1} \right) \triangle i_{M,t-1} \\ &+ \left(\alpha + \sum_m \left(\alpha^*_{up,mj} D_{up,t} + \alpha^*_{down,mj} D_{down,t} \right) X_{m,k,t-1} \right) \left(i_{L,k,t-1} - i_{M,t-1} \right) \\ &+ \sum_m \lambda_m X_{m,k,t-1} + \phi \overline{Z}_{k,t} + \varepsilon_{k,t}. \end{aligned} \tag{2}$$

As shown in the above equation, we adopt an approach to examine the importance of asymmetry between rising and falling interest rate phases by estimating the coefficient on each dummy separately.[36,37]

Figure 17 presents the long-term interest rate pass-through estimation results based on equation (2). We find that the pass-through estimates do not differ greatly between rising and falling interest rate phases. In addition, the relationship between each explanatory variable and pass-through does not differ between the two phases. However, for the SME ratio, the negative relationship with pass-through is more clearly observed in a rising interest rate phase. This suggests that banks with a high proportion of relationship lending tend to be more restrained in raising their loan interest rates in response to market interest rate hikes.

---

[35] Mojon (2000), Sander and Kleimeier (2004, 2006), and Kwapil and Scharler (2010) find evidence supporting the existence of pass-through asymmetry. In contrast, Hofmann (2006) and Karagiannis, Panagopoulos, and Vlamis (2010) report no asymmetry on pass-through. Graeve, Jonghe, and Vennet (2007) find that asymmetry exists, although its quantitative importance is not particularly large.

[36] $D_{up,t}$ takes unity if the difference in market interest rate from the previous period is positive. The opposite is applied for $D_{down,t}$. With respect to long-term interest rates, the number of rising interest rate periods is 19 quarters, and that of falling interest rates is 28 quarters. With respect to short-term interest rates, the number of periods of interest rate rises is 20 quarters, and that of interest falls is 27 quarters.

[37] We introduce dummies for each explanatory variable separately because singularity problems arise if we introduce dummies for multiple explanatory variables.

Figure 18 shows the short-term interest rate pass-through estimation results based on equation (2). These results also indicate that pass-through differences between rising and falling interest rate phases are not necessarily large. However, for the liquidity ratio, the positive relationship with pass-through is more clearly observed in a falling interest rate phase. This suggests that in response to declining market interest rates, banks with a large liquidity buffer tend to lower their short-term loan interest rates further, even if loan spreads are at least temporarily reduced.

These results suggest that asymmetry in pass-through between rising and falling interest rate phases is not necessarily large on the whole, although it is a partially observed phenomenon in some respects.

4 Conclusion

In this study, we investigated the determinants of loan interest rate pass-through – the responsiveness of loan interest rates to market interest rate variations – using a bank-level dataset from Japan. Based on data collected since the early 2000s, we found that pass-through tends to be lower for banks with a high proportion of relationship lending. This result is consistent with findings of previous studies using European data. We further examined the influence of borrowing firms' balance sheet characteristics on loan interest rate pass-through and found that these factors are also important determinants of pass-through dispersion.

However, we also found that following the recent global financial crisis, even banks with a high proportion of relationship lending have largely lowered their loan interest rates by raising pass-through, and that pass-through policy has not necessarily been determined in accordance with borrowing firms' balance sheet characteristics. These results differ from those of recent studies on European countries. Possible background factors explaining this change are that (i) pressure to lower loan interest rates has strengthened due to extensive monetary easing and more intense lending competition among banks, while Japan's banking system as a whole has maintained its resilience in the post-crisis period; (ii) demand for bank lending has increased substantially due to disruptions in alternative funding markets, such as the commercial paper and corporate bond markets; and (iii) public measures aimed at increasing bank lending have been broadly introduced in Japan.

Appendix: Interest rate pass-through calculation method

In this appendix, we describe the method used to calculate interest rate pass-through. First, equation (1) used for estimating loan interest rate pass-through is rewritten as follows[38]:

$$\triangle i_{L,t} = \kappa_1 \triangle i_{L,t-1} + \kappa_2 \triangle i_{L,t-2} + \beta_0 \triangle i_{M,t} + \beta_1 \triangle i_{M,t-1} + \alpha(i_{L,t-1} - i_{M,t-1})$$

In the above equation, $i_{L,t}$ is the loan interest rate at period t ($\triangle$ denotes the difference from the previous period), $i_{M,t}$ is the market interest rate at period t. In the above equation, we ignore fixed effects and control variables in model equation (1), but these variables are irrelevant to the results of the analytic expressions of interest rate pass-through. The loan interest rate is expressed as:

$$i_{L,t} = \varsigma_1 i_{L,t-1} + \varsigma_2 i_{L,t-2} + \varsigma_3 i_{L,t-3} + \eta_1 i_{M,t} + \eta_2 i_{M,t-1} + \eta_3 i_{M,t-2}$$

where:

$$\varsigma_1 = 1 + \kappa_1 + \alpha, \quad \varsigma_2 = \kappa_2 - \kappa_1, \quad \varsigma_3 = -\kappa_2, \quad \eta_1 = \beta_0, \quad \eta_2 = \beta_1 - \beta_0 - \alpha, \quad \eta_3 = -\beta_1$$

If the market interest rate fluctuates at period t_0, the change in the loan interest rate at subsequent period is calculated as:

$$\frac{\triangle i_{L,t_0}}{\triangle i_{M,t_0}} = \eta_1, \quad \frac{\triangle i_{L,t_0+1}}{\triangle i_{M,t_0}} = \eta_2 + \varsigma_1 \frac{\triangle i_{L,t_0}}{\triangle i_{M,t_0}}, \quad \frac{\triangle i_{L,t_0+2}}{\triangle i_{M,t_0}} = \eta_3 + \varsigma_1 \frac{\triangle i_{L,t_0+1}}{\triangle i_{M,t_0}} + \varsigma_2 \frac{\triangle i_{L,t_0}}{\triangle i_{M,t_0}}$$

At period $t_0 + 3$ or later it is given by:

$$\frac{\triangle i_{L,t_0+3}}{\triangle i_{M,t_0}} = \varsigma_1 \frac{\triangle i_{L,t_0+2}}{\triangle i_{M,t_0}} + \varsigma_2 \frac{\triangle i_{L,t_0+1}}{\triangle i_{M,t_0}} + \varsigma_3 \frac{\triangle i_{L,t_0}}{\triangle i_{M,t_0}}$$

Calculating the cumulative change in the loan interest rate, one-quarter-ahead loan interest rate pass-through is given by:

$$\sum_{j=0}^{1} \frac{\triangle i_{L,t_0+j}}{\triangle i_{M,t_0}} = (1 + \varsigma_1)\eta_1 + \eta_2$$

The first term in the above equation is the sum of the contribution at period t_0 from the market interest rate and the lagged loan interest rate. The second term is the contribution at period $t_0 + 1$

[38] The short-term loan interest rate model is obtained by setting $\beta_1 = 0$.

from the market interest rate. In an analogous way, one-year-ahead pass-through is calculated as:

$$\begin{aligned}\sum_{j=0}^{4}\frac{\triangle i_{L,t_0+j}}{\triangle i_{M,t_0}} &= (1+\varsigma_1+\varsigma_2+\varsigma_3+\varsigma_1^2+\varsigma_2^2+2\varsigma_1\varsigma_2+2\varsigma_1\varsigma_3+\varsigma_1^3+3\varsigma_1^2\varsigma_2+\varsigma_1^4)\eta_1 \\ &\quad +(1+\varsigma_1+\varsigma_2+\varsigma_3+\varsigma_1^2+2\varsigma_1\varsigma_2+\varsigma_1^3)\eta_2 \\ &\quad +(1+\varsigma_1+\varsigma_2+\varsigma_1^2)\eta_3\end{aligned}$$

References

[1] Arellano, M., Bond, S., 1991. "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations," *Review of Economic Studies,* 58, 277–297.

