Bank Profitability and Risk-Taking in a Low Interest Rate Environment: The Case of Thailand

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Abstract

This paper studies the effects of monetary policy on the bank profitability and risk-taking. Using bank-level and account-level data sets of Thai banks during the period 2004-2017, we find that lower interest rates tend to reduce profitability, more so for small banks. The effect works mainly through the impact of the interest rates on bank net interest income. At the bank level we find limited evidence of increased riskiness in the overall balance sheet of Thai banks when interest rates are low. However, the account-level results from a duration analysis suggest that low rates may lead to higher loan default risk and lower loan quality for long-term loans, particularly those in the portfolio of small and medium banks. Small firms seem to be more affected by bank risk-taking behavior. We also find that when the interest rate remains low for a protracted period, this tends to further increase bank risk-taking in new loans, though it helps lower the default risk for existing loans. The findings overall point to the potential unintended consequences of a low-for-long monetary policy accommodation with implications on financial stability.

JEL classification: E43, E52, G21

Keywords: Bank profitability, Bank risk-taking, Low interest rates, Monetary policy, Thailand.

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1. Introduction

The global financial crisis has spurred an increasing interest on the link between monetary policy and the financial system. In particular, one of the current debates has focused on the so-called risk-taking channel of monetary policy (Borio and Zhu, 2012; Adrian and Shin, 2008 and 2010) which refers to the potential effect of policy rate changes on the *quality*, not just the quantity, of bank credit through its influence on risk perceptions or risk tolerance. As policy rates in many countries particularly in advanced economies remain exceptionally low for an extended period of time, another debate has ensued on whether this persistently low interest rates would also weigh down on bank profitability, and hence the soundness of the banking sector (Borio et al. 2017; Claessens et al. 2017).

Accommodate monetary policy in response to shocks is in general crucial to improve macroeconomic conditions and support the soundness of the financial and banking system as it helps stimulate aggregate demand, lower the cost of debt and bank funding, reduce default risk, prop asset prices and hence borrower's creditworthiness. The strength of the banking system and the ability of banks to generate adequate profits are, in turn, enable banks to provide sufficient credit to support the economy. On the other hand, however, persistently low interest rates may erode bank profitability as they tend to depress bank net interest margins and weaken bank capital positions. At the same time, low interest rates may also influence bank risk-taking by influencing asset valuations which may lead to underpricing of risks (Borio and Zhu, 2012; Adrian and Shin, 2009), and by increasing incentives for banks and other financial institutions to take on more risk in search for higher yield in a low investment return environment (Brunnermeier, 2001; Rajan, 2005). This could contribute to banking system fragility and derail economic recovery. The net impact of monetary policy on bank profitability and bank risk is ultimately an empirical question.

Empirical evidence broadly supports the hypotheses that a low policy rate is associated with lower bank profitability and greater risk taking. However, much of the existing literature has been done on advanced and European economies, with a few exceptions that use cross-country sample. Evidence of this relationship for the banking sector in Asian economies remains scant. These same questions studied using an Asian bank sample could potentially yield different results given that the risk attitude as well as the structure of Asian banking systems may vastly differ from those of the advanced economies and the Western system. This paper thus contributes to the literature by addressing the current research issues above in the case of Thailand as an emerging market in Asia.[1] Thailand also provides as a unique case study given its highly concentrated loan market and banking sector in general, which may have an implication on the influence of monetary policy on bank profitability and risk-taking behavior.

This study employs two data sets: the bank-level and the loan-level data constructed from various data sources including the supervisory account-level credit information from all commercial banks in Thailand. The bank-level data set covers 23 banks starting from 2004Q1 to 2017Q3 at the quarterly frequency. The monthly loan-level data set contains about 10 million loan accounts during 2004M1-2017M9. For the link between monetary policy and bank profitability, we assess the effect of changes in the short-term interest rate and yield curve slope on overall bank profitability

[1] Huey and Li (2016) studies the bank risk-taking channel of monetary policy in Malaysia using a micro-level account level credit information from the credit register database.

measured by ROA and ROE as well as their main components including net interest income, non-interest income and loan loss provisions. To investigate the effect of monetary policy on bank risk-taking, we carry out the empirical tests both at the bank and the loan level. Bank-level risk is measures by three alternative indicators, namely, bank Z-score, risk-weighted asset ratio, and non-performing loan ratio. For the loan-level analysis, loan risk is captured by the hazard rate of loan default under the survival analysis framework using a duration model. Finally, we also consider the impact of changes in the interest rate on the probability of banks granting loans with lower quality using a probit model approach. Macroeconomic and financial conditions, the lending bank characteristics, and borrower characteristics are controlled for in all specifications where applicable.

We find that the level of interest rates and bank profitability as measured by ROA and ROE are positively correlated. That is, lower interest rates tend to reduce profitability. The effect works mainly through the impact of the interest rates on bank net interest income. Although loan loss provisions are also lower when the interest rates are low which should partly help increase profitability, this effect is not large enough to offset the decline in net interest income. In the meanwhile, non-interest income does not seem to be affected by changes in the interest rate. We find that small banks tend to be more sensitive to the policy rate than large and medium banks, suggesting that their profitability could be more adversely affected when interest rates are low, perhaps due to high cost structures as well as stronger competition in search for yield and for quality customers in a low rate environment.

As for bank risk taking, using the standard balance sheet measures of risk at the bank level, we find limited evidence of increases in overall riskiness of banks when interest rates are low. However, when investigated at the loan level, we find that low interest rate is associated with higher loan hazard rates for long-term general loans. Loan portfolios of medium and small banks appear to be more responsive to the policy rate, in terms of changes in loan riskiness, than those of large banks. In addition, the hazard rates of small firms appear to be more contingent on the level of interest rate compared to those of large firms, suggesting that small firms may potentially be more affected by bank risk-taking behavior. We also find that when the interest rate remains low for a protracted period, this tends to further increase bank risk-taking in new loans, though it helps lower the default risk for existing loans.

Our analysis points to the potential unintended side effects of unusually low interest rates on banking sector fragility and risk, as well as possible distributional consequences that monetary policy may have on banks and borrowers, which could contribute to a build-up of financial imbalances and, in turn, hamper economic recovery. This lends support to the notion that financial stability considerations should be incorporated into monetary policy setting in order to reach an optimal policy decision for the overall macroeconomic and financial stability.

A few caveats should be noted. First, our measures of bank-level risk are based only on banks' balance sheet information which may not capture risks stemmed from increases in the riskiness of financial assets held by banks, nor does it capture banks' off-balance sheet activity. In addition, these measures—including the hazard rate implied by default incidences in the loan-level analysis, are ex-post indicators which could be subject to changes in economic and financial conditions as well as idiosyncratic shocks hitting banks or borrowers. The use of ex-ante risk indicators such as loan rating at origination or the expected default frequency of banks should provide a cleaner measure of banks' changing lending standards. Finally, in this paper we assess the impact of monetary policy on bank profits and risk-taking taking macroeconomic conditions as given. An

analysis that allows for dynamic interactions among monetary policy, the state of the economy, and bank variables would be more realistic and more comprehensive, but it is beyond the scope of this study.

The rest of the paper proceeds as follows. Section 2 reviews related literatures on the impact of short-term rates on bank profitability and risk-taking. Section 3 presents the data used in this study and key stylized facts. Section 4 discusses empirical strategy. Results are presented and discussed in Section 5. Section 6 concludes.

2. Review of Literature

2.1 The Impact of Interest Rates on Bank Profitability

Borio et al. (2017) discusses various channels through which the level of interest rates can influence the different components of bank overall profitability as typically measured by return on assets (ROA). The first component considered is *net interest income (NII)*, or alternatively *net interest margins (NIMs)*, which is the key factor determining profitability for a typical traditional bank.[2] The low interest rates could adversely affect NII or NIMs through a price channel as bank margins tend to compress when interest rate decline to a very low level. However, if low interest rates induce greater volume of loans, either due to expanding bank loan supply or increasing loan demand, then this quantity channel of interest rates may lead to an inverse relationship between interest rates and bank profitability, at least temporarily. The second component of bank profitability is *non-interest income (NNI)* comprising capital gains from investment, gains on trading, dividend income, fees and commissions. The relationship between interest rates and non-interest income is even less clear. That said, it is likely to be a negative one as low interest rates may contribute to valuation gains on banks' securities portfolios, and at the same time may also encourage banks to shift their focus to fee-generating services if their traditional lending business yields low profits. The search for yield may also become stronger at low rates and drive banks to engage in riskier non-lending investments that generate higher short-term returns. The third component of bank profitability is *loan loss provision (LLP)*. For given macroeconomic conditions, high interest rates could raise the debt service burdens of the existing borrowers, increasing the likelihood of loan default, and hence increase the loan loss provisions by banks. This would depress bank performance, offsetting a potential positive effect of high rates on net interest income. Given many possible ways low rates can affect bank profits, whether the net impact will be a positive or a negative one is largely empirical.

Empirical evidence from past literature broadly suggests that short-term interest rates are positively correlated with bank profitability and net interest margins. Borio et al. (2017) studied the influence of monetary policy on bank profitability in 19 advanced economies and found that higher interest rates and a steeper yield curve are associated with higher return on assets. The impact works through increased net interest income that offsets the cost stemmed from increased loan loss provisions and decreased non-interest income. They also found significant non-linearities in the relationship that suggest a larger effect of interest rates on bank profitability when the rates are

[2] The average shares of interest income to total income are about 75%, 82%, and 83% for large, medium, and small banks in Thailand respectively.

particularly low. Claessens et al. (2017) investigated the impact on net interest margins in 47 countries. Their results show that a decline in interest rates contributes to a reduction in net interest margins, as interest income falls more than interest expenses. Moreover, this negative effect is larger at low interest rates than at high interest rates and net interest margins are more adversely affected the longer period that rates are low. Net interest margins are also found to be positively related to the level and the slope of the yield curve by Alessandri and Nelson (2015), using quarterly data from United Kingdom banks. But this relationship only holds in the long run, whereas higher interest rate is found to compress interest margins in the short run.

Altavilla et al. (2017) who examined the European countries argued that low monetary policy rates and flattened yield curve likely coincide with lower ROA. However, once taking into account underlying macroeconomic and financial conditions, this relationship becomes insignificant. Results on different components of bank profitability show that lower rates are associated with decreased loan loss provisions, decreased net interest income, and increased non-interest income. They additionally found that a protracted low interest rate environment would have a significant adverse impact on bank profits only after a long period of time.

2.2 The Impact of Interest Rates on Bank Risk Taking

The impact of policy rates on loan-related risk can be divided into two parts. First, lower interest rates could spur banks to soften their lending standards and grant more loans to lower quality borrowers in search for yield. This impact on the quality of new loans is considered as the risk-taking channel. The second part is that low rates also impact the existing loans by reducing interest burdens and hence, credit risk of outstanding loans. This second impact could be larger since the size of outstanding loans tend to be much larger than that of newly granted loans for each period, and the net impact of low interest rates on overall bank loan portfolio might be positive.

Various measures have been proposed in measuring bank risk-taking, from extensive and intensive margins of lending to ex-ante and ex-post measures of risk. Regardless of the measures employed, existing studies appear to point to the same conclusion that lower policy rates tend to spur bank risk taking and that monetary policy affects the supply of bank credit.

One of the widely cited paper is Jiménez et al. (2012), who investigated the effects of monetary policy on the extensive margin of lending and the role of the bank balance sheet channel. Using a loan-level dataset from Spain, they found that a lower level of short-term interest rates increases the probability of banks granting more risky new loans, and this relationship is stronger for banks with weaker balance sheets. They extended the study in their 2014 paper to examine both extensive and intensive margins of lending in a two-stage model. The probability of loan granting similar to Jimenez et al. (2012) is analyzed in the first step. Conditional on loans being granted from step one, loan outcomes such as committed credit amount and future default are analyzed in the second step. Consistent with the previous finding, they found that a lower overnight policy rate induces higher loan risk-taking by banks. Banks with low capital tend to grant more loans to ex-ante risky firms when rates are low. Moreover, the loans committed are larger-sized, more likely to be uncollateralized, and have a higher ex-post likelihood of default. They alternatively applied a duration model approach with the same data in their 2007 paper and found similar evidences of risk-taking behavior.

Ioannidou et al. (2015) used detailed credit data from Bolivia to study the effect of monetary policy on bank loan risk-taking. They adopted a number of measures of risk taking such as the time to default, past non-performing loans (NPL), ex-ante subprime rating, and ex-post default probability. Controlling for relevant factors, a decrease in the US federal funds rate increases the likelihood of granting loans to riskier borrowers with ex-ante less creditworthiness and a higher ex-post default rate. They also observed that banks dealing with small firms, having more liquid assets, and having lower capital ratios tend to take more risks.

Alternative measures of risk taking are expected default frequency (EDF) such as that adopted by Altunbas et al. (2010), internal rating explored by Dell'Ariccia et al. (2017), ratio of NPL to total loans adopted by Delis and Kouretas (2011), risk-weighted asset (RWA) to total assets adopted by De Nicolò et al. (2010), as well as Z-score, CoVaR, and Shapley value measure.

3. Data and Stylized Facts

3.1 Data Sources

The empirical analysis employs two datasets that originate from the following four main data sources: (1) bank-level financial data from Data Management System (DMS) database; (2) contract-level loan and collateral data from Bank of Thailand's Loan Arrangement Database (LAR); (3) firm-level balance sheet characteristics from the Ministry of Commerce's Corporate Profile and Financial Statement (CPFS) database; and (4) interest rates and macroeconomic variables from the Bank of Thailand.

Banks' financial data from DMS include balance sheet and profit and loss statement items that are reported to the Bank of Thailand on a quarterly basis. The database covers 39 Thai commercial banks and foreign banks' subsidiaries and branches that operate in Thailand, inclusive of new entry or exit banks during the sample period. The data characterizes loan portfolio and overall financial health at the bank level. Banks are grouped into large, medium, and small banks based on their asset sizes.