[2] Berger, A. N., 1995. "The profit-structure relationship in banking: Tests of market-power and efficient-structure hypothesis," *Journal of Money, Credit and Banking*, 27, 404–431.

[3] Berlin, M., Mester, L. J., 1998. "On the profitability and cost of relationship lending," *Journal of Banking & Finance*, 22, 873–897.

[4] Boot, A. W. A., 2000. "Relationship banking: What do we know?" *Journal of Financial Intermediation*, 9, 7–25.

[5] Degryse, H., Kim, M., Ongena, S., 2009. *Microeconometrics of Banking: Methods, Applications, and Results*, Oxford University Press.

[6] Donnay, M., Degryse, H., 2001. "Bank lending rate pass-through and differences in the transmission of a single EMU monetary policy," Discussion Paper, Center for Economic Studies, K.U. Leuven, 01.17.

[7] Elyasiani, E., Goldberg, L. G., 2004. "Relationship lending: A survey of the literature," *Journal of Economics & Business*, 56, 315–330.

[8] Gambacorta, L., 2008. "How do bank banks set interest rate?" *European Economic Review*, 52, 792–819.

[9] Gambacorta, L., Mistrulli, P. E., 2014. "Bank heterogeneity and interest rate setting: What lessons have we learned since Lehman Brothers?" *Journal of Money, Credit and Banking*, 46, 753–778.

[10] Gigineishvili, N., 2011. "Determinants of interest rate pass-through: Do macroeconomic conditions and financial market structure matter?" IMF Working Paper No. 11/176.

[11] Graeve, F. De, Jonghe, O. De, Vennet, R. V., 2007. "Competition, transmission and bank pricing policies: Evidence from Belgian loan and deposit markets," *Journal of Banking & Finance*, 31, 259–278.

[12] Hofmann, B., 2000. "Non-linear adjustment of loan rates to money market rates: Some evidence for the euro area," Paper Presented at Internal ECB Seminar, 18 October.

[13] Hofmann, B., 2006. "EMU and the transmission of monetary policy: Evidence from business lending rates," *Empirica*, 33, 209–229.

[14] Horváth, R., Podpiera, A., 2009. "Heterogeneity in bank pricing policies: The Czech evidence," Czech National Bank Working Paper Series 8.

[15] Illes, A., Lombardi, M. J., Mizen, P. 2015. "Why did bank lending rates diverge from policy rates after the financial crisis?" BIS Working Papers, 486.

[16] Karagiannis, S., Panagopoulos, Y., Vlamis, P., 2010. "Interest rate pass-through in Europe and the US: Monetary policy after the financial crisis," *Journal of Policy Modeling*, 32, 323–338.

[17] Kwapil, C., Scharler, J., 2010. "Interest rate pass-through, monetary policy rules and macroeconomic stability," *Journal of International Money and Finance*, 29, 236–251.

[18] Mojon, B., 2000. "Financial structure and the interest rate channel of ECB monetary policy," ECB Working Paper 40.

[19] Ongena, S., Smith, D.C., 2000. "Bank relationships: A survey," in P. Harker and S.A. Zenios, eds., *The Performance of Financial Institutions*, Cambridge University Press, London, 221-258.

[20] Ono, A., 2007. *Current perspectives on small and medium-sized enterprise finances*, Toyo Keizai Inc. (in Japanese).

[21] Ono, A., 2011. "Chusho kigyo muke kashidashi wo meguru jissho bunseki: genjyo to tembo," *Kinyu Kenkyu,* 30 (in Japanese).

[22] Ono, A., Uesugi, I., 2009. "Role of collateral and personal guarantees in relationship lending: Evidence from Japan's SME loan market," *Journal of Money, Credit and Banking*, 41, 5.

[23] Ono, A., Uesugi, I., Yasuda, Y., 2013. "Are lending relationships beneficial or harmful for public credit guarantees? Evidence from Japan's emergency credit guarantee program," *Journal of Financial Stability*, 9, 151–167.

[24] Paries, M. D., Moccero, D. N., Krylova, E., Marchini, C., 2014. "The retail bank interest rate pass-through: The case of the euro area during the financial and sovereign debt crisis," ECB Occasional Paper 155.

[25] Sander H., Kleimeier, S., 2004. "Convergence in euro-zone retail banking? What interest rate pass-through tells us about monetary policy transmission, competition and integration," *Journal of International Money and Finance*, 23, 461–492.

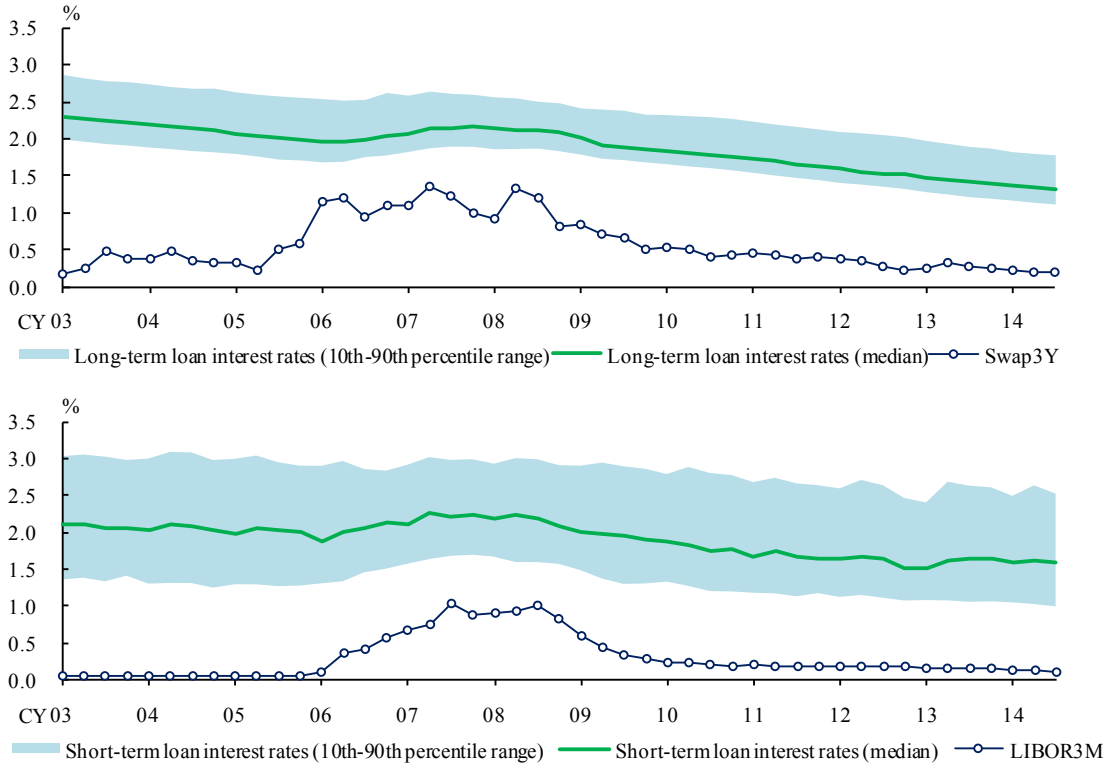
[26] Sander, H., Kleimeier, S., 2006. "Expected versus unexpected monetary policy impulses and interest rate pass-through in Euro-zone retail banking markets," *Journal of Banking & Finance*, 30, 1839–1870.

[27] Sørensen, C. K., Werner, T., 2006. "Bank interest rate pass-through in the euro area. A cross country comparison," ECB Working Paper 580.

[28] Uchida, H., Udell, G. F., Watanabe, W., 2008. "Bank size and lending relationships in Japan," *Journal of the Japanese International Economies*, 22, 242–267.

[29] Weth, M. A., 2002. "The pass-through from market interest rates to bank lending rates in Germany," Economic Research Center of the Deutsche Bundesbank Discussion Paper 11.

Figure 1: Loan Interest Rates and Market Interest Rates



Notes: 1. Major banks and regional banks are counted. The latest data are as of September 2014.
2. Short-term loans include discount bills and overdrafts.
Sources: Bloomberg; BOJ.

Figure 2: Estimating Loan Interest Rate Pass-through (Conceptual Diagram)

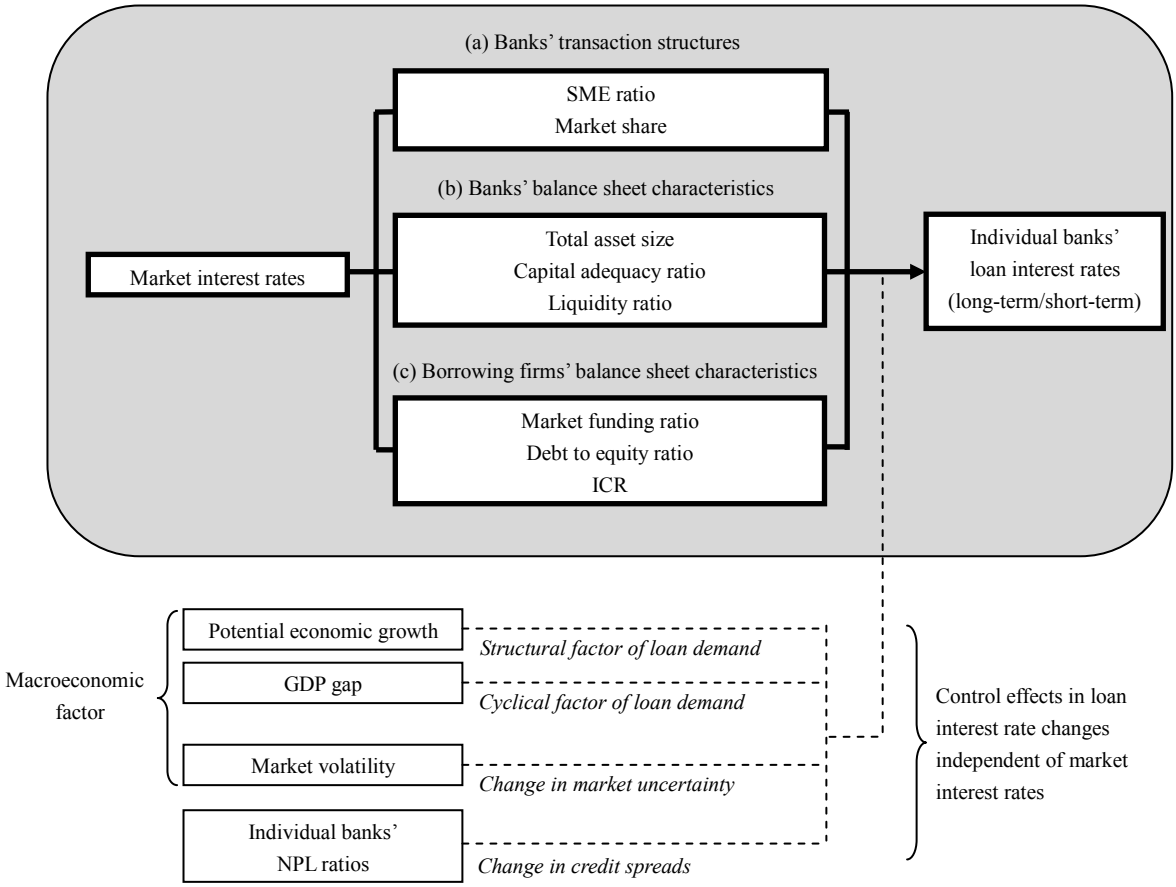


Figure 3: Determinants of Loan Interest Rate Pass-through

Variables	Definitions and Sources
(a) Banks' transaction structures	
SME ratio	Loans to Small and Medium-sized Enterprises / Loans BOJ, "*Loans and Bills Discounted by Sector*"
Market share	Weighted average Herfindahl indexes by bank loans outstanding for each region BOJ, "*Deposits, Vault Cash, and Loans and Bills Discounted by Prefecture*"; BOJ, "*Financial Institutions Accounts*"
(b) Banks' balance sheet characteristics	
Total asset size	Logarithm of total assets BOJ, "*Financial Institutions Accounts*"
Capital adequacy ratio	Capital Adequacy Ratio (Internationally active banks correspond to total capital adequacy ratios, domestic banks correspond to capital adequacy ratios or core capital ratios) - Regulatory Levels (Internationally active banks correspond to 8%, domestic banks correspond to 4%) BOJ
Liquidity ratio	(Securities + Cash + Current Account Balance at the BOJ) / Total Assets BOJ, "*Financial Institutions Accounts*"
(c) Borrowing firms' balance sheet characteristics	
Market funding ratio	(Commercial Paper + Corporate Bonds) / (Discounts + Short-term Loans + Long-term Loans + Commercial Paper + Corporate Bonds) Teikoku Databank, "*SPECIA*"; BOJ, "*Deposits, Vault Cash, and Loans and Bills Discounted by Prefecture*"
Debt to equity ratio	Debt / Equity Teikoku Databank, "*SPECIA*"; BOJ, "*Deposits, Vault Cash, and Loans and Bills Discounted by Prefecture*"
Interest coverage ratio (ICR)	(Operating Profits + Interest Received + Dividends Received) / Interest Payments Teikoku Databank, "*SPECIA*"; BOJ, "*Deposits, Vault Cash, and Loans and Bills Discounted by Prefecture*"

Notes: 1. Large enterprises are classified as companies capitalized at 1 billion yen or more and with more than a specified number of regular employees. Small and medium-sized enterprises are classified as others.

2. The Herfindahl index for each region is calculated as the sum of squared regional loans outstanding for each bank divided by the square of the sum of regional loans outstanding across banks. The maximum value of the Herfindahl index is 1, and the minimum value is the inverse of the number of banks for each region. A higher index indicates the market is monopolistic, whereas a lower index indicates the market is competitive.

Figure 4: Descriptive Statistics

	Mean	Median	Std. Dev.
Long-term loan interest rates (%)	1.95	1.94	0.43
Short-term loan interest rates (%)	2.03	1.91	0.72

Note: 1. Major banks and regional banks are counted. The period is from March 2003 to September 2014.

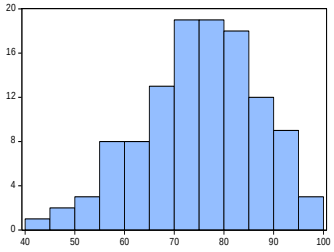
	Mean	Median	Std. Dev.
(a) Banks' transaction structures			
SME ratio (%)	79.84	82.15	11.18
Market share	0.21	0.20	0.07
(b) Banks' balance sheet characteristics			
Total asset size (tril. yen)	6.18	2.44	17.80
Capital adequacy ratio (%pt)	6.22	6.18	2.74
Liquidity ratio (%)	28.07	27.56	7.30
(c) Borrowing firms' balance sheet characteristics			
Market funding ratio (%)	7.71	5.72	5.38
Debt to equity ratio (%)	194.12	185.70	50.86
Interest coverage ratio (ICR)	6.45	5.93	2.71

Note: 1. Major banks and regional banks are counted. The period is from March 2003 to September 2014.