The second data source is LAR database which contains contract-level loans extended to corporates and individuals with a total credit line or loan outstanding above 20 million Baht within a single bank. LAR provides data on loan characteristics such as loan type, contract effective dates and maturity, loan outstanding, and classification on loan status. The information regarding collaterals associated with each loan is also available.[3] The data is reported on a monthly basis by all financial institutions under the Bank of Thailand's supervision. Reporting financial institutions include Thai commercial banks, foreign banks' subsidiaries, foreign banks' branches, government's specialized financial institutions (SFIs), finance companies, and credit fonciers. Only loans from the first three types of financial institutions are used in this study. Loans from SFIs are excluded since they may be influenced by government policies and thus do not reflect commercially-driven private bank behavior.

[3] This is taken from a companion database on loan collaterals. However, since it is self-reported and some fields are optional, the data from this database are subject to some inconsistency and incompleteness especially in terms of the value of the collateral pledged under each loan contract. Moreover, the data is only available up to 2015. Thus, to avoid mismeasurement, in this study we only use the presence of collateral simply to indicate which loan is collateralized, and disregard the information on the value of the collaterals.

Although LAR has a minimum reporting threshold of 20 million Baht credit line or loan outstanding which would exclude a large number of smaller-sized loans, on average the LAR dataset covers roughly 75 percent of total credit in the banking system. Thus, we could say that LAR data represent the aggregate credit fairly well. Other key advantages of this data set include the relatively long time span of the contract-level LAR data dating back to 2004 which covers both high- and low-level of the policy rates, the wide coverage of loans from all 39 commercial banks operating in Thailand, as well as the fact that these loan data can be matched with the lenders' and the borrowers' balance sheet information.

CPFS database provides financial data and characteristics of all firms in Thailand that register with the Ministry of Commerce. The data is reported on an annual basis at year end and only available with a two-year time lag. Loans from LAR database are categorized as corporate loans if the borrower is present in CPFS database.

Lastly, data regarding interest rates and macroeconomic variables are from the Bank of Thailand. The main short-term interest rate explored in this study is the policy rate which is a one-day repurchase rate in the case of Thailand. The slope of the yield curve, expected GDP, and expected inflation that reflect economy outlook are also explored.

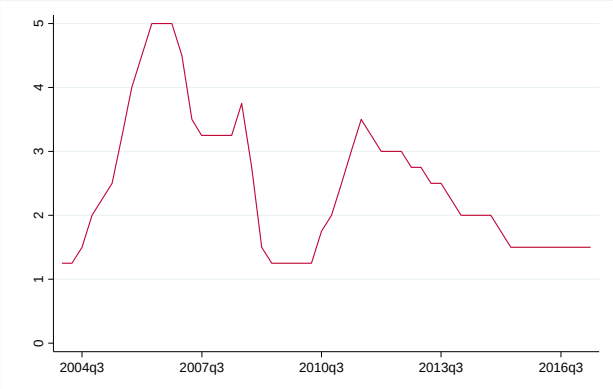
Combining data from the four sources yield two datasets used in this study. The first dataset is a quarterly bank-level panel data containing 39 banks during the period of 2004:Q1 to 2017:Q3. However, the analysis will focus mainly on 23 banks that have remained in the data set throughout the study period (i.e. no new entry or exit) since the entry and exit banks tend to have abnormal financial ratios around the periods of entering or closing.[4] The second dataset is a loan-level monthly data that covers about 10 million loan accounts from 39 commercial banks with details on loan characteristics, collateralization, the lender's characteristics, and the borrowing firm's characteristics. The sample period starts from January 2004 to September 2017. This more granular loan-level dataset complements the bank-level analysis and allows the investigation of heterogeneity among different types and attributes of loans, which cannot be explored at the bank level.

3.2 Low Interest Rates in the Context of Thailand

Similar to advanced economies, Thailand has experienced a prolonged period of low interest rates. As Figure 1 shows, the monetary policy rate has been stagnant at 1.5% since 2015:Q2 and has not been raised for 26 consecutive quarters since 2011:Q3 (as of 2018:Q1). This constitutes the longest period that the policy rate has been in the downward trend ever since the Bank of Thailand has switched to the inflation targeting regime in 2000.

[4] We believe that excluding these banks from our main analysis does not give rise to biases in our results because all of the new entry or exit banks are relatively very small in size.

Figure 1: Policy rate

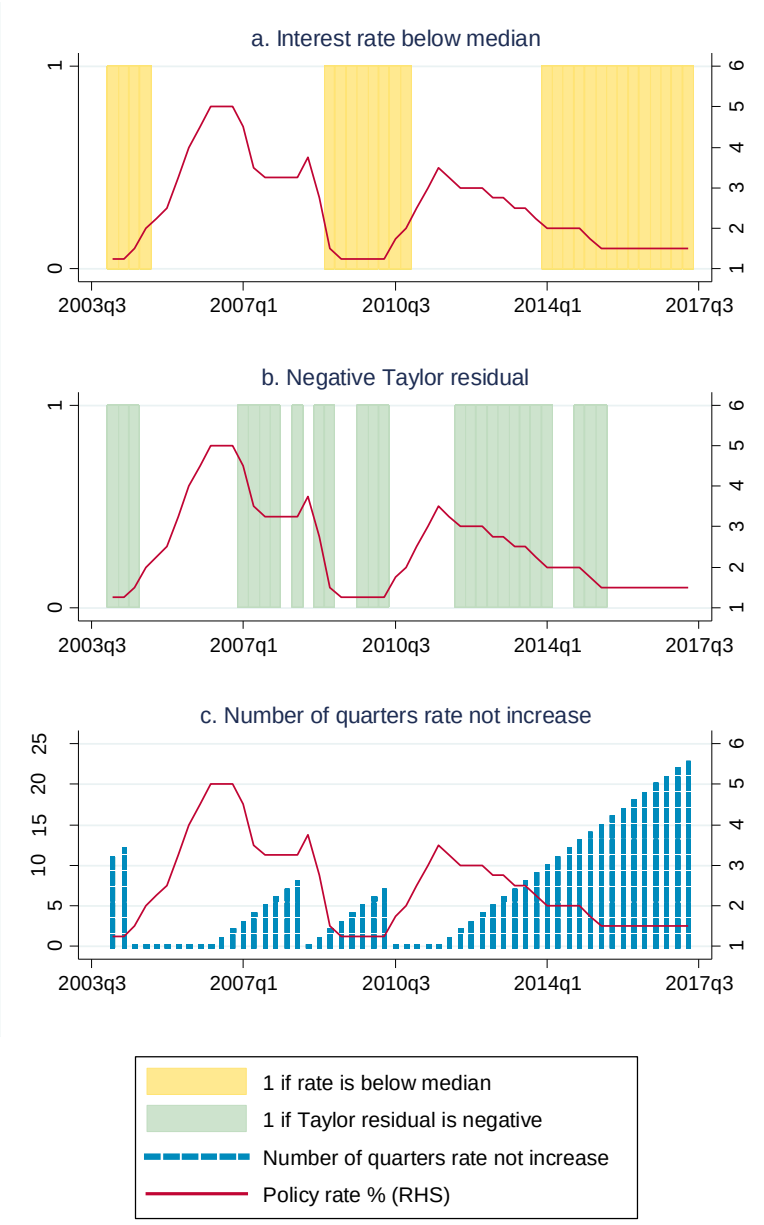


Source: Bank of Thailand.

Apart from the policy rate, three alternative measures that may also capture the prolonged low rates are explored as illustrated in Figure 2. Following the low interest rate literature, the first two measures (panel a. and b.) are binary indicators that take the values of one (shaded area) when the policy rate is below sample median and when the residuals from Taylor rule are negative, respectively, and zero otherwise.[5] Interestingly, these two indicators show contrasting pictures in the last few years where the policy rates are below the sample median (panel a.) but the Taylor residuals are not negative (panel b.) suggesting that the policy rate might not be considered as abnormally low given the macroeconomic conditions. This is because deviations from Taylor rule indicate the monetary policy *stance* rather than directly reflect the level of nominal interest rates relative to the average level. The third measure in panel c. counts the number of consecutive quarters in which the policy rate does not increase. It is more able to reflect the prolonged aspect of the low rate environment than the first two binary indicators. However, it cannot distinguish between non-increasing rates at the low or high level. For instance, the magnitudes of this indicator are roughly the same (7 quarters) during 2007-2008 when the policy rate was above 3% and during 2009-2010 when the policy rate reached its sample minimum at 1.25%.

[5] Taylor rule is estimated from $i_t = \alpha + \beta_1(\pi_t^e - \pi^*) + \beta_2(y_t - y^*) + \rho_{t-1}i_{t-1} + \varepsilon_t$ using GMM estimation with standard variable notation. Three values of target inflation π^* are explored, which are 2%, 2.5%, and the sample median of 2.8%. All three ultimately yield the same 0/1 binary indicator.

Figure 2: Low for long indicators



Note: The shaded areas in panel a. and b. represent the periods when the indicators equal to one.

Source: Bank of Thailand. Authors' calculations.

3.3 Bank Profitability and Risk

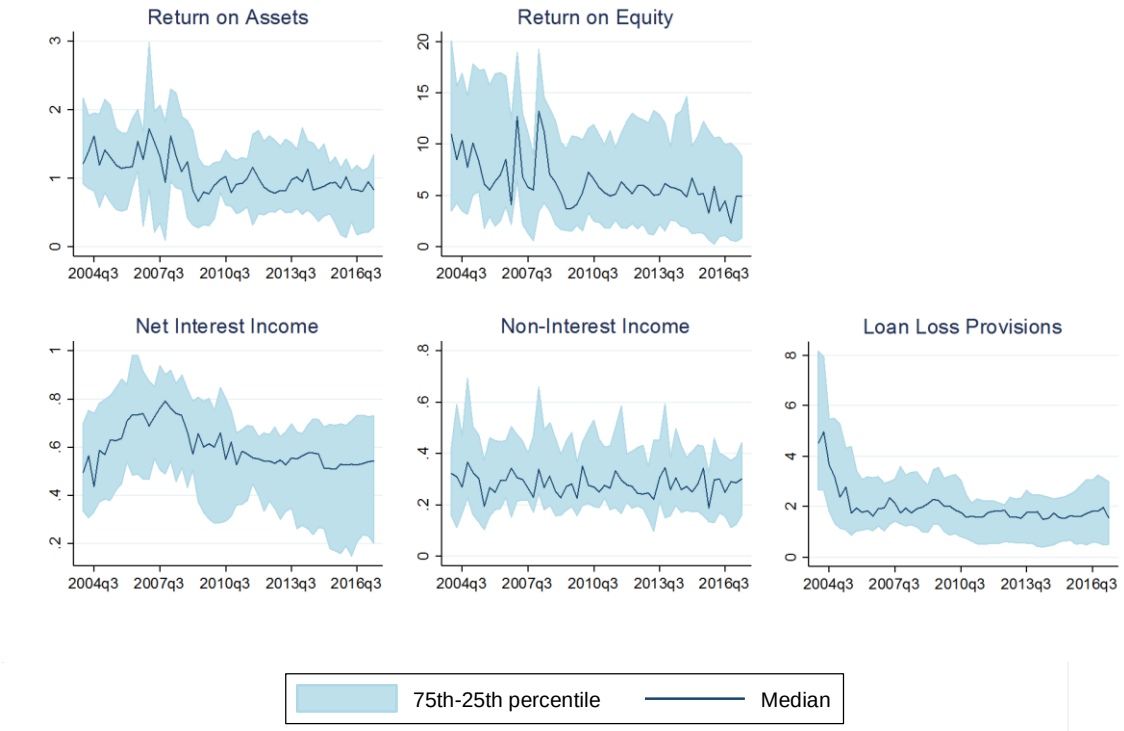
Bank profitability is captured by return on assets (ROA) and return on equity (ROE). To better understand the underlying movements of the ROA, we also explore its three main components: net interest income (NII), non-interest income (NNI), and loan loss provision (LLP), all expressed as percentages to total assets. Figure 3 shows the evolution of these five measures over time. The lines represent the median for each group of banks in each quarter, and the shaded areas show the cross-sectional dispersions across banks. Only banks that are present throughout the sample period are included, comprising of 23 banks. From Figure 3a, no clear downward trend of profitability in recent years under the low rate environment is observed, though the dispersion of NII among banks increases. This is mainly because NII of small banks declines in recent years and considerably diverge from medium and large banks (Figure 3b). Small banks also show decreasing ROA and ROE trends during the last few years as compared to medium and large banks, and they generally hold lower levels of LLP. Median ROA and ROE of medium banks are volatile and dipped below zero a few times during the sample period, possibly driven by irregular movements of some individual banks given a small number of banks in the medium bank category.

Three measures of bank risk at the bank level are examined, based on the availability of data. These include balance sheet Z-score, risk-weighted assets (RWA) to total assets, and non-performing loans (NPL) to total loans as depicted in Figure 4. As standard, bank Z-score is computed as ROA plus capital to assets ratio divided by the standard deviation of ROA. It captures the extent to which banks' profits and capital could withstand the volatility of profitability. Higher values of Z-score are associated with lower risk. All three measures suggest that overall, there is no sign of increasing risk in the banking sector, and some measures even suggest improvement. The bank Z-score shows increasing trend in the last few quarters, and the level and the dispersion of NPL among banks decreases, indicating lower bank risk. However, there are some caveats with these risk measures that need to be taken into account. First, these indicators are ex-post measures of bank-level risk which may depend on the concurrent economic conditions. Second, they only reflect certain aspects of risk from the overall bank balance sheet and hence cannot capture changes in bank risk-taking behavior at a more micro level such as in some specific portions of loan portfolio.[6] Our loan-level analysis will attempt to overcome these drawbacks of the bank-level analysis.