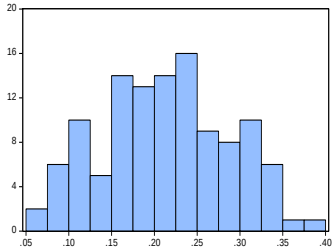
Figure 5: Distributions of Determinants of Loan Interest Rate Pass-through

(a) Banks' transaction structures

SME ratio

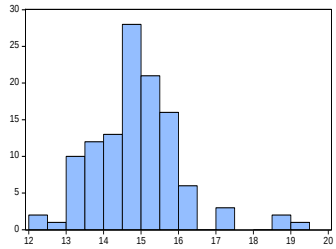


Market share

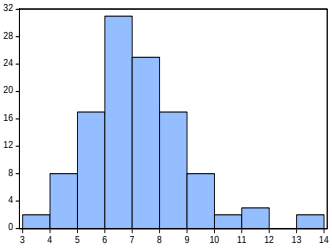


(b) Banks' balance sheet characteristics

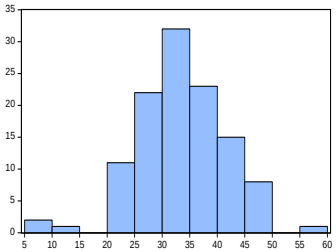
Total asset size



Capital adequacy ratio

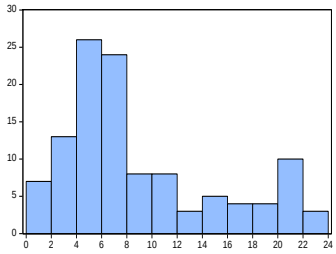


Liquidity ratio

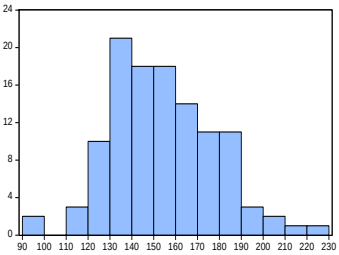


(c) Borrowing firms' balance sheet characteristics

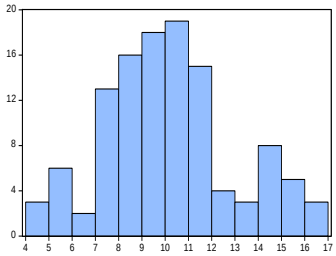
Market funding ratio



Debt to equity ratio



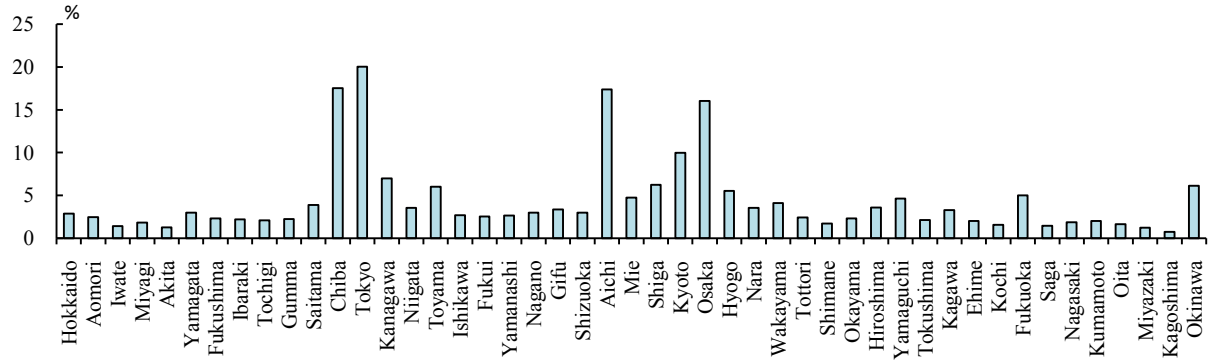
ICR



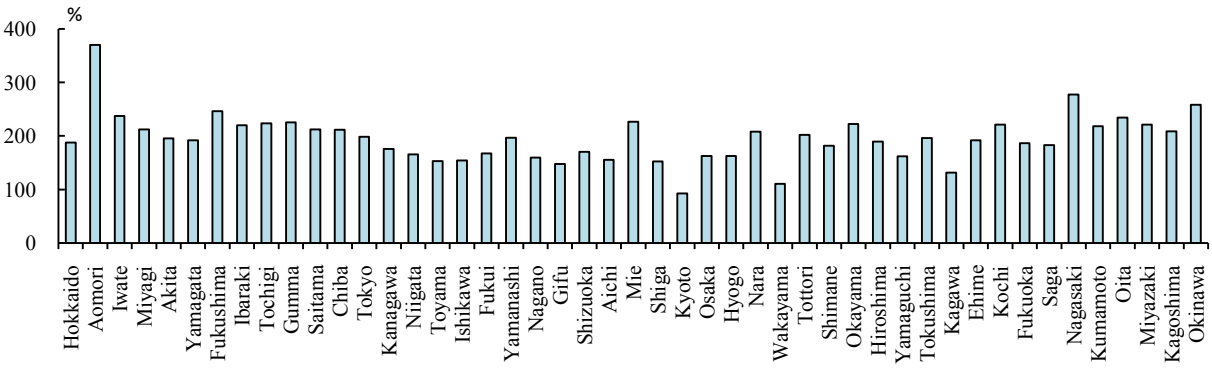
Notes: 1. Major banks and regional banks are counted. The data are as of September 2014.
2. The vertical axes show the number of banks.

Figure 6: Regional Differences in Borrowing Firms' Balance Sheet Characteristics

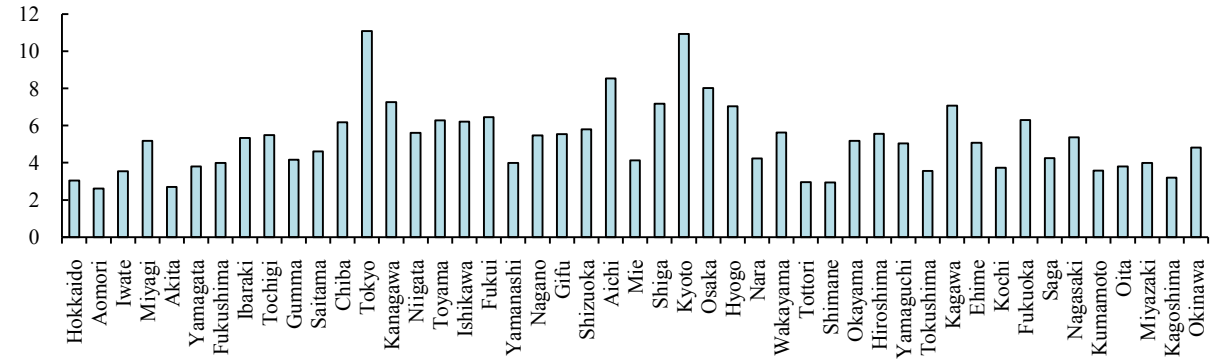
(i) Market funding ratio



(ii) Debt to equity ratio



(iii) Interest coverage ratio (ICR)



Note: 1. Financial indices are averages for fiscal 2002-2013.
Source: Teikoku Databank, "SPECIA"

Figure 7: Estimation Results on Long-term Loan Interest Rate Pass-through

		(i)	(ii)	(iii)	(iv)
(a) Banks' transaction structure					
SME ratio	25% point	0.19 ***	0.26 ***	0.27 ***	0.45 ***
	75% point	0.16 ***	0.22 ***	0.22 ***	0.42 ***
Market share	25% point	0.20 ***	0.26 ***	0.26 ***	0.46 ***
	75% point	0.15 ***	0.22 ***	0.23 ***	0.41 ***
(b) Banks' balance sheet characteristics					
Total asset size	25% point	0.17 ***	0.24	0.24 ***	0.44
	75% point	0.18 ***	0.24	0.25 ***	0.43
Capital adequacy ratio	25% point	0.17 ***	0.24 ***	0.24 ***	0.43
	75% point	0.18 ***	0.25 ***	0.25 ***	0.44 *
Liquidity ratio	25% point	0.20 ***	0.26 ***	0.27 ***	0.45 ***
	75% point	0.15 ***	0.22 ***	0.21 ***	0.40 ***
(c) Borrowing firms' balance sheet characteristics					
Market funding ratio	25% point		0.23 ***		
	75% point		0.28 ***		
Debt to equity ratio	25% point			0.25 ***	
	75% point			0.23 ***	
ICR	25% point				0.40 ***
	75% point				0.47 ***
One-year-ahead pass-through (median)		0.18	0.24	0.24	0.43
Three-year-ahead pass-through (median)		0.50	0.61	0.58	0.89
Error-correction term (α)		-0.04 ***	-0.05 ***	-0.04 ***	-0.09 ***
Potenrial economic growth (%)		0.08 ***	0.07 ***	0.07 ***	0.11 ***
GDP gap (%)		0.00 *	0.00 ***	0.00 *	0.00 **
Market volatility		0.04 ***	0.02	0.03 ***	-0.01
NPL ratio (%)		0.03 ***	0.02 ***	0.02 ***	0.02 ***
Number of banks		115	115	115	115
Number of obs.		5,130	5,130	5,130	5,130
AR(1), AR(2)		0.00, 0.79	0.00, 0.73	0.00, 0.75	0.00, 0.49
Sargan test		0.14	0.21	0.18	0.16

Notes: 1. The estimation period is from March 2003 through September 2014.
2. One-year-ahead pass-through is estimated by adjusting each determinant of pass-through at the 25%, 50%, and 75% points, other things being equal.
3. AR(1) and AR(2) indicate p-values of the serial correlation test. The null hypothesis is that the model errors are not serially correlated.
4. The Sargan test indicates p-values of the over-identifying restrictions test. The null hypothesis is that the over-identifying restrictions are valid.
5. 1% significance represented by ***, 5% by **, and 10% by *.

Figure 8: Estimation Results on Short-term Loan Interest Rate Pass-through

		(i)	(ii)	(iii)	(iv)
(a) Banks' transaction structure					
SME ratio	25% point	0.56 ***	0.72 ***	0.74 ***	0.85
	75% point	0.50 ***	0.65 ***	0.60 ***	0.82
Market share	25% point	0.48 ***	0.64 ***	0.62 ***	0.79 ***
	75% point	0.58 ***	0.74 **	0.73 ***	0.87 **
(b) Banks' balance sheet characteristics					
Total asset size	25% point	0.49 ***	0.66 ***	0.65 **	0.83
	75% point	0.57 ***	0.72 **	0.71 **	0.85
Capital adequacy ratio	25% point	0.53	0.68	0.67	0.84
	75% point	0.54	0.70	0.69	0.84
Liquidity ratio	25% point	0.52	0.69	0.69	0.86
	75% point	0.54	0.68	0.67	0.81 *
(c) Borrowing firms' balance sheet characteristics					
Market funding ratio	25% point		0.70		
	75% point		0.66 **		
Debt to equity ratio	25% point			0.67	
	75% point			0.69	
ICR	25% point				0.81 *
	75% point				0.86 *
One-year-ahead pass-through (median)		0.53	0.69	0.68	0.84
Three-year-ahead pass-through (median)		0.86	0.96	0.96	0.99
Error-correction term (α)		-0.21 ***	-0.24 ***	-0.25 ***	-0.32 ***
Potenrial economic growth (%)		0.30 ***	0.30 ***	0.34 ***	0.42 ***
GDP gap (%)		0.00 ***	0.00 **	0.00 ***	0.00 *
Market volatility		0.05 ***	0.05 **	0.05 ***	0.04 *
NPL ratio (%)		0.07 ***	0.07 ***	0.07 ***	0.06 ***
Number of banks		115	115	115	115
Number of obs.		5,130	5,130	5,130	5,130
AR(1), AR(2)		0.00, 0.54	0.00, 0.97	0.00, 0.98	0.00, 0.98
Sargan test		0.48	0.21	0.31	0.23

Notes: 1. The estimation period is from March 2003 through September 2014.
2. One-year-ahead pass-through is estimated by adjusting each determinant of pass-through at the 25%, 50%, and 75% points, other things being equal.
3. AR(1) and AR(2) indicate p-values of the serial correlation test. The null hypothesis is that the model errors are not serially correlated.
4. The Sargan test indicates p-values of the over-identifying restrictions test. The null hypothesis is that the over-identifying restrictions are valid.
5. 1% significance represented by ***, 5% by **, and 10% by *.

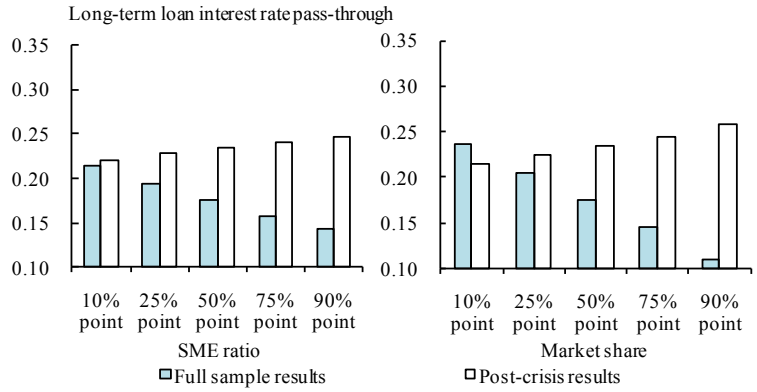
Figure 9: Estimation Results on Long-term Loan Interest Rate Pass-through (Post-crisis)

		(i)	(ii)	(iii)	(iv)
(a) Banks' transaction structure					
SME ratio	25% point	0.23 **	0.30 **	0.28 ***	0.47 **
	75% point	0.24 **	0.33 **	0.34 ***	0.50 **
Market share	25% point	0.22 ***	0.30 **	0.33 **	0.51 ***
	75% point	0.24 ***	0.33 **	0.29 **	0.46 ***
(b) Banks' balance sheet characteristics					
Total asset size	25% point	0.18 ***	0.25 ***	0.24 ***	0.44 ***
	75% point	0.28 ***	0.36 ***	0.37 ***	0.52 ***
Capital adequacy ratio	25% point	0.26 ***	0.35 ***	0.35 ***	0.51 ***
	75% point	0.20 ***	0.27 ***	0.26 ***	0.44 ***
Liquidity ratio	25% point	0.24	0.31	0.31	0.50 *
	75% point	0.23	0.32	0.31	0.46 **
(c) Borrowing firms' balance sheet characteristics					
Market funding ratio	25% point		0.32		
	75% point		0.31		
Debt to equity ratio	25% point			0.31	
	75% point			0.32	
ICR	25% point				0.47
	75% point				0.50 *
One-year-ahead pass-through (median)		0.23	0.32	0.31	0.48
Three-year-ahead pass-through (median)		0.53	0.66	0.66	0.89
Error-correction term (α)		-0.05 ***	-0.07 ***	-0.07 ***	-0.13 ***
Potenrial economic growth (%)		0.07 ***	0.09 ***	0.21 ***	0.19 ***
GDP gap (%)		0.00	0.00	0.00	0.00
Market volatility		0.07 ***	0.08 ***	0.10 ***	0.07 ***
NPL ratio (%)		0.03 ***	0.02 ***	0.02 ***	0.03 ***
Number of banks		115	115	115	115
Number of obs.		2,284	2,284	2,284	2,284
AR(1), AR(2)		0.00, 0.10	0.00, 0.08	0.00, 0.09	0.00, 0.11
Sargan test		0.33	0.07	0.65	0.32

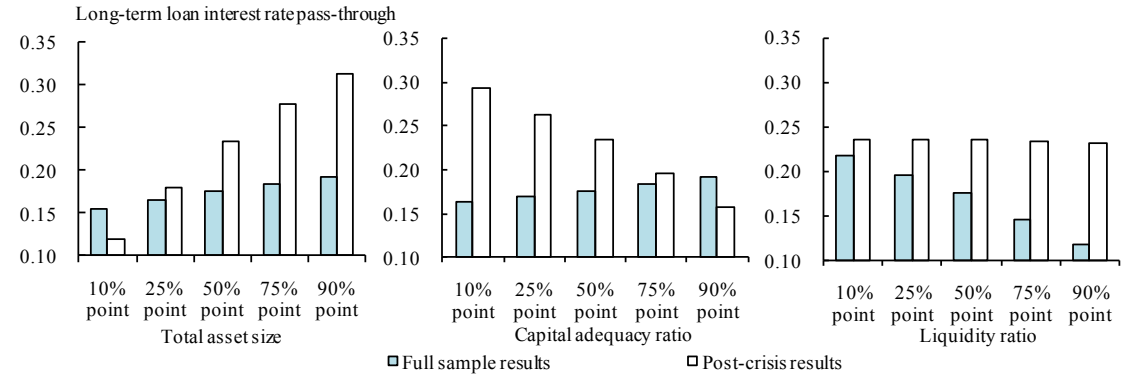
Notes: 1. The estimation period is from September 2008 through September 2014.
2. One-year-ahead pass-through is estimated by adjusting each determinant of pass-through at the 25%, 50%, and 75% points, other things being equal.
3. AR(1) and AR(2) indicate p-values of the serial correlation test. The null hypothesis is that the model errors are not serially correlated.
4. The Sargan test indicates p-values of the over-identifying restrictions test. The null hypothesis is that the over-identifying restrictions are valid.
5. 1% significance represented by ***, 5% by **, and 10% by *.