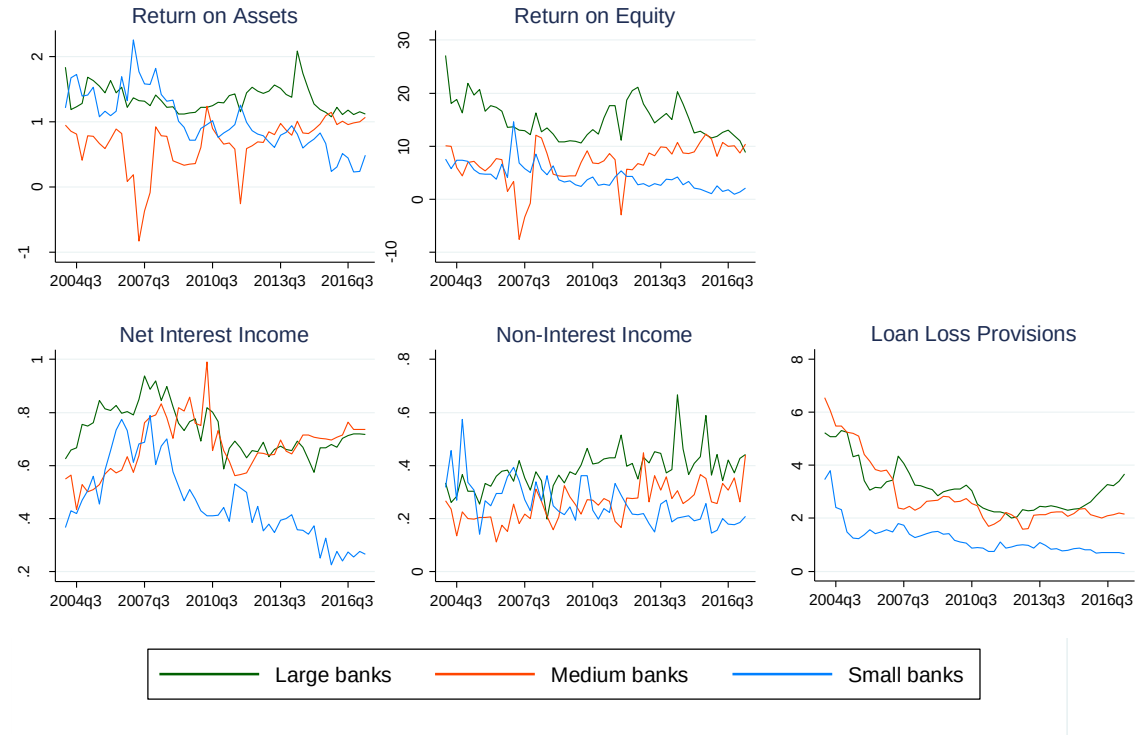
[6] Data on other bank-level measures of bank risk that are more forward-looking such as expected default frequency (EDF) are not available.

Figure 3: Bank profitability and its main components

a. Median across all sample banks



b. Medians by bank size

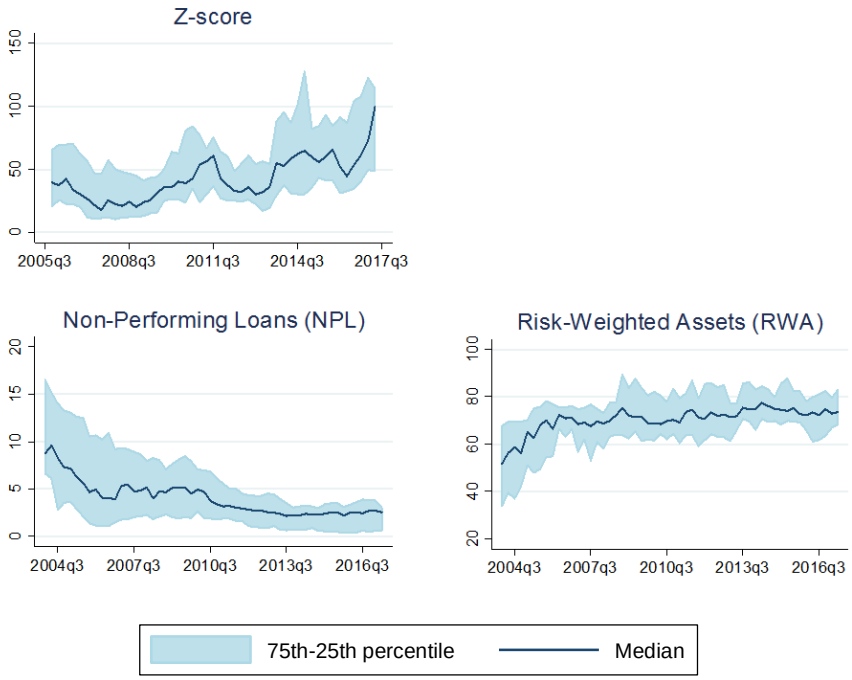


Note: The figure includes 23 non-exit, non-entry banks. All variables are ratios in percentage. The solid lines represent the median value of each indicator and for each group of banks. The shaded areas show interquartile range of the distribution.

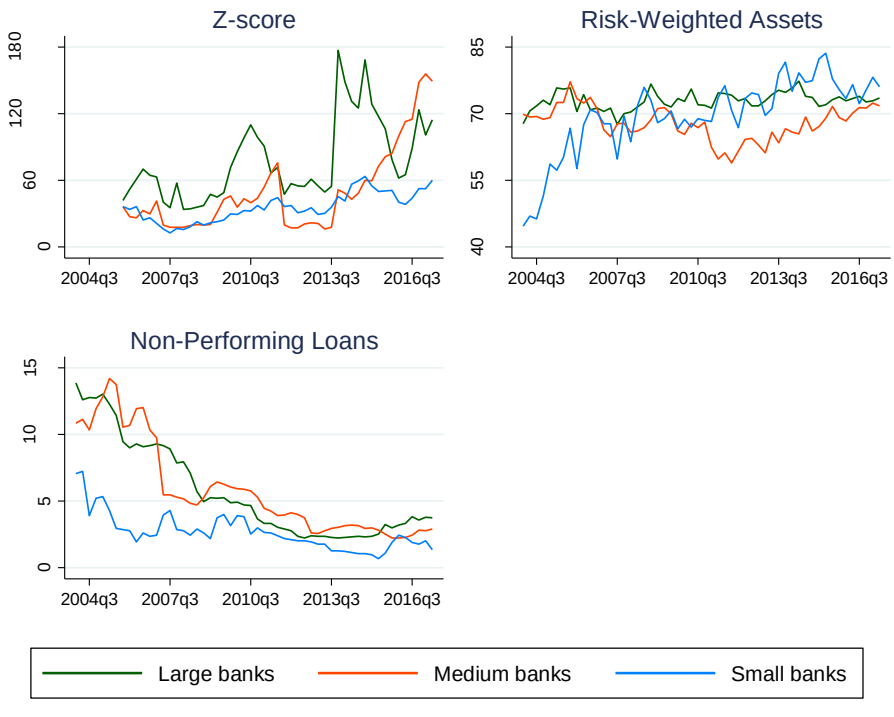
Source: Bank of Thailand. Authors' calculations.

Figure 4: Bank risk measures

a. Median across all sample banks



b. Medians by bank size



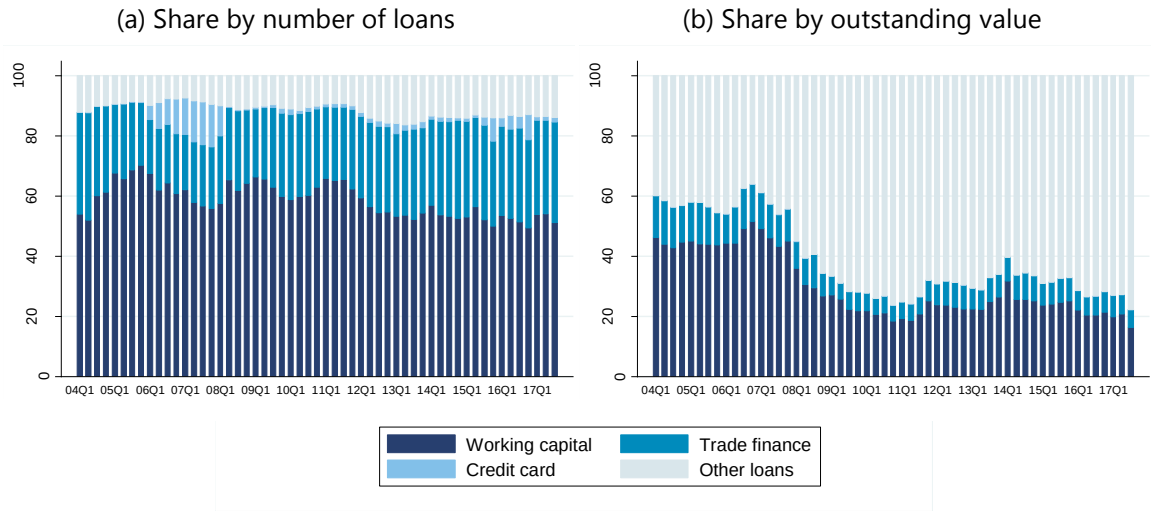
Note: The figure only includes 23 non-exit, non-entry banks. The balance sheet Z-score is defined as eight-quarter averaged ROA plus capital-to-asset ratio, divided by the standard deviation of ROA over eight quarters. Risk-weighted assets (RWA) are percentages of total assets. Non-performing loans (NPL) are percentages of total loans. The solid lines represent the median value of each indicator. The shaded areas show interquartile range of the distribution.

Source: Bank of Thailand. Authors' calculations.

3.4 Loan Characteristics and Account-Level Risk Measures

We turn to the loan-level analysis to exploit the granularity of the data in coming up with alternative measure of bank risk. We group loans into four categories according to loan purposes and characteristics: (1) working capital, (2) trade finance, (3) credit card, and (4) other general loans which include long-term business loans.[7] Figure 5 presents the share of new loans in each loan category, by number of loan contracts (panel a) and by outstanding value at loan origination (panel b). The number of *working capital* accounts constitutes around half of the total number of new loans, but they tend to be small in aggregate value. In contrast, the share of *other loans* account for as much as 80% of total value of new loans in recent years, but they represent only 15% of total loan accounts, suggesting that each loan account under this category is typically large in size. There is also a relatively large number of trade finance accounts, but with small share in value. Credit card loans appear to be insignificant both in terms of number of accounts and in terms of loan value. One observation from the evolution of the loan composition over time is that the share of working capital loans appear to decline substantially, from about 40% to 20%, after 2008-2009 which coincides with the global financial crisis period.

Figure 5: Share of new loans by types over time



Note: Outstanding is at loan origination.

Source: Bank of Thailand. Authors' calculations using LAR data.

Loan characteristics across the four types of loans are further explored in Table 1. Other general loans are divided into short- and long-term loans with a cut-off at one year based on adjusted loan maturity.[8] It is clear that other loans are the largest in their average loan size, with the median of 7 and 4 million Baht in the case of short-term and long-term loan, respectively. Working capital and

[7] Trade finances are bills, notes, and loans for export and import purposes. Working capital comprises of overdraft, notes that are not considered trade finance, and factoring. Other loans include short- and long- terms loans such as general business loans, leasing, hire purchase, real estate loans, and bank guarantees. Trade finance and credit card can generally be considered as loans for working capital, but here we examine them separately due to their specific characteristics and purposes.

[8] Maturity is an optional field in LAR. It is replaced with the actual duration of the loan when maturity data is missing or inconsistent.

trade finance loans are typically smaller than 2 million baht, while credit card loan outstanding per account is minimal. The average maturity of working capital and other short-term types of loans stands at around 2-4 months, while long-term loans have the average maturity exceeding seven years. Most of these working capital and short-term loans are used by corporate borrowers, whereas long-term loans have lower share of corporate loans, reflecting the fact that long-term loans also include mortgage borrowing by non-corporate individuals. About half of the long-term loans are collateralized, which is higher than that of working capital and other short-term loans.[9] The last two rows show share of loans that eventually defaulted (within our sample period) and share of classified loans flagged as special mention (SM) or below. It is clear that other long-term loans have the highest default rate at 7.25%, and as high as 17% including the cases of SM. Overall, these summary statistics suggest that the nature of loans varies across different types of borrowing, particularly for the long-term general loans that seem to stand out from other types with their large size and several other unique features. We will thus need to analyze these different types of loans separately in our empirical investigation.

Table 1: Loan characteristics by loan type

		Working capital	**Trade finance**	**Credit card**	**Other loans**	
					Short-term	**Long-term**
Size of loan (thousand baht)	Median	1,800	1,650	3	7,657	4,154
	Mean	11,436	7,194	13	168,223	40,589
Maturity (months)	Median	2	3	1	2	60
	Mean	4.3	4.3	15.1	2.5	86.3
Share of corporate loans		85.4%	98.6%	92.3%	82.4%	65.4%
Share of collateralized loans		25.4%	22.4%	1.9%	19.4%	53.0%
Share of defaulted loans		1.59%	1.12%	0.23%	3.06%	7.25%
Share of SM and defaulted loans		3.96%	4.90%	2.14%	5.44%	17.29%

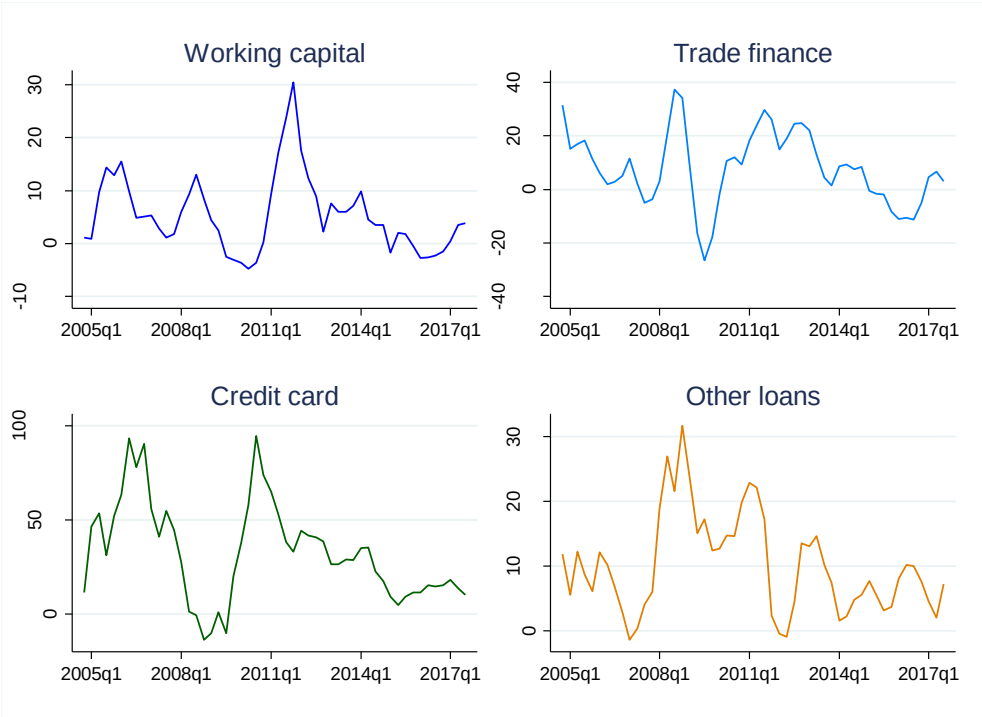
Note: Short- and long-term loans refer to loans with adjusted maturity not more than one year, and more than one year, respectively.