Figure 10: Relationships between Long-term Interest Rate Pass-through and Determinants

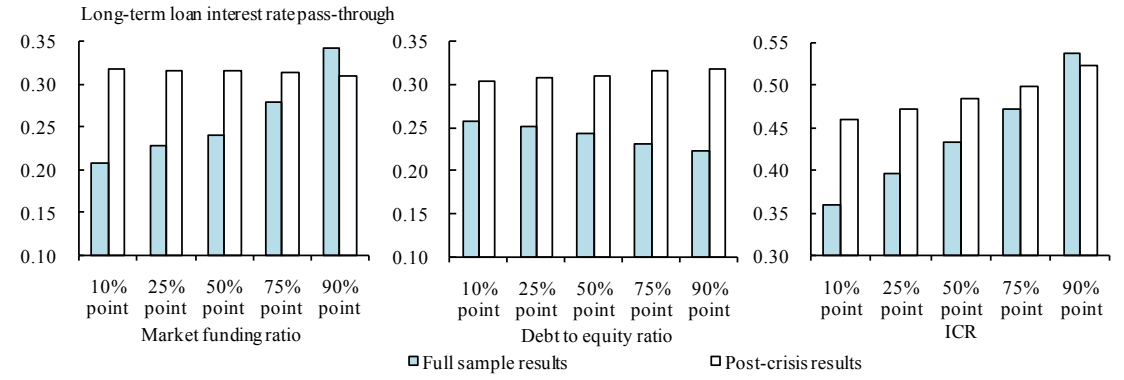
(a) Banks' transaction structure



(b) Banks' balance sheet characteristics

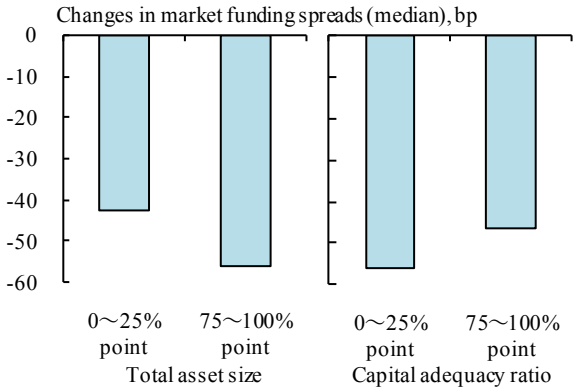


(c) Borrowing firms' balance sheet characteristics



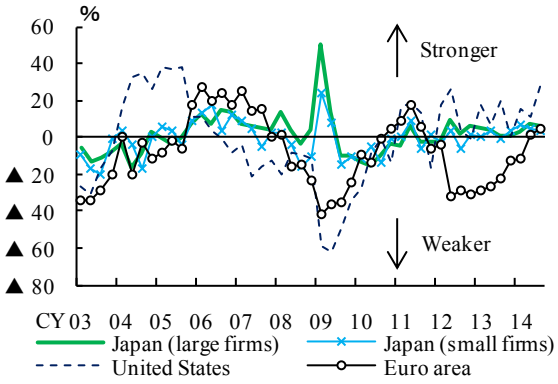
Notes: 1. The full sample period is from March 2003 through September 2014. The post-crisis period is from September 2008 through September 2014.
2. The vertical axes show one-year-ahead long-term loan interest rate pass-through.
3. The horizontal axes show loan interest rate pass-through estimated by adjusting each determinant for the pass-through, other things being equal.
4. The upper and middle panels are estimation results obtained using the model without borrowing firms' balance sheet characteristics. The lower panels are estimation results obtained using models including borrowing firms' balance sheet characteristics.

Figure 11: Market Funding Spreads in Post-crisis Period



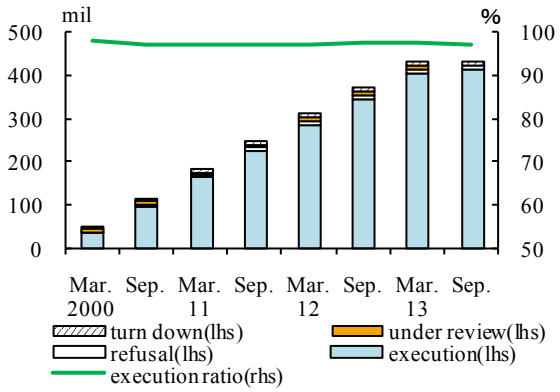
Notes: 1. Major banks and regional banks are counted. Banks with observations including discontinuous data are excluded from the sample.
2. The vertical axes show changes in market funding spreads from September 2008 through September 2014.
3. Market funding spreads are calculated by subtracting the market interest rate (LIBOR rate or swap rate) from individual banks' market-based funding costs (corporate bond yields and others).
Source: BOJ.

Figure 12: Firms' Loan Demand (Loan Surveys)



Note: 1. Figures for the United States are simple averages for large and medium firms and small firms.
Sources: ECB; FRB; BOJ.

Figure 13: Acceptance Status of the SME Financing Facilitation Act



Notes: 1. Debtors classified as small and medium-sized firms are counted.
2. The execution ratio is calculated as the number of executions divided by the number of executions and refusals combined.
Source: Financial Services Agency.

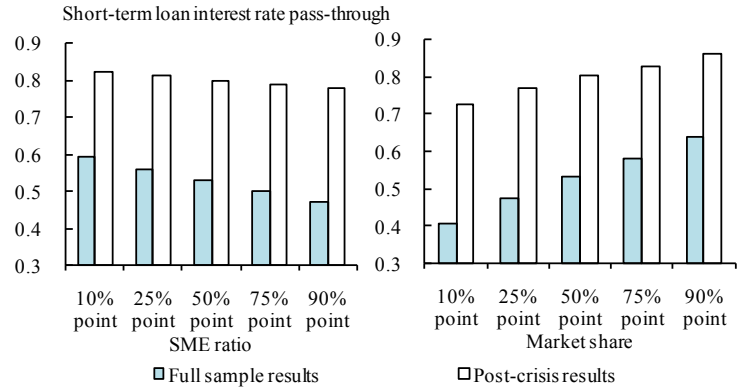
Figure 14: Estimation Results on Short-term Loan Interest Rate Pass-through (Post-crisis)

		(i)	(ii)	(iii)	(iv)
(a) Banks' transaction structure					
SME ratio	25% point	0.81 **	0.87 ***	0.92 ***	0.88
	75% point	0.79 **	0.84 ***	0.88 ***	0.89
Market share	25% point	0.77 ***	0.85	0.88 ***	0.87 ***
	75% point	0.83 ***	0.87	0.92 ***	0.90 ***
(b) Banks' balance sheet characteristics					
Total asset size	25% point	0.75 ***	0.81 ***	0.86 ***	0.86 ***
	75% point	0.83 ***	0.89 ***	0.92 ***	0.90 ***
Capital adequacy ratio	25% point	0.79 **	0.85	0.90	0.89
	75% point	0.82 **	0.87 *	0.89	0.88
Liquidity ratio	25% point	0.79 ***	0.84 ***	0.89	0.88
	75% point	0.82 ***	0.88 ***	0.91	0.89
(c) Borrowing firms' balance sheet characteristics					
Market funding ratio	25% point		0.87 ***		
	75% point		0.80 ***		
Debt to equity ratio	25% point			0.91 ***	
	75% point			0.88 ***	
ICR	25% point				0.88 *
	75% point				0.90 **
One-year-ahead pass-through (median)		0.80	0.86	0.90	0.88
Three-year-ahead pass-through (median)		0.98	0.99	1.00	1.00
Error-correction term (α)		-0.30 ***	-0.32 ***	-0.33 ***	-0.40 ***
Potenrial economic growth (%)		0.35 ***	0.45 ***	0.69 ***	0.58 ***
GDP gap (%)		0.00 ***	0.00	0.00 *	0.00 **
Market volatility		0.38	0.41 ***	0.47 ***	0.41 ***
NPL ratio (%)		0.07 ***	0.11 ***	0.07 ***	0.06 ***
Number of banks		115	115	115	115
Number of obs.		2,284	2,284	2,284	2,284
AR(1), AR(2)		0.00, 0.78	0.00, 0.84	0.00, 0.96	0.00, 0.95
Sargan test		0.09	0.31	0.18	0.31