Source: Bank of Thailand. Authors' calculations using LAR data.

Next we turn to look at loan market developments in recent years as well as loan-level risk measures. Figure 6 presents the rate of credit growth by loan type aggregated from individual loan contracts. Except for some contraction around the 2008-2009 global financial crisis period, credit growth across all loan types have generally remained positive. The growth rate of credit card is most volatile, reaching almost 100% around 2006 and 2010. Although there appears to be some strong increases in credit growth around 2011-2013, there has not been an overwhelming sign of accelerating credit growth in any particular loan type in more recent years under the prolonged low interest rate condition.

[9] Loans with collaterals are defined as having collaterals at any time during the duration of the loans. However, due to complex nature of collateralization and possible inconsistency in the data collection, the data might be underestimated.

Figure 6: Credit growth by loan type (% year-on-year)



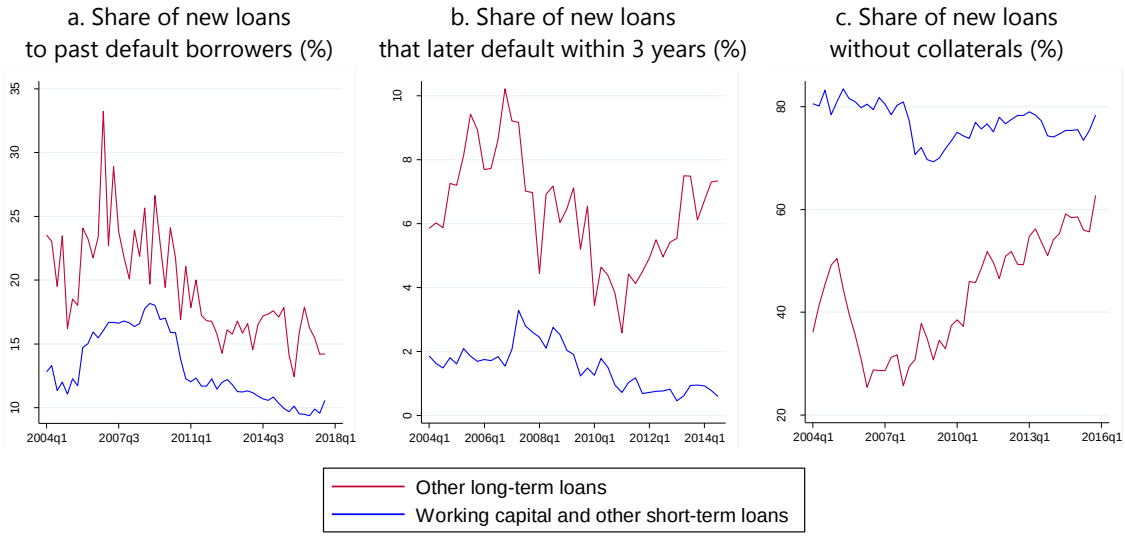
Note: Credit growth is year-on-year changes in aggregated loan outstanding.

Source: Bank of Thailand. Authors' calculations using LAR data.

To supplement the bank-level analysis, we explore alternative measures of bank risk-taking using the account-level loan data. Three dimensions of new loan quality are examined. The first two indicators will make use of default information pertaining to individual loan and the borrower, and the last indicator relies on collateral information. On the first measure, we calculate the share of loans that are granted to borrowers who used to default in the past at any bank prior to the granting of new loan under consideration. The second measure looks at the share of new loans granted that later default within the following three years after loan origination. The last measure considers the share of loans without collaterals. Figure 7 compares these three indicators of the quality of new loans between long-term loans and the rest. The share of new loans to past-default borrowers does not suggest higher risk in a low rate environment (panel a.) as the share of these potentially more risky loans decline over time. However, on the second measure, the proportion of new *long-terms* loans that subsequently default within three years after the loan is granted exhibits a strong increasing trend since around 2011 (panel b.), which is also the period that the policy rates started to decline. But this is not observed in other loan types. New long-term loans also have an increasing share of loans without collaterals which could potentially be indicative of higher risk-taking by banks.[10]

[10] Caveats apply in that whether the loan is collateralized or not depends crucially on the type and nature of loans. For example, real estate loans, mortgage, and leasing would generally require collaterals. Thus, the observed upward trend might be due to changing loan composition over times and may not reflect an increasing risk.

Figure 7: Measures of quality of new loans



Note: Long-term loans refer to loans with adjusted maturity more than one year. Past default is at borrower level. Future default is based on loan level. For panel b, only loans that can be observed for subsequent three years are included; thus, the figure excludes new loans after 2014:Q3. Loans with collaterals are defined as having collaterals at any time during the duration of the loans.

Source: Bank of Thailand. Authors' calculations using LAR data.

4. Empirical Strategy

To assess the impact of low interest rates on bank profitability and risk-taking, two levels of regression analyses are performed: (1) bank-level panel regressions to study the impact of low rates on bank profitability and risk measures, and (2) loan-level duration analysis and probit models to investigate the effects on loan quality and loan risk.

4.1 Bank-Level Panel Analysis

In this section we use a bank-level panel dataset to study the impact of monetary policy rate on banks' performance and risk-taking behavior. As described in the data section, the five measures of bank profitability include ROA and ROE (in percentage) and its components (NII, NNI, and LLP, as percentage to bank's total assets). And the three measures of bank risk used in this study are bank balance sheet Z-score, NPL to total loans, and RWA to total assets. The main explanatory variable of interest is the short-term policy rate. The baseline specification is as follows:

$$Y_{i,t} = \alpha_i + \delta Y_{i,t-1} + \beta_1 MP_t + \beta_2 YieldSpread_t + \Phi MacroControls_t + \Omega BankChars_{i,t-1} + \varepsilon_{i,t}$$

where the dependent variable $Y_{i,t}$ is one of the five measures of profitability and the three measures of risk of bank i at time t, MP_t denotes the policy rate, and $YieldSpread_t$ is a difference between two-year and ten-year government bond rates, to account for interest rate outlook and long-term rate. Macroeconomic controls include year-on-year percentage changes in nominal GDP and CPI, estimated GDP growth, estimated inflation, credit-to-GDP gap, Herfindahl Hirschman Index (HHI) which measures the degree of loan market concentration, and a crisis dummy variable that takes the value of one during 2008-2009, and zero otherwise.

Bank characteristics ($BankChars_{i,t-1}$) include capital ratio, liquidity ratio, log of total assets, funding composition defined as a share of deposits to total liabilities, efficiency ratio or cost-to-income ratio, loans to total assets, and bank size. The bank size is captured by three dummy variables: *Large*, *Medium*, and *Small*. All time-variant bank characteristics are one-period lagged. The regression also includes a lagged dependent variable.

In addition to the baseline specification, the interaction terms between the policy rate and bank characteristics will be included to test whether the policy rate affects banks of different attributes differently. Details of the variables and summary statistics are provided in Table A1 in the Appendix. The main estimation method is a fixed-effect panel regression. The system GMM dynamic panel regression will be supplemented as a robustness check.[11]

4.2 Loan-Level Duration Analysis

The loan-level dataset enables us to examine risk of individual loans based on available information on loan characteristics. We resort to a duration model in this loan-level analysis, in which the time to default or repayment of each loan represents the measure of risk and loan quality. Our conjecture is that low interest rates could spur banks to take more risk in the loan portfolio by granting loans to lower quality borrowers who have a higher hazard to subsequently default on the granted loan in a shorter time period.[12]

The concept of the duration model is illustrated in Figure 8, which also clarifies the timing of the variables used in the model. A given loan is granted in month τ. The loan may end with full repayment or default that occurs in month $\tau+T$. T is thus the span of time (in months) from loan origination to default or repayment. It is referred to as a spell or survival time in the survival analysis. Default is considered as a complete spell, and repayment is considered as right-censored, in which the default event cannot be observed.[13] Since only newly granted loans are studied, there is no left-censoring.

The behavior of the spell can be examined through the hazard function, which determines the hazard rate. The hazard rate here can be interpreted as the probability of loan default in period *t*, conditional on the loan surviving until this period, *i.e.* given that default did not occur before. The estimation of hazard functions typically assumes a proportional hazard specification as follows:

$$\lambda(t, X, \beta) = \lambda_0(t)\exp(\beta' X)$$

where $\lambda(t, X, \beta)$ is the hazard function, $\lambda_0(t)$ is the baseline hazard function at time t, X is a set of observable explanatory variables or covariates, and β is a vector of coefficients associated with the explanatory variables. The model specification mainly employed in this paper is semi-parametric

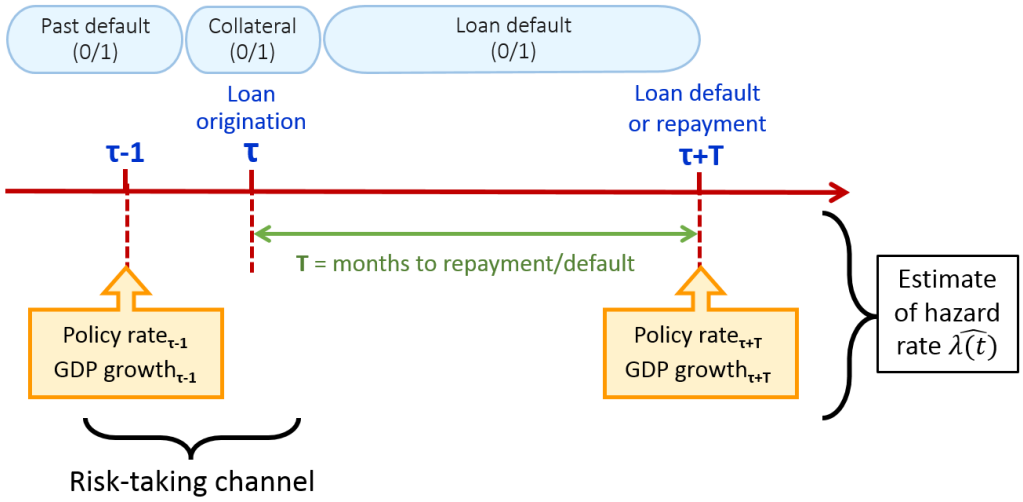
[11] The fixed-effect panel regression is argued to be biased and inconsistent for "large N, small T" samples, and a dynamic panel regression is typically used when the regression includes lagged dependent variable. However, the bank-level dataset in this study is not considered "large N, small T" with 23 banks over 54 quarters. Thus, the bias arising from lagged independent variables tends to be insignificant, while the use of dynamic panel regression could be sensitive to the chosen specification such as system versus difference GMM and the choices of instruments. See Roodman (2009) for further discussion.

[12] See Ioannidou et al. (2015) for a more detailed discussion of advantages of using duration model to study loan-level risk-taking.

[13] Loans that have not ended in the last sample month are also considered as right-censored. Excluding these loans does not change the main results from the analysis.

Cox (1972) proportional hazard model, which specifies no shape for $\lambda_0(t)$. The estimation is based on maximum likelihood (ML) method.

Figure 8: Duration analysis and the timing of the variables



Source: The figure is adapted from Jiménez et al. (2007)

The time to default and the hazard rate are considered as measures of loan risk. And an increase in the loan hazard rate can be considered as a proxy for bank risk-taking. The interpretation of the results from the duration model is equivalent to having the hazard rate as the left-hand side dependent variable. A positive coefficient on an explanatory variable implies that an increase in the covariate leads to an increase in the hazard rate or the likelihood of loan default given that the loan survives until time *t*.

The main explanatory variable of interest is the policy rate. The model allows us to disentangle the influence of the policy rate on loan granting decision at the origination of the loan (at τ-*1*) from the impact of the interest rate condition at the end of the loan (at τ+*T*). Therefore, although the duration model adopted is non time-varying and pools all observation as cross-sectional data, the time dimension of interest rate could be somewhat captured by these interest rates at two points in time. A low rate at the beginning of the loan is expected to increase the hazard rate, reflecting the risk-taking channel of the interest rate policy. A low rate environment at the end of the loan life is expected to help lower the interest rate burden on the borrowers, and hence decrease the risk of default and the hazard rate. GDP growth is another covariate that enters the model at two points in time (τ-*1* and τ+*T*) to control for economic conditions.

The explanatory variables concerning bank characteristics and other macroeconomic controls are similar to those entering the bank-level regressions. Additional covariates are variables related to loans, borrowers, and firms. Loan characteristics explored are the type of loans, loan outstanding size, and collateralization. Borrower characteristics include a dummy variable capturing whether the borrower used to default in the past before the granting of the new loan under consideration, and the number of bank relationships that the borrower has when the loan is granted. Three firm characteristics included in the regressions are firm age, firm size, and ROA.

4.3 Loan-Level Probit Model

The duration analysis using loan-level data is supplemented with a loan-level probit model to examine alternative aspects of loan risk. This analysis aims to test whether low interest rates spur bank to grant more loans with lower quality. Three dimensions of loan quality are captured by (1) past default history, (2) ex-post loan default, and (3) collateralization. We investigate whether a low interest rate leads to higher probability of low-quality loans being granted. The probit model takes the following form.

$$P(Y = 1|X) = \Phi(X\beta)$$

where *P* denotes the probability of a new loan granted being low quality as indicated by one of the three measures above given all the loan, bank, and firm characteristics and macro controls (*X*). Φ is the cumulative distribution function (CDF) of the standard normal distribution. *Y* signifies one of the three binary indicators that takes a value of 1 (1) when loan *i* is granted at time *t* by bank *b* to borrowers that used to default at any time in the past; (2) when the loan under consideration defaults at some point in the future; or (3) when the loan is granted with collateral, and 0 otherwise. *X* is a vector of explanatory variables similar to the first two types of regression in Section 4.1 and 4.2, and β is their corresponding parameters estimated by maximum likelihood method.

5. Main Results

5.1 Bank Profitability

The regression results on bank profitability at bank level are presented in Table 2. Overall, profitability of banks as measured by ROA and ROE increases with the policy rate. One percentage point increase in the policy rate leads to about 0.1 and 0.8 percentage point increase in ROA and ROE, respectively. Net interest income and loan loss provision also increase with the policy rate.[14] Non-interest income is not statistically significantly affected. Although provision is considered as a cost to bank, the net effect on ROA and ROE are still positive. This suggests that, during the downtrend of the policy rate, the impact of lower rates on bank profitability works mainly through a reduction in net-interest income, while a decreasing cost from lower loan loss provision works to offset part of the decline in profitability. These results are in line with the findings from previous literature (see Borio et al. (2017) and Altavilla et al. (2017) for example).

Table 3 further investigates how banks with different characteristics are affected by the policy rate by adding interaction terms between the interest rate and bank characteristics. The results show that small banks tend to be more sensitive to the policy rate, suggesting that their profitability could be more adversely affected in a low rate environment. Banks with higher capital and liquidity ratios also appear to be more responsive to the rate changes, but this largely reflects those of small banks as they tend to hold more capital and liquid assets (as percentage of total assets) compared to large and medium banks.

[14] We also investigate net interest margins (NIM) as an alternative to NII. The results are similar and not reported.

Table 2: The impact of the policy rate on bank profitability

	(1)	(2)	(3)	(4)	(5)
Dependent variable	**ROA**	**ROE**	**NII/TA**	**NNI/TA**	**LLP/TA**
Lagged dependent variable	**0.381*** **	**0.511*** **	**0.713*** **	**0.164*** **	**0.823*** **
	(4.048)	(14.267)	(9.146)	(7.154)	(18.091)
Monetary conditions					
Policy rate $_{t}$	**0.135** **	**0.784*** **	**0.010***	0.011	**0.065** **
	(2.811)	(3.213)	(1.949)	(1.047)	(2.245)
Yield spread $_{t}$	0.118	**0.714** **	**0.011***	0.005	**0.072***
	(1.586)	(2.324)	(1.882)	(0.409)	(1.913)
Macroeconomic conditions					
GDP growth $_{t}$	0.018	**0.114** **	-0.001	0.001	0.000
	(1.551)	(2.377)	(-1.410)	(0.391)	(0.122)
CPI growth $_{t}$	0.005	0.214	0.002	0.003	-0.016
	(0.210)	(1.253)	(1.346)	(0.547)	(-1.547)
Credit-to-GDP gap $_{t}$	0.003	0.043	**-0.001** **	0.001	-0.004
	(1.232)	(1.589)	(-2.109)	(1.052)	(-1.495)
HHI $_{t}$	0.001	**0.013***	-0.000	0.000	0.001
	(0.890)	(1.910)	(-0.735)	(1.690)	(1.709)
Crisis dummy $_{t}$	0.098	1.545	-0.010	0.017	0.036
	(0.950)	(1.447)	(-1.255)	(0.947)	(0.775)
Bank characteristics					
ln(Total assets) $_{t-1}$	-0.125	-0.524	0.004	-0.023	**0.161** **
	(-1.249)	(-0.732)	(0.238)	(-0.758)	(2.308)
Capital ratio $_{t-1}$	0.011	0.006	-0.001	**0.004** **	0.002
	(1.568)	(0.212)	(-0.864)	(2.575)	(0.496)
Liquidity ratio $_{t-1}$	-0.004	-0.032	-0.001	**-0.004***	0.002
	(-1.059)	(-1.428)	(-1.645)	(-1.825)	(0.603)
Funding composition $_{t-1}$	-0.001	-0.000	0.001	0.001	0.001
	(-0.746)	(-0.045)	(1.462)	(0.833)	(1.077)
Loans/Assets $_{t-1}$	**0.006***	**0.037***	0.000	**0.004*** **	-0.001
	(1.742)	(1.807)	(0.650)	(2.938)	(-0.374)
Efficiency $_{t-1}$	-0.001	0.010	**-0.000***	0.000	**-0.001** **
	(-0.569)	(1.072)	(-1.772)	(0.828)	(-2.132)
Constant	0.528	-10.786	0.156	-0.096	**-2.690*** **
	(0.353)	(-1.230)	(0.552)	(-0.181)	(-2.825)
Observations	1,197	1,197	1,197	1,197	1,197
Number of banks	23	23	23	23	23
R-squared	0.250	0.313	0.678	0.071	0.822

The standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. All regressions include bank fixed-effects. *** p<0.01, ** p<0.05, * p<0.1

Table 3: The impact of the policy rate on bank profitability
Different bank characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ROA**	**ROA**	**ROA**	**ROE**	**ROE**	**ROE**
Lagged dependent variable	**0.373*** **	**0.368*** **	**0.372*** **	**0.499*** **	**0.506*** **	**0.508*** **
	(4.094)	(4.006)	(3.996)	(16.155)	(13.838)	(14.615)
Monetary conditions						
Policy rate $_t$	0.075	**-0.129***	**0.414*** **	**0.891** **	-0.260	**2.215*** **
	(1.277)	(-1.915)	(10.716)	(2.751)	(-0.472)	(6.499)
Yield spread $_t$	0.120	0.105	0.113	**0.744** **	**0.658** **	**0.682** **
	(1.606)	(1.524)	(1.488)	(2.352)	(2.227)	(2.197)
Macroeconomic conditions						
GDP growth $_t$	0.018	0.017	0.018	**0.112** **	**0.110** **	**0.115** **
	(1.505)	(1.476)	(1.555)	(2.292)	(2.270)	(2.338)
CPI growth $_t$	0.005	0.004	0.005	0.216	0.214	0.214
	(0.207)	(0.209)	(0.210)	(1.237)	(1.250)	(1.235)
Credit-to-GDP gap $_t$	0.003	0.003	0.003	0.041	0.043	0.041
	(1.261)	(1.314)	(1.065)	(1.637)	(1.628)	(1.538)
HHI $_t$	0.001	0.001	0.000	**0.013***	**0.013***	0.011
	(0.840)	(0.724)	(0.432)	(1.837)	(1.838)	(1.615)
Crisis dummy $_t$	0.098	0.094	0.087	1.520	1.509	1.475
	(0.945)	(0.896)	(0.822)	(1.433)	(1.410)	(1.378)
Bank characteristics						
ln(Total assets) $_{t-1}$	-0.128	-0.127	-0.108	-0.467	-0.511	-0.444
	(-1.456)	(-1.554)	(-1.092)	(-0.782)	(-0.784)	(-0.639)
Capital ratio $_{t-1}$	0.009	**-0.021** **	0.009	-0.005	**-0.113** **	-0.007
	(1.317)	(-2.325)	(1.257)	(-0.174)	(-2.127)	(-0.244)
Liquidity ratio $_{t-1}$	-0.004	**-0.025*** **	-0.005	-0.032	**-0.122*** **	-0.037
	(-1.016)	(-4.067)	(-1.231)	(-1.390)	(-3.435)	(-1.596)
Funding composition $_{t-1}$	-0.002	-0.000	0.003	-0.003	0.004	0.034
	(-0.858)	(-0.097)	(0.817)	(-0.282)	(0.397)	(1.670)
Loans/Assets $_{t-1}$	0.005	0.006	**0.013** **	0.034	**0.036***	**0.061** **
	(1.556)	(1.657)	(2.567)	(1.629)	(1.812)	(2.421)
Efficiency $_{t-1}$	-0.000	-0.000	-0.000	0.011	0.011	0.011
	(-0.376)	(-0.321)	(-0.371)	(1.164)	(1.143)	(1.189)
Policy rate $_t$ x Medium banks (0/1)	**-0.170*** **			**-1.964*** **		
	(-3.205)			(-3.037)		
Policy rate $_t$ x Small banks (0/1)	**0.130*** **			0.263		
	(2.969)			(0.809)		
Policy rate $_t$ x Capital ratio $_{t-1}$		**0.011*** **			**0.042** **	
		(4.548)			(2.204)	
Policy rate $_t$ x Liquidity ratio $_{t-1}$		**0.008*** **			**0.036*** **	
		(4.331)			(3.745)	
Policy rate $_t$ x Funding composition $_{t-1}$			-0.002			-0.014
			(-1.244)			(-1.706)
Policy rate $_t$ x Loans/Assets $_{t-1}$			**-0.003** **			-0.010
			(-2.208)			(-1.220)
Constant	0.662	1.365	0.061	-11.047	-7.650	-12.835
	(0.463)	(1.049)	(0.040)	(-1.162)	(-0.907)	(-1.387)
Observations	1,197	1,197	1,197	1,197	1,197	1,197
Number of banks	23	23	23	23	23	23
R-squared	0.263	0.268	0.261	0.324	0.318	0.318

The standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. All regressions include bank fixed-effects. *** p<0.01, ** p<0.05, * p<0.1

Table 4: The impact of the policy rate on bank risk

	(1)	(2)	(3)
Dependent variable	**Z-score**	**RWA/Assets**	**NPL/Loans**
Lagged dependent variable	**0.798*** **	**0.825*** **	**0.749*** **
	(44.048)	(34.566)	(10.364)
Monetary conditions			
Policy rate $_t$	-3.339	0.126	0.315
	(-1.439)	(0.415)	(1.489)
Yield spread $_t$	3.273	-0.015	0.337
	(1.214)	(-0.036)	(1.210)
Macroeconomic conditions			
GDP growth $_t$	-0.602	-0.056	-0.019
	(-1.618)	(-0.781)	(-1.218)
CPI growth $_t$	**1.391** **	0.204	-0.106
	(2.551)	(1.051)	(-1.531)
Credit-to-GDP gap $_t$	0.018	0.015	**-0.026** **
	(0.189)	(0.503)	(-2.173)
HHI $_t$	-0.024	-0.004	**0.005** *
	(-0.513)	(-0.565)	(1.938)
Crisis dummy $_t$	**-11.186*** **	-0.648	0.340
	(-3.359)	(-0.733)	(1.433)
Bank characteristics			
ln(Total assets) $_{t-1}$	3.054	0.126	0.357
	(1.128)	(0.085)	(1.465)
Capital ratio $_{t-1}$	**0.452** **	-0.003	-0.010
	(2.168)	(-0.043)	(-0.331)
Liquidity ratio $_{t-1}$	-0.036	0.017	-0.010
	(-0.631)	(0.279)	(-0.561)
Funding composition $_{t-1}$	0.066	-0.009	0.004
	(1.328)	(-0.211)	(0.718)
Loans/Assets $_{t-1}$	-0.010	-0.017	-0.018
	(-0.112)	(-0.434)	(-1.166)
Efficiency $_{t-1}$	**-0.022** **	**-0.019*** **	0.007
	(-2.659)	(-3.044)	(1.302)
Constant	-0.961	17.551	**-8.954** *
	(-0.013)	(0.725)	(-1.983)
Observations	1,038	1,197	1,197
Number of banks	23	23	23
R-squared	0.690	0.723	0.734

The standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. All regressions include bank fixed-effects. *** p<0.01, ** p<0.05, * p<0.1

The key results remain unchanged when expected GDP growth and expected inflation are included as controls instead of actual GDP growth and inflation. The coefficients of both expected macroeconomic variables are not only statistically significant in the ROE regression, but also for ROA and NII, suggesting that the outlook about the economy might matter more for bank profitability than the concurrent economic conditions, possibly through bank adjustment in business strategy in response to the future path of the economy.

5.2 Bank-Level Risk

At the overall bank level, there is no evidence that the low interest rate leads to higher bank risk-taking based on the risk indicators from bank balance sheet information (Table 4). The coefficients of the policy rate on Z-score, RWA, and NPL are all statistically insignificant. These three measures appear to largely depend on their lagged values. The influence of other explanatory variables is also generally small. We check for robustness of the results by employing a system estimation instead of the fixed effect panel method. The results overall remain unaffected by the change of the model, confirming the no effect of interest rates on balance sheet-based risk measures at the bank level.

We will next turn to a more granular loan-level data in investigating the impact of the change in interest rate on loan risk, taking into account various sources of heterogeneity across different types of loans and borrowers that cannot be analyzed at the bank level.

5.3 Loan-Level Duration Model

A duration model is applied to the loan-level data to examine whether a change in the policy rate induces a change in the hazard rate of new loans; particularly, whether banks grant loans with higher credit risk when the rate has been at a low level. The regression result of the impact of policy rate on loan risk is reported in Table 5. The first column reports the result using the full sample of loan accounts. Based on the stylized facts in Section 3 which show the vast differences between long-term and other types of loans, in Column 2 and 3 we run separate regressions for two subsamples: (1) long-term loans and (2) the rest including working capital, trade finance, credit card, and other short-term loans.

For the full sample (Column 1), it appears that the interest rate level at the loan origination (at τ) does not have any statistically significant effect on the loan risk as measured by the hazard rate, consistent with the finding from the bank-level regressions. However, when separating loans into the two subsamples, we find the coefficient on the interest rate to have opposite signs: negative in the case of long term loans and positive in the case of the other types of loans (Column 2 and 3). This implies that low interest rate leads to *higher* hazard rates for long-term general loans, but *lower* hazard rates for non-long-term loans. One possible reason can be that working capitals and short-term loans tend to have shorter maturity. In this case, the positive impact of low rate through a reduction in the debt burden of the borrowers (demand side) could be greater than the negative impact due to bank risk-taking behavior (supply side), and thus leads to lower default risk of these short-term loans. In the case of long term loans, the low interest rate at the origination may matter more in terms of influencing bank risk-taking, while the interest burden benefit would not be realized until later years. Together, the opposite effects of interest rate on the two types of loans could offset each other, resulting in a muted impact when analyzing the full sample data.