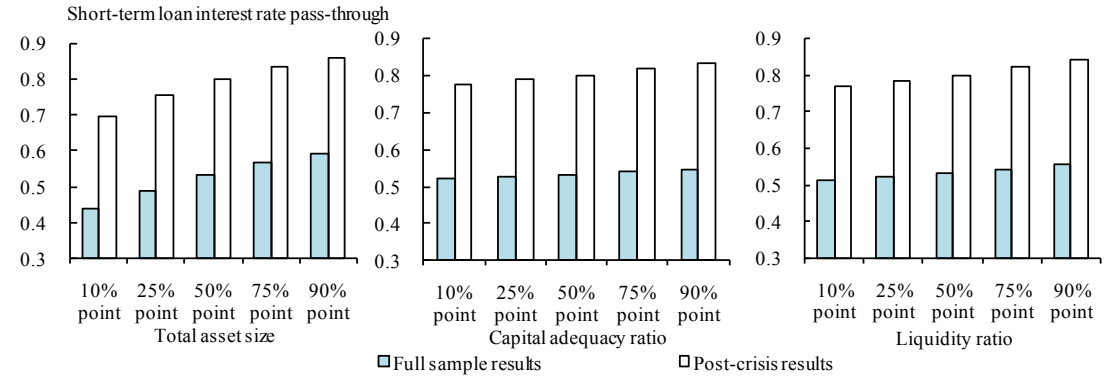
Notes: 1. The estimation period is from September 2008 through September 2014.
2. One-year-ahead pass-through is estimated by adjusting each determinant of pass-through at the 25%, 50%, and 75% points, other things being equal.
3. AR(1) and AR(2) indicate p-values of the serial correlation test. The null hypothesis is that the model errors are not serially correlated.
4. The Sargan test indicates p-values of the over-identifying restrictions test. The null hypothesis is that the over-identifying restrictions are valid.
5. 1% significance represented by ***, 5% by **, and 10% by *.

Figure 15: Relationships between Short-term Interest Rate Pass-through and Determinants

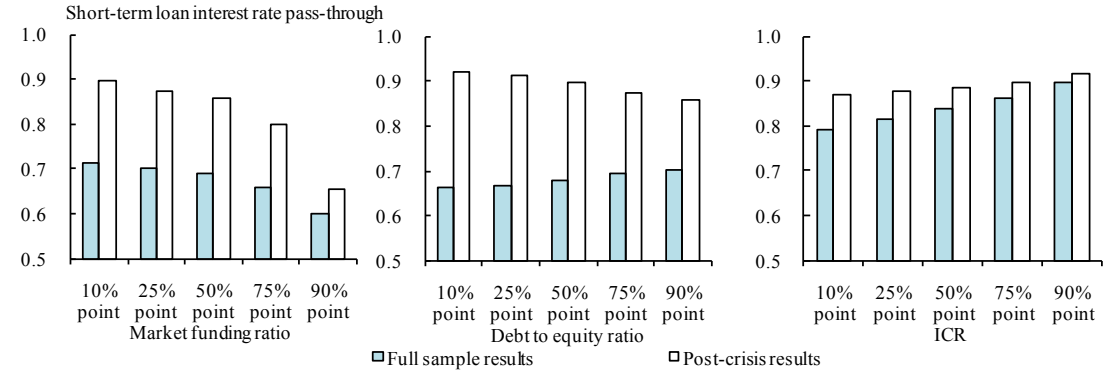
(a) Banks' transaction structure



(b) Banks' balance sheet characteristics

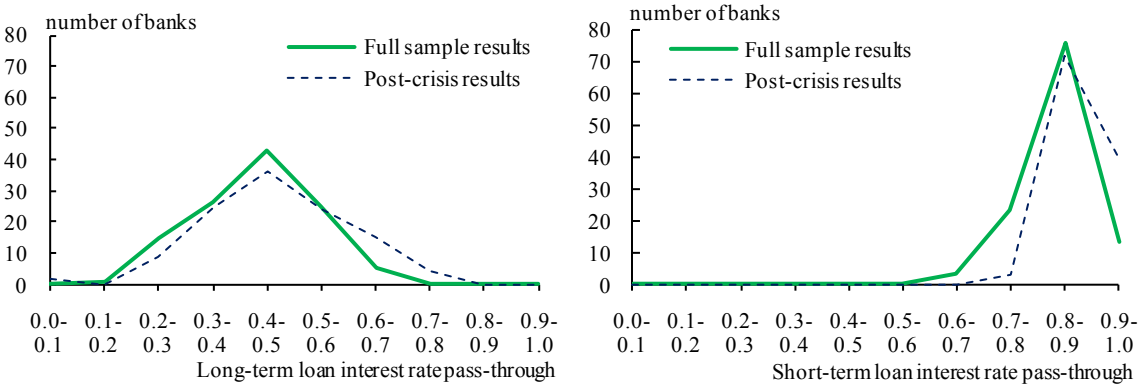


(c) Borrowing firms' balance sheet characteristics



Notes: 1. The full sample period is from March 2003 through September 2014. The post-crisis period is from September 2008 through September 2014.
2. The vertical axes show one-year-ahead short-term loan interest rate pass-through.
3. The horizontal axes show loan interest rate pass-through estimated by adjusting each determinant for the pass-through, other things being equal.
4. The upper and middle panels are estimation results obtained using the model without borrowing firms' balance sheet characteristics. The lower panels are estimation results obtained using models including borrowing firms' balance sheet characteristics.

Figure 16: Distributions of Loan Interest Rate Pass-through

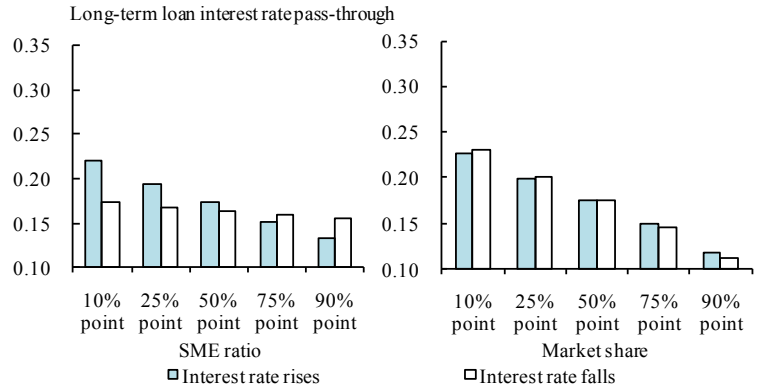


Notes: 1. Major banks and regional banks are counted.