As expected, higher interest rates at the end of loan duration ($\tau+T$) leads to higher default risk as the interest burden could increase and impair the borrower's ability to repay. The positive coefficients are statistically significant and consistent across different specifications, suggesting a robust relationship. Higher GDP growth both at the beginning and the end of loan duration helps to lower the default risk, while higher bank market competition (low HHI) increases the hazard rate. A high competition could encourage banks to soften their lending standard and grant loan to relatively riskier borrowers in order to increase or maintain their market share.

The coefficients on loan and borrower characteristics have expected signs. They are statistically significant and largely consistent across all types of loans. Loans granted to borrowers with default history tend to have higher hazard rates, whereas having collaterals and more relationships with other banks decrease the default risk. Larger loan size is related to slightly lower hazard rates for the long-term loans, but the relationship is reverse for non-long-term loans.

The last two columns of Table 5 investigate bank characteristics by adding bank size dummies and interaction terms between the policy rate and bank characteristics. Loans issued by medium and small banks tend to have higher hazard rates. Interestingly, medium and particularly small banks are more responsive to policy rate in terms of loan risk-taking. For large banks, lower interest rate does not seem to raise the hazard rate of their loan portfolio.

To explore heterogeneity across different firm characteristics, the subsample of only corporate loans is used in Table 6. The finding that low rates at loan origination and high rates at the end of loan duration lead to higher hazard rate remain robust across all specifications. The coefficients on macroeconomic controls and characteristics of loans and borrowers are also generally preserved. Three firm characteristics examined are firm size, firm age, and ROA of firms. The firm size is a binary indicator indicating whether the firm is large (1) or small (0) based on the size of total revenues.[15] The results indicate that smaller, younger, and less profitable firms tend to be associated with higher hazard rates. The hazard rates of small firms appear to be more contingent on the level of interest rate compared to those of large firms, suggesting that small firms may potentially be more affected by bank risk-taking behavior.

Next, alternative measures of low rate environment are employed in Table 7. Column 1 adds the variable that counts the number of consecutive quarters in which the interest rate does not increase. The result show that when the interest rate remains *'low for longer'*, it tends to increase bank risk-taking in new loans, but helps lower the default risk for existing loans. The other two measures considered as substitutes to the policy rate are the binary indicator capturing whether the rate is below the sample median, and whether the Taylor residuals are negative. The results in Column 2 and 3 imply that the hazard rate is lower when the interest rate at the end of loan duration is below the sample median. The negative Taylor residuals both at the beginning and the end of loan duration are found to be associated with higher hazard rates, which contradicts the main results established earlier. This inconsistency is possibly because Taylor rules might convey information regarding the monetary policy *stance* rather than reflect the nominal rate environment that might matter more for bank risk-taking.

[15] The cut-off is arbitrarily chosen at the 25th percentile, with the top 25 percent of the firms assigned as 'large' and the rest as 'small'. Using continuous revenue size and total assets size instead of the binary variable also yields similar findings.

Table 5: The impact of policy rate on loan risk in duration models

	(1)	(2)	(3)	(4)	(5)
	Total sample	**Sub sample by loan types**		**Total Sample**	
		Long-term loans	**Non long-term loans**	**Bank characteristics**	
Monetary conditions					
Policy rate $_{\tau-1}$	-0.014	**-0.357*** **	**0.198*** **	-0.008	**-0.206*** **
	(-1.337)	(-17.651)	-15.168	(-0.768)	(-7.577)
Policy rate $_{\tau+T}$	**0.276*** **	**0.795*** **	**0.102*** **	**0.263*** **	**0.273*** **
	(45.331)	(57.108)	-12.668	(43.777)	(44.855)
Yield spread $_{\tau-1}$	**0.044*** **	**-0.581*** **	**0.273*** **	0.015	**0.028** **
	(3.290)	(-20.661)	-16.916	(1.164)	(2.068)
Macroeconomic conditions					
GDP growth $_{\tau-1}$	**-0.006*** **	**-0.011*** **	0.001	**-0.007*** **	**-0.007*** **
	(-4.370)	(-4.465)	-0.639	(-4.814)	(-4.617)
GDP growth $_{\tau+T}$	**-0.004*** **	**-0.043*** **	**-0.003***	**-0.004** **	**-0.004*** **
	(-2.865)	(-12.079)	(-1.844)	(-2.492)	(-2.740)
HHI $_{\tau-1}$	**-14.543*** **	**-8.072*** **	**-15.273*** **	**-14.903*** **	**-16.932*** **
	(-12.126)	(-3.448)	(-10.900)	(-12.453)	(-13.398)
Bank characteristics					
ln(Total assets) $_{\tau-1}$	**0.085*** **	**0.283*** **	**0.070*** **		**0.086*** **
	(14.456)	(24.087)	-8.174		(14.639)
Bank ROA $_{\tau-1}$	**-0.090*** **	**-0.104*** **	**-0.105*** **	**-0.072*** **	**-0.091*** **
	(-16.995)	(-8.065)	(-17.989)	(-13.122)	(-17.098)
Capital ratio $_{\tau-1}$	-0.004	**-0.114*** **	**0.032*** **	**-0.009*** **	**-0.017** **
	(-1.474)	(-17.713)	-11.175	(-3.564)	(-2.548)
Liquidity ratio $_{\tau-1}$	**-0.031*** **	**-0.008** **	**-0.035*** **	**-0.028*** **	**-0.077*** **
	(-19.561)	(-2.503)	(-19.052)	(-17.783)	(-19.463)
NPL/Loans $_{\tau-1}$	**0.041*** **	-0.002	**0.047*** **	**0.040*** **	**0.041*** **
	(33.871)	(-0.694)	-31.959	(32.724)	(33.563)
Loans/Assets $_{\tau-1}$	-0.000	**0.019*** **	**-0.010*** **	-0.000	0.000
	(-0.111)	(12.229)	(-11.674)	(-0.623)	(0.241)
Loan/borrower characteristics					
Past default (0/1)	**1.176*** **	**0.680*** **	**1.409*** **	**1.174*** **	**1.176*** **
	(120.465)	(33.878)	-124.191	(120.067)	1.176***
Collateralized (0/1)	**-0.360*** **	**-0.420*** **	**-0.188*** **	**-0.379*** **	**-0.359*** **
	(-32.673)	(-20.760)	(-14.270)	(-33.143)	(-32.627)
ln(Loan size) $_{\tau}$	**0.050*** **	**-0.045*** **	**0.097*** **	**0.049*** **	**0.050*** **
	(44.441)	(-24.107)	-61.716	(43.566)	(43.924)
Bank relationship $_{\tau}$	**-0.989*** **	**-0.527*** **	**-1.222*** **	**-0.995 *** **	**-0.984*** **
	(-79.116)	(-17.215)	(-86.125)	(-78.667)	(-78.695)
Bank interaction terms					
Medium banks (0/1)				**0.099** **	
				(2.500)	
Small banks (0/1)				**0.186*** **	
				(5.178)	
Policy rate $_{\tau-1}$ x Medium banks (0/1)				**-0.044*** **	
				(-3.435)	
Policy rate $_{\tau-1}$ x Small banks (0/1)				**-0.094*** **	
				(-7.698)	
Policy rate $_{\tau-1}$ x Capital ratio $_{\tau-1}$					**0.005** **
					(2.461)
Policy rate $_{\tau-1}$ x Liquidity ratio $_{\tau-1}$					**0.017*** **
					(13.007)
Observations	5,040,315	178,273	4,862,042	5,040,315	5,040,315
Pseudo-R	0.0255	0.0235	0.0357	0.0254	0.0257
log likelihood	-630120	-143037	-464989	-630188	-630033

The estimates are based on ML estimation of cox proportional hazards model and adjusted for right censoring. Non long-term loans includes working capital, trade finance, credit cards, and other short-term loans. τ is the month the loan was granted. T is the time to default or repayment of the loan. The z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6: The impact of policy rate on corporate loan risk in duration models

	(1)	(2)	(3)	(4)	(5)
Monetary conditions					
Policy rate $_{\tau-1}$	**-0.099*** **	**-0.149*** **	**-0.150*** **	**-0.098*** **	**-0.147*** **
	(-6.516)	(-9.458)	(-7.577)	(-6.459)	(-7.374)
Policy rate $_{\tau+T}$	**0.291*** **	**0.313*** **	**0.299*** **	**0.285*** **	**0.311*** **
	(35.484)	(37.972)	(36.241)	(34.711)	(37.486)
Yield spread $_{\tau-1}$	**-0.060*** **	**-0.065*** **	**-0.077*** **	**-0.073*** **	**-0.085*** **
	(-2.747)	(-2.941)	(-3.491)	(-3.326)	(-3.855)
Macroeconomic conditions					
GDP growth $_{\tau-1}$	**-0.006*** **	**-0.006*** **	**-0.007*** **	**-0.006*** **	**-0.007*** **
	(-3.217)	(-3.282)	(-3.633)	(-3.460)	(-3.607)
GDP growth $_{\tau+T}$	**-0.005*** **	**-0.007*** **	**-0.006*** **	**-0.005*** **	**-0.007*** **
	(-2.911)	(-3.407)	(-3.081)	(-2.918)	(-3.416)
HHI $_{\tau-1}$	**-25.351*** **	**-26.848*** **	**-26.708*** **	**-25.083*** **	**-27.137*** **
	(-13.784)	(-14.558)	(-14.520)	(-13.647)	(-14.716)
Bank characteristics					
ln(Total assets) $_{\tau-1}$	0.008	0.011	**0.015** **	0.005	0.011
	(1.147)	(1.539)	(2.028)	(0.697)	(1.564)
Bank ROA $_{\tau-1}$	**-0.124*** **	**-0.118*** **	**-0.125*** **	**-0.124*** **	**-0.120*** **
	(-22.049)	(-20.656)	(-22.213)	(-22.156)	(-21.010)
Capital ratio $_{\tau-1}$	-0.001	-0.002	-0.000	-0.001	-0.003
	(-0.221)	(-0.844)	(-0.074)	(-0.405)	(-0.930)
Liquidity ratio $_{\tau-1}$	**-0.038*** **	**-0.042*** **	**-0.038*** **	**-0.038*** **	**-0.042*** **
	(-19.750)	(-21.716)	(-19.426)	(-19.722)	(-21.415)
NPL/Loans $_{\tau-1}$	**0.044*** **	**0.043*** **	**0.044*** **	**0.043*** **	**0.042*** **
	(27.814)	(27.031)	(27.370)	(27.067)	(26.179)
Loans/Assets $_{\tau-1}$	**-0.001***	**-0.004*** **	**-0.002** **	-0.001	**-0.004*** **
	(-1.789)	(-4.943)	(-2.016)	(-1.466)	(-4.506)
Loan/borrower characteristics					
Past default (0/1)	**1.334*** **	**1.357*** **	**1.363*** **	**1.310*** **	**1.347*** **
	(111.447)	(113.091)	(113.335)	(109.153)	(111.425)
Collateralized (0/1)	**-0.339*** **	**-0.445*** **	**-0.371*** **	**-0.354*** **	**-0.465*** **
	(-24.616)	(-32.149)	(-26.804)	(-25.690)	(-33.445)
ln(Loan size) $_{\tau}$	**0.064*** **	**0.057*** **	**0.062*** **	**0.063*** **	**0.056*** **
	(40.684)	(36.326)	(39.824)	(40.223)	(35.943)
Bank relationship $_{\tau}$	**-1.128*** **	**-0.632*** **	**-1.052*** **	**-1.092*** **	**-0.592*** **
	(-76.751)	(-37.793)	(-70.109)	(-74.222)	(-35.059)
Firm characteristics					
Firm size (0/1) $_{\tau-1}$		**-1.074*** **			**-1.029*** **
		(-31.866)			(-29.291)
Firm size (0/1) $_{\tau-1}$ x Policy rate $_{\tau-1}$		**0.071*** **			**0.075*** **
		(6.694)			(6.750)
ln(Firm age) $_{\tau-1}$			**-0.198*** **		**-0.065*** **
			(-11.476)		(-3.594)
ln(Firm age) $_{\tau-1}$ x Policy rate $_{\tau-1}$			**0.013** **		-0.005
			(2.385)		(-0.831)
Firm ROA $_{\tau-1}$				**-0.956*** **	**-0.822*** **
				(-24.783)	(-20.182)
Firm ROA $_{\tau-1}$ x Policy rate $_{\tau-1}$				**0.030** **	0.017
				(2.403)	(1.316)
Observations	4,072,616	4,072,616	4,072,616	4,072,616	4,072,616
Pseudo-R	0.0332	0.0380	0.0339	0.0351	0.0397
log likelihood	-404543	-402533	-404254	-403744	-401824

The estimates are based on ML estimation of cox proportional hazards model and adjusted for right censoring. τ is the month the loan was granted. T is the time to default or repayment of the loan. The z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: The impact of low interest rate on loan risk in duration models

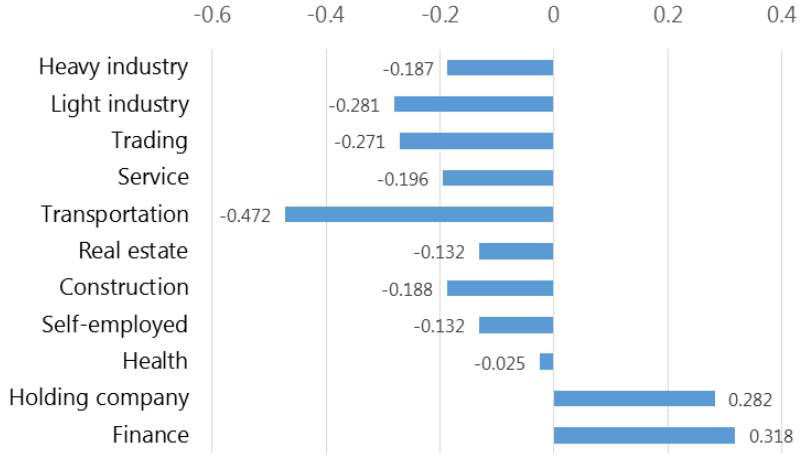
	(1)	(2)	(3)
	Quarter rate not increase	**Rate below median**	**Negative Taylor residual**
Monetary conditions			
Policy rate $_{\tau-1}$	0.012		
	(1.143)		
Policy rate $_{\tau+T}$	**0.225*** **		
	(32.941)		
Yield spread $_{\tau-1}$	**-0.147*** **	**0.032*** **	**-0.065*** **
	(-10.346)	(3.160)	(-8.541)
ln(Quarter rate not increase) $_{\tau-1}$	**0.268*** **		
	(40.472)		
ln(Quarter rate not increase) $_{\tau+T}$	**-0.238*** **		
	(-38.163)		
Rate below median (0/1) $_{\tau-1}$		-0.004	
		(-0.295)	
Rate below median (0/1) $_{\tau+T}$		**-0.496*** **	
		(-43.087)	
Negative Taylor residual (0/1) $_{\tau-1}$			**0.118*** **
			(11.507)
Negative Taylor residual (0/1) $_{\tau+T}$			**0.392*** **
			(40.499)
Macroeconomic conditions			
GDP growth $_{\tau-1}$	**-0.019*** **	**-0.007*** **	**-0.006*** **
	(-12.764)	(-5.208)	(-4.410)
GDP growth $_{\tau+T}$	0.005***	-0.001	-0.002
	(3.177)	(-0.880)	(-1.355)
HHI $_{\tau-1}$	**-4.246*** **	**-20.768*** **	**-22.259*** **
	(-3.476)	(-21.658)	(-23.202)
Bank characteristics			
ln(Total assets) $_{\tau-1}$	**0.098*** **	**0.073*** **	**0.022*** **
	(16.445)	(12.674)	(3.885)
Bank ROA $_{\tau-1}$	**-0.074*** **	**-0.069*** **	**-0.045*** **
	(-13.836)	(-13.199)	(-8.374)
Capital ratio $_{\tau-1}$	**-0.005***	**-0.010*** **	**-0.028*** **
	(-1.791)	(-3.874)	(-11.309)
Liquidity ratio $_{\tau-1}$	**-0.038*** **	**-0.032*** **	**-0.039*** **
	(-23.652)	(-20.833)	(-25.175)
NPL/Loans $_{\tau-1}$	**0.047*** **	**0.046*** **	**0.058*** **
	(38.986)	(41.303)	(53.672)
Loans/Assets $_{\tau-1}$	0.000	**0.001***	**0.002*** **
	(0.698)	(1.781)	(3.267)
Loan/borrower characteristics			
Past default (0/1)	**1.165*** **	**1.170*** **	**1.173*** **
	(119.092)	(119.930)	(120.394)
Collateralized (0/1)	**-0.362*** **	**-0.376*** **	**-0.430*** **
	(-32.688)	(-34.249)	(-39.336)
ln(Loan size) $_{\tau}$	**0.049*** **	**0.049*** **	**0.049*** **
	(42.692)	(43.466)	(43.974)
Bank relationship $_{\tau}$	**-1.008*** **	**-0.986*** **	**-0.996*** **
	(-80.691)	(-79.085)	(-79.952)
Observations	5,040,315	5,040,315	5,040,315
Pseudo-R	0.0272	0.0253	0.0253
log likelihood	-629038	-630252	-630289

The estimates are based on ML estimation of cox proportional hazards model and adjusted for right censoring. τ is the month the loan was granted. T is the time to default or repayment of the loan. The z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

A number of alternative specifications and robustness checks have been explored. First, the industry dummies (17 industries) and interaction terms are added to allow for differential effects across firms in different industries. The results are reported in Table A2 in the Appendix. The net impact of the policy rate on the hazard rate by industry is summarized in Figure 9. Only the statistically significant coefficients are shown. The result suggests that borrowers in different industries may be subject to bank risk-taking behavior to a different degree. Sectors that appear to be relatively more negatively affected include transportation, light industry, trading, services, construction, and heavy industry. Interestingly, these sectors tend to be the ones that co-move more with business cycle, compared to the sectors that are found not to be affected by the level of interest rate including agriculture, communication, education, government, mining and utilities (not reported in Figure 9). Increased default risk due to low interest rate is not observed for loans granted to holding companies or finance institutions. In fact, the coefficients for these two sectors are positive suggesting their default risk is actually lower in a low rate environment.

Another set of robustness checks allows for the change in model specification. The main duration models in Table 5 are re-estimated using Weibull distribution instead of Cox hazard model adopted. The results are similar and not reported. Lastly, the main findings are unchanged when (1) removing borrowers with the largest numbers of loan accounts to address potential outlier effects; (2) excluding loans issued by foreign banks' subsidiaries and branches; and (3) excluding loans made to financial institutions.

Figure 9: Net coefficients of the policy rate on loan hazard rate by industry



Note: The figure only shows the results for the sectors with statistically significant coefficients.

Source: Authors' calculations.

5.4 Loan-Level Probit Model

To supplement the loan-level analysis using the duration model, a probit model is also explored. Three alternative binary measures of loan risk are used as dependent variables under the probit model approach: (1) past default by the borrower, (2) ex-post loan default, and (3) collateralization. The resulting coefficients and average marginal effects are reported in Table 8. The main question we address in this probit model setting is whether a low interest rate leads to higher probability of banks granting loans to low quality customers as proxied by the three indicators above. The One

percentage point decrease in the policy rate increases the likelihood that banks grant new loans to borrowers with default history, new loans that subsequently default, and new loans that require collaterals by 0.55, 0.16 and 3.84 percent respectively. The magnitudes of the impact are small, but the results broadly confirm the main finding that low rate environment could lead to lower quality of new loans granted.

In addition, the results also show that higher GDP growth tends to help reduce the likelihood of risky loans. The greater number of bank relationships is found to increase the chance of past-default borrowers getting new loans, but decrease the likelihood of future default, which are both intuitive.

6. Conclusion

In this paper, we study the link between monetary policy and bank profitability and risk-taking in Thailand through several approaches. Various data sources including supervisory loan account-level data as well as bank and firm financial statements are collected to construct two main data sets used in the analyses. The bank-level data set covers 23 banks starting from 2004Q1 to 2017Q3 at the quarterly frequency. The monthly loan-level data set contains about 10 million loan accounts during 2004M1-2017M9. We consider the impact of changes in the short-term interest rate and yield curve slope on overall bank profitability measured by ROA and ROE as well as their main components including net interest income, non-interest income and loan loss provisions. A bank fixed-effects model is used in the case of bank profitability, controlling for macroeconomic and financial conditions as well as bank-specific characteristics at different points in time.

To examine the effect of monetary policy on bank risk-taking, we carry out the empirical tests both at the bank and the loan level. Bank-level risk is measures by three alternative indicators, namely, bank Z-score, risk-weighted asset ratio, and non-performing loan ratio. For the loan-level analysis, loan risk is captured by the hazard rate of loan default under the survival analysis framework using a duration model. We also investigate the impact of changes in the interest rate on the probability of banks granting loans with lower quality using a probit model approach. Macroeconomic and financial conditions, the lending bank characteristics, and borrower characteristics are controlled for in all specifications.

We find that the level of interest rates and bank profitability as measured by ROA and ROE are positively correlated. That is, lower interest rates tend to reduce profitability. The effect works mainly through the impact of the interest rates on bank net interest income. Although loan loss provisions are also lower when the interest rates are low which should partly help increase profitability, this effect is not large enough to offset the decline in net interest income. In the meanwhile, non-interest income does not seem to be affected by changes in the interest rate. We find that small banks tend to be more sensitive to the policy rate than large and medium banks, suggesting that their profitability could be more adversely affected when interest rates are low, perhaps due to high cost structures as well as stronger competition in search for yield and for quality customers in a low rate environment.

Table 8: The impact of policy rate on loan quality in probit models

Dependent variable	(1) **Past borrower default** (0/1)		(2) **Loan ex-post default** (0/1)		(3) **Collateralized** (0/1)	
	Coefficients	Marginal effects	Coefficients	Marginal effects	Coefficients	Marginal effects
Monetary conditions						
Policy rate $_{\tau-1}$	**-0.027*** ** (-20.899)	-0.55%	**-0.042*** ** (-15.933)	-0.16%	**-0.138*** ** (-102.231)	-3.84%
Yield spread $_{\tau-1}$	**0.004** ** (2.413)	0.08%	**-0.056*** ** (-17.000)	-0.22%	**-0.104*** ** (-60.199)	-2.90%
Macroeconomic conditions						
GDP growth $_{\tau-1}$	**-0.007*** ** (-41.320)	-0.15%	**-0.018*** ** (-49.308)	-0.07%	**-0.013*** ** (-84.790)	-0.37%
CPI growth $_{\tau-1}$	**0.020*** ** (54.173)	0.41%	**0.022*** ** (31.729)	0.09%	**0.031*** ** (88.818)	0.86%
Credit-to-GDP gap $_{\tau-1}$	**0.001*** ** (9.836)	0.01%	**0.000*** ** (3.481)	0.00%	**0.013*** ** (238.992)	0.36%
HHI $_{\tau-1}$	**-17.335*** ** (-109.262)	-349.60%	**-24.775*** ** (-76.407)	-96.71%	**-13.230*** ** (-93.641)	-369.57%
Bank characteristics						
ln(Total assets) $_{\tau-1}$	**0.039*** ** (53.451)	0.78%	**0.047*** ** (30.351)	0.18%	**-0.473*** ** (-686.749)	-13.22%
Bank ROA $_{\tau-1}$	**-0.047*** ** (-86.724)	-0.96%	**-0.049*** ** (-58.810)	-0.19%	**-0.098*** ** (-183.661)	-2.75%
Liquidity ratio $_{\tau-1}$	**-0.005*** ** (-32.175)	-0.10%	**0.004*** ** (12.136)	0.02%	**0.010*** ** (72.573)	0.28%
Loans/Assets $_{\tau-1}$	**0.003*** ** (54.209)	0.07%	**0.008*** ** (51.762)	0.03%	**0.020*** ** (324.266)	0.55%
NPL/Loans $_{\tau-1}$	**0.020*** ** (107.482)	0.40%	**0.053*** ** (165.181)	0.21%	**0.023*** ** (130.683)	0.63%
Loan/borrower characteristics						
ln(Loan size) $_{\tau}$	**-0.003*** ** (-22.865)	-0.06%	**-0.001*** ** (-5.477)	-0.01%	**0.084*** ** (502.991)	2.34%
Bank relationship $_{\tau}$	**0.411*** ** (401.433)	8.29%	**-0.332*** ** (-130.705)	-1.30%	**-0.296*** ** (-271.471)	-8.27%
Constant	**-0.395*** ** (-17.977)		**-0.357*** ** (-7.967)		**5.454*** ** (270.207)	
Observations	9,978,690		9,978,690		8,248,799	
Pseudo-R	0.033		0.081		0.102	
log likelihood	-3681862.9		-784501.66		-4074432.7	

Note: Including capital ratio leads to the ML estimation of collateralized regression that does not converge; thus, it is omitted only in the probit models. The z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

As for bank risk taking, using the standard balance sheet measures of risk at the bank level, we do not detect an increase in bank risk when interest rates are low. However, when investigated at the loan level, we find that low interest rate is associated with higher loan hazard rates for long-term general loans. Loan portfolios of medium and small banks appear to be more responsive to the policy rate, in terms of changes in loan riskiness, than those of large banks. In addition, the hazard rates of small firms appear to be more contingent on the level of interest rate compared to those of large firms, suggesting that small firms may potentially be more affected by bank risk-taking behavior. We also find that when the interest rate remains low for a protracted period, this tends to further increase bank risk-taking in new loans, though it helps lower the default risk for existing loans.

Our analysis points to the potential unintended side effects of unusually accommodative monetary policy on bank profitability and bank risk-taking. Weakening bank profitability may have implications for the banking system vulnerability and also for impeded monetary policy transmission. In the case of Thailand, although there is no overwhelming evidence of increases in bank risk-taking—possible due to a conservative stance and rigorous risk management at the bank overall balance sheet, but at a more micro level there seems to emerge pockets of risk in some types of loans and borrowers, especially those belonging to small and low profitability banks. This is important not only for financial stability but also for the possible distributional consequences that monetary policy may have across banks and borrowers.

At the macro level, these potential adverse effects of monetary policy easing on the banking sector may, in turn, undermine the effectiveness of monetary policy in lifting economic activity, especially if the rates are kept at a low level for long. The potential interaction among macro conditions, monetary policy decisions, and bank health and risk-taking implied by our analysis lend support to the notion that policy makers may need to integrate prudential regulation into the macroeconomic policy framework to provide an effective set of tools to deal simultaneously with the objectives of price stability and financial stability. The finding on the differential responses to and the distributional effects of policies also point to the need for more targeted policy tools in dealing with various forms of heterogeneity across different types of players.

References

Adrian, T., & Shin, H. S. (2008). Financial intermediaries, financial stability, and monetary policy. Federal Reserve Bank of New York Staff Reports No 346.

Adrian, T., & Shin, H. S. (2009). Money, Liquidity, and Monetary Policy. *American Economic Review*, *99*(2), 600-605.

Adrian, T., & Shin, H. S. (2010). Financial intermediaries and monetary economics. In *Handbook of Monetary Economics* (Vol. 3, pp. 601-650). Elsevier.

Alessandri, P., & Nelson, B. D. (2015). Simple banking: profitability and the yield curve. *Journal of Money, Credit and Banking*, 47(1), 143-175.

Altavilla, C., Boucinha, M., & Peydró, J.-L. (2017). Monetary policy and bank profitability in a low interest rate environment. *European Central Bank Working Paper*.

Altunbas, Y., Gambacorta, L., & Marques-Ibanez, D. (2010). Does monetary policy affect bank risk-taking? *BIS Working Papers* No 298.

Borio, C., & Zhu, H. (2012). Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?. *Journal of Financial Stability*, *8*(4), 236-251.

Borio, C., Gambacorta, L., & Hofmann, B. (2017). The influence of monetary policy on bank profitability. *International Finance*, 20, 48–63.

Brunnermeier, M. (2001). *Asset Pricing under Asymmetric Information: Bubbles, Crashes, Technical Analysis, and Herding*. Oxford University Press.

Claessens, S., Coleman, N., & Donnelly, M. (2017). "Low-For-Long" Interest Rates and Banks' Interest Margins and Profitability: Cross-Country Evidence. *International Finance Discussion Papers*. Board of Governors of the Federal Reserve System.