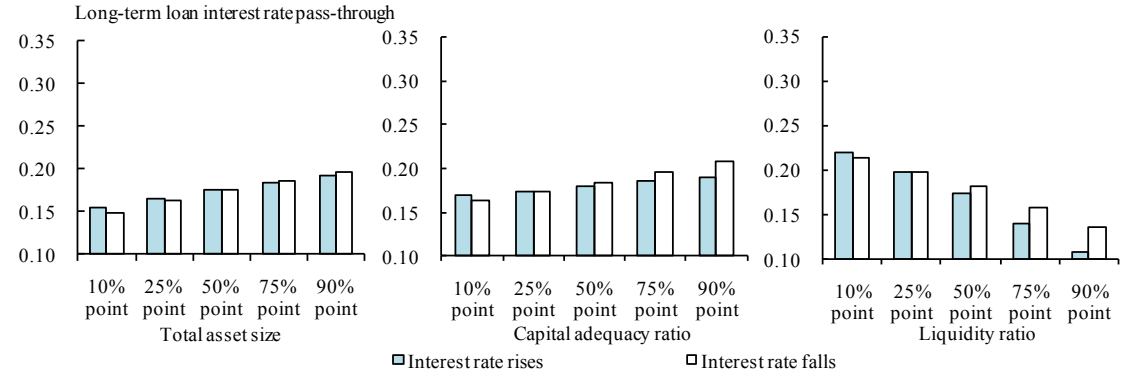
2. The estimation period for the full sample is from March 2003 through September 2014. The estimation period for the post-crisis sample is from September 2008 through September 2014.
3. Determinants of loan interest rate pass-through are the SME ratio, market share, total asset size, the capital adequacy ratio, the liquidity ratio, and the ICR.

Figure 17: Asymmetric Relationship of Long-term Interest Rate Pass-through

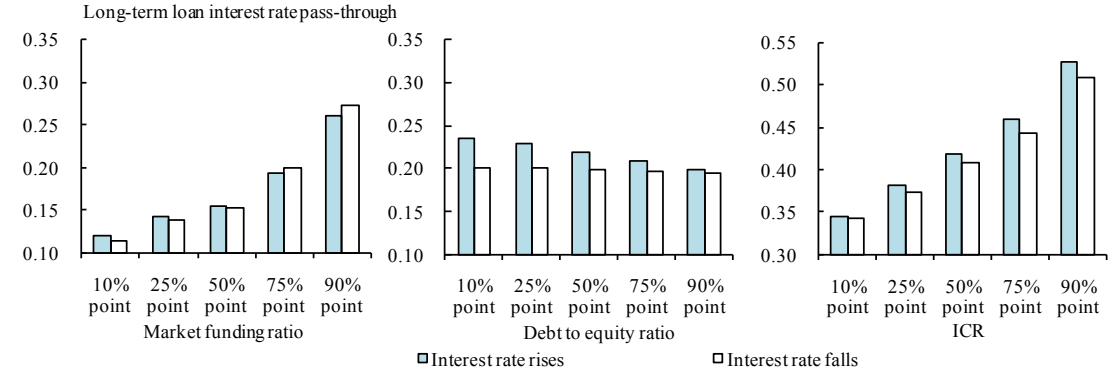
(a) Banks' transaction structure



(b) Banks' balance sheet characteristics



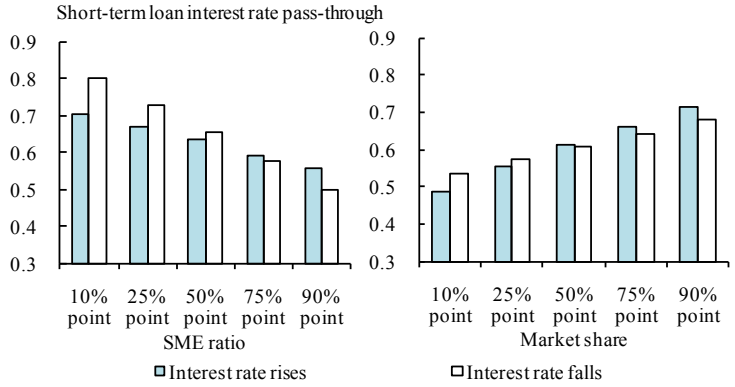
(c) Borrowing firms' balance sheet characteristics



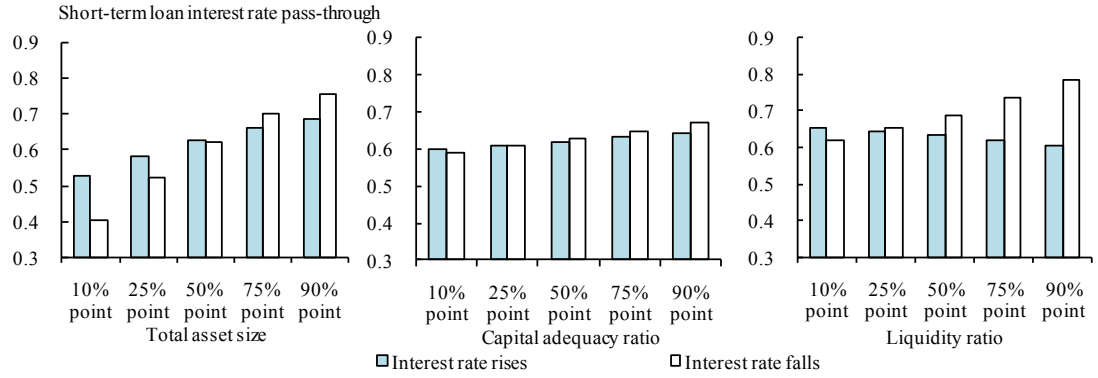
Notes: 1. The estimation period is from March 2003 through September 2014.
2. The vertical axes show one-year-ahead long-term loan interest rate pass-through after interest rate rises or falls.
3. The horizontal axes show loan interest rate pass-through estimated by adjusting each determinant for the pass-through, other things being equal.
4. The model includes dummies in the coefficients α^* and β^* on explanatory variables of determinants of the pass-through $X_{m,k,t-1}$ to differentiate between rising and falling interest rate phases.
5. The upper and middle panels are estimation results of the model without borrowing firms' balance sheet characteristics. The lower panels are estimation results of models including borrowing firms' balance sheet characteristics.

Figure 18: Asymmetric Relationship of Short-term Interest Rate Pass-through

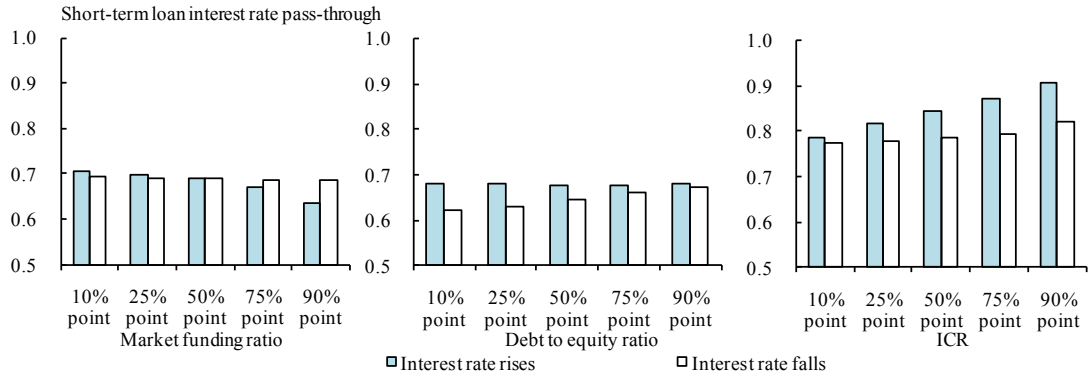
(a) Banks' transaction structure



(b) Banks' balance sheet characteristics



(c) Borrowing firms' balance sheet characteristics



Notes: 1. The estimation period is from March 2003 through September 2014.
2. The vertical axes show one-year-ahead short-term loan interest rate pass-through after interest rate rises or falls.
3. The horizontal axes show loan interest rate pass-through estimated by adjusting each determinant for the pass-through, other things being equal.
4. The model includes dummies in the coefficients α^* and β^* on explanatory variables of determinants of the pass-through $X_{m,k,t-1}$ to differentiate between rising and falling interest rate phases.
5. The upper and middle panels are estimation results of the model without borrowing firms' balance sheet characteristics. The lower panels are estimation results of models including borrowing firms' balance sheet characteristics.