De Nicolò, G., Dell'Ariccia, G., Laeven, L., & Valencia, F. (2010). Monetary Policy and Bank Risk Taking. *IMF Staff Position Note*.

Delis, M. D., & Kouretas, G. P. (2011). Interest rates and bank risk-taking. *Journal of Banking & Finance*, 35, 840–855.

Dell'Ariccia, G., Laeven, L., & Suarez, G. A. (2017). Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States. *The Journal of Finance,* 72(2), 613-654.

Huey, T. T., & Li, D. C. S. (2016). Measuring Bank Risk-Taking Behaviour: The Risk-taking Channel of Monetary Policy in Malaysia. *IFC Working Papers*, No 16.

Ioannidou, V., Ongena, S., & Peydró, J. L. (2015). Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment. *Review of Finance*, 19, 95–144.

Jiménez, G., Ongena, S., Peydró, J. L., & Saurina, J. (2007). Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk?

Jiménez, G., Ongena, S., Peydró, J. L., & Saurina, J. (2012). Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications. *American Economic Review*, 102(5), 2301–2326.

Jiménez, G., Ongena, S., Peydró, J. L., & Saurina, J. (2014). Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking? *Econometrica*, 82(2), 463–505.

Rajan, R. G. (2005). Has Financial Development Made the World Riskier? *National Bureau of Economic Research Working Paper Series*, No 11728.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal*, 9(1), 86-136.

Appendix

Table A1: Descriptive Statistics

Variables	Definition	Units	Source	Mean	SD	Min	Median	Max
Dependent variables								
ROA	Return on assets of bank	%	DMS	0.91	1.41	-11.62	0.95	13.68
ROE	Return on equity	%	DMS	6.15	10.83	-138.46	5.72	39.29
NII/TA	Ratio of net interest income over total assets	%	DMS	0.59	0.32	-0.40	0.58	2.73
NNI/TA	Ratio of non-interest income over total assets	%	DMS	0.32	0.41	-2.00	0.26	5.23
LLP/TA	Ratio of loan loss provision over total assets	%	DMS	2.11	1.82	0.00	1.78	13.43
Z-score	Eight-quarter averaged ROA plus capital-to-asset ratio, divided by the standard deviation of ROA over eight quarters	-	Authors' calculation	55.28	51.81	-0.06	39.06	432.75
RWA/Assets	Ratio of risk-weighted assets over total assets	%	DMS	68.76	19.72	0	70.44	167.89
NPL/Loans	Ratio of non-performing loans over total loans	%	DMS	4.91	6.24	0	2.98	90.65
Time to loan default or repayment	Number of months from loan origination to default or repayment of the loan	Months	Authors' calculation	2.57	7.04	0	1	164
Past borrower default	Equals 1 if the borrower had defaulted on any loan ever before the loan origination, and 0 otherwise	0/1	LAR	0.13	0.33	0	0	1
Loan ex-post default	Equals 1 if the granted loan defaults, and 0 otherwise	0/1	LAR	0.02	0.13	0	0	1
Collateralized	Equals 1 if the granted loan is collateralized, and 0 otherwise	0/1	LAR	0.24	0.43	0	0	1
Monetary conditions								
Policy rate	Monetary policy rate	%	BOT	2.48	1.08	1.25	2.25	5.00
Yield spread	A difference between two-year and ten-year government bond rates	%	BOT	1.10	0.72	0.16	1.01	3.07
ln(Quarter rate not increase)	The log of the number of consecutive quarters in which the policy rate does not increase	-	Authors' calculation	1.54	1.11	0	1.79	3.18
Rate below median	Equals 1 when the policy rate is below sample median, and 0 otherwise	0/1	Authors' calculation	0.48	0.50	0	0	1
Negative Taylor residual	Equals 1 when the residuals from Taylor rule are negative, and 0 otherwise	0/1	Authors' calculation	0.46	0.50	0	0	1
Macroeconomic conditions								
GDP growth	Annual growth of the gross domestic product	%	BOT	3.66	3.30	-4.59	3.51	15.30
CPI growth	Annual change of the consumer price index	%	BOT	2.41	2.19	-2.82	2.59	7.55

Variables	Definition	Units	Source	Mean	SD	Min	Median	Max
Credit-to-GDP gap	The difference between the credit-to-GDP ratio and its long-run trend	-	BIS	-8.24	19.67	-41.00	-8.70	16.30
HHI	Herfindahl Hirschman Index (HHI) computed as the sum of squared bank shares of outstanding loans	-	Authors' calculation	1107	52	1008	1113	1211
Crisis dummy	Equals 1 during 2008-2009 global financial crisis, and 0 otherwise	0/1		0.15	0.36	0	0	1
Expected GDP growth	Expected GDP growth	%	BOT	3.68	3.32	-4.28	3.49	15.47
Expected inflation	Expected CPI growth	%	BOT	1.08	16.19	-35.14	0	66.67
Bank characteristics								
ln(Total assets)	The log of total assets	-	DMS	11.64	1.75	7.71	11.85	14.89
Capital ratio	Ratio of capital over total assets	%	DMS	15.40	11.79	0	12.15	98.38
Liquidity ratio	Ratio of liquid assets (cash and short-term investment) over total assets	%	DMS	12.13	12.68	0.00	7.43	99.10
Funding composition	Ratio of deposits over total liabilities	%	DMS	63.69	24.67	0	69.12	99.25
Loans/Assets	Ratio of bank loans over total assets	%	DMS	52.84	25.00	0	63.16	95.82
Efficiency	Ratio of operating cost to net revenues	%	DMS	62.23	60.36	14.39	48.01	484.28
Medium banks	Equals 1 when the bank is medium-sized, and 0 otherwise	0/1				0		1
Small banks	Equals 1 when the bank is small-sized, and 0 otherwise	0/1				0		1
Loan characteristics								
ln(Loan size)	The log of one plus loan amount at origination	-	LAR	13.59	3.76	0	14.41	26.51
Borrower characteristics								
Bank relationship	The log of one plus the number of banks the borrower is currently borrowing from	-	LAR	1.12	0.48	0.69	1.10	3.47
Industry	Grouping of industry of the borrower based on ISIC code	0/1	LAR					
Firm characteristics								
Firm size	Equals 1 if the firm is large and 0 otherwise based on the size of total revenues. The cut-off is arbitrarily chosen at 25th percentile of largest firms.	0/1	CPFS	0.69	0.46	0	1	1
ln(Firm age)	The log of one plus the age of the firm	-	CPFS	2.68	0.74	0	2.83	4.57
Firm ROA	The return on assets of firm	%	CPFS	0.03	0.10	-3.37	0.02	0.59

Table A2: The impact of policy rate on loan risk by industry

	(1)	(2)	(3)	(4)
	All loans		**Long-term loans**	
Monetary conditions				
Policy rate $_{\tau-1}$	-0.003	-0.070***	-0.313***	-0.390***
	(-0.326)	(-5.196)	(-15.344)	(-16.543)
Policy rate $_{\tau+T}$	0.276***	0.270***	0.835***	0.838***
	(44.877)	(42.915)	(59.167)	(59.290)
Yield spread $_{\tau-1}$	0.063***	0.063***	-0.519***	-0.514***
	(4.629)	(4.637)	(-18.310)	(-18.082)
Macroeconomic conditions				
GDP growth $_{\tau-1}$	-0.006***	-0.006***	-0.012***	-0.012***
	(-4.394)	(-4.251)	(-4.818)	(-4.696)
GDP growth $_{\tau+T}$	-0.005***	-0.006***	-0.047***	-0.046***
	(-3.342)	(-3.746)	(-13.114)	(-13.045)
HHI $_{\tau-1}$	-14.407***	-13.992***	-6.254***	-2.873
	(-11.993)	(-11.606)	(-2.670)	(-1.211)
Bank characteristics				
ln(Total assets) $_{\tau-1}$	0.086***	0.083***	0.336***	0.333***
	(14.477)	(13.966)	(27.968)	(27.611)
ROA $_{\tau-1}$	-0.094***	-0.094***	-0.139***	-0.146***
	(-17.730)	(-17.784)	(-11.120)	(-11.736)
Capital ratio $_{\tau-1}$	0.002	0.002	-0.096***	-0.096***
	(0.785)	(0.977)	(-15.045)	(-14.973)
Liquidity ratio $_{\tau-1}$	-0.031***	-0.031***	-0.013***	-0.012***
	(-19.879)	(-19.521)	(-3.952)	(-3.800)
NPL/Loans $_{\tau-1}$	0.041***	0.042***	-0.008***	-0.010***
	(33.439)	(33.900)	(-2.862)	(-3.208)
Loans/Assets $_{\tau-1}$	-0.002***	-0.002***	0.013***	0.013***
	(-3.202)	(-2.632)	(7.922)	(7.818)
Loan characteristics				
Past default (0/1)	1.165***	1.164***	0.688***	0.692***
	(117.741)	(117.656)	(33.881)	(34.060)
Collateralized (0/1)	-0.335***	-0.335***	-0.353***	-0.356***
	(-30.085)	(-30.126)	(-17.200)	(-17.361)
ln(Loan size) $_{\tau}$	0.053***	0.053***	-0.044***	-0.044***
	(45.600)	(45.365)	(-23.208)	(-23.035)
Bank relationship $_{\tau}$	-1.013***	-1.009***	-0.300***	-0.298***
	(-78.035)	(-77.656)	(-9.289)	(-9.235)
Industry dummy variables				
Agriculture (0/1)	0.026	-0.126	-0.788***	-1.336***
	(0.485)	(-0.823)	(-7.233)	(-3.409)
Communication (0/1)	-0.066	-1.648***	-0.245	-0.643
	(-0.822)	(-6.866)	(-1.313)	(-1.198)
Construction (0/1)	0.961***	0.763***	0.054	-0.484***
	(44.135)	(13.113)	(0.956)	(-2.827)
Education (0/1)	-0.328**	-0.392	-0.246	-0.255
	(-2.117)	(-0.941)	(-1.297)	(-0.470)
Finance (0/1)	-2.542***	-3.193***	-3.034***	-5.240***
	(-21.754)	(-9.871)	(-12.470)	(-6.333)
Government (0/1)	-1.407***	-0.472	-46.573	-45.088
	(-9.292)	(-1.106)	(.)	(.)
Health (0/1)	-0.974***	-1.104***	-1.051***	-2.121***
	(-6.797)	(-2.868)	(-5.131)	(-3.327)
Heavy industry (0/1)	0.107***	0.154***	-0.145***	-0.700***
	(6.578)	(3.658)	(-4.595)	(-7.713)
Holding company (0/1)	-1.035***	-1.606***	-0.792**	-2.784***
	(-4.846)	(-2.811)	(-2.501)	(-2.817)

Table A2 cont.

	(1)	(2)	(3)	(4)
	All loans		**Long-term loans**	
Light industry (0/1)	0.134***	-0.257***	0.089***	-0.199**
	(8.502)	(-6.473)	(2.763)	(-2.199)
Mining (0/1)	-0.542***	-0.754**	-0.136	-0.542
	(-4.286)	(-2.186)	(-0.835)	(-1.078)
Real estate (0/1)	-0.311***	-0.740***	-0.408***	-1.118***
	(-10.169)	(-9.048)	(-9.601)	(-9.211)
Self-employed (0/1)	-0.319***	-0.702***	-1.363***	-2.049***
	(-8.813)	(-6.999)	(-20.362)	(-10.110)
Service (0/1)	-0.409***	-0.567***	-0.278***	-0.820***
	(-11.662)	(-5.985)	(-5.980)	(-6.119)
Trading (0/1)	0.051***	-0.220***	-0.221***	-0.536***
	(3.418)	(-5.648)	(-7.712)	(-6.364)
Transportation (0/1)	0.390***	0.246***	0.578***	0.775***
	(15.028)	(3.335)	(17.291)	(8.100)
Utilities (0/1)	-0.552***	0.061	-0.750***	-0.241
	(-6.026)	(0.222)	(-5.793)	(-0.556)
Industry interaction terms				
Policy rate $_{\tau-1}$ x Agriculture (0/1)		0.056		0.195
		(1.106)		(1.517)
Policy rate $_{\tau-1}$ x Communication (0/1)		0.533***		0.150
		(7.766)		(0.809)
Policy rate $_{\tau-1}$ x Construction (0/1)		0.073***		0.202***
		(3.711)		(3.414)
Policy rate $_{\tau-1}$ x Education (0/1)		0.026		0.014
		(0.186)		(0.082)
Policy rate $_{\tau-1}$ x Finance (0/1)		0.229**		0.708***
		(2.283)		(3.180)
Policy rate $_{\tau-1}$ x Government (0/1)		-0.556**		-1.674
		(-2.295)		(.)
Policy rate $_{\tau-1}$ x Health (0/1)		0.048		0.365*
		(0.367)		(1.926)
Policy rate $_{\tau-1}$ x Heavy industry (0/1)		-0.016		0.203***
		(-1.085)		(6.690)
Policy rate $_{\tau-1}$ x Holding company (0/1)		0.202		0.672**
		(1.143)		(2.440)
Policy rate $_{\tau-1}$ x Light industry (0/1)		0.140***		0.109***
		(10.629)		(3.507)
Policy rate $_{\tau-1}$ x Mining (0/1)		0.079		0.154
		(0.664)		(0.871)
Policy rate $_{\tau-1}$ x Real estate (0/1)		0.156***		0.258***
		(5.793)		(6.498)
Policy rate $_{\tau-1}$ x Self-employed (0/1)		0.142***		0.258***
		(4.103)		(3.688)
Policy rate $_{\tau-1}$ x Service (0/1)		0.059*		0.194***
		(1.939)		(4.540)
Policy rate $_{\tau-1}$ x Trading (0/1)		0.100***		0.119***
		(7.497)		(4.014)
Policy rate $_{\tau-1}$ x Transportation (0/1)		0.051*		-0.082**
		(1.901)		(-2.293)
Policy rate $_{\tau-1}$ x Utilities (0/1)		-0.264**		-0.210
		(-2.341)		(-1.226)
Observations	5,040,315	5,040,315	178,273	178,273
Pseudo-R	0.0286	0.0292	0.0302	0.0307
log likelihood	-628168	-627781	-142055	-141986

Note: z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1