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Abstract

This study empirically investigates the relationship between Chinese banks' green lending and their credit risk, and how China's green finance regulations contribute to the solvency of individual banks and the resilience of the financial system as a whole. Using a sample of 41 Chinese banks for the period 2007-2018, we find that the association between a bank's (relative) green lending as a proportion of its overall loan portfolio and its credit risk depends critically on the size and structure of state ownership. While the implementation of China's Green Credit Policy reduces credit risk for the major state-controlled banks, it increases credit risk for city and regional commercial banks. This performance difference is largely due to information and expertise asymmetries, with city and regional commercial banks having less access to information and expertise necessary to evaluate the credit risk of green lending. Understanding this phenomenon can help policymakers tailor green finance policies according to banks' characteristics. It also suggests that mechanisms and platforms for city/regional commercial banks to learn from major state-controlled banks could be beneficial.

Keywords: Green loan, Credit risk, China green credit policy

Executive Summary

This paper investigates the relationship between banks' green lending and their credit risk, and examines how Chinese green finance regulations contribute to the solvency of individual banks. The study uses data covering the period 2007-2018 for a sample of 41 Chinese banks, including state-controlled banks and city/regional commercial banks. The study measures green lending by the proportion of green loans in a given bank's total loan book; bank-level credit risk is evaluated on a similar metric, the proportion of impaired loans.

Chinese green finance policies, notably the Green Credit Policy launched in 2007, have served as an important starting motivation for this research. In this first empirical study to examine the impact of green credit policies across both important categories of banks in China—that is, the major state-controlled banks and the city/regional commercial banks—one of the most important findings is that the credit risk performance of the two types of bank varies greatly.

Key findings:

- The association between bank green lending and risk performance varies greatly by bank ownership structure and size.
- While an increase in the proportion of green lending *reduces* credit risk for state-owned major banks, it actually *increases* credit risks for smaller city/regional commercial banks.
- State-controlled banks outperform city/regional commercial banks in implementing the Green Credit Policy.

Results: We find that, in general, the lagged one-year effect of green lending on credit risk is insignificant during the sample period for all sample banks. Drawing on the theory of relationship banking, we then further investigate whether the impact of China's Green Credit Policy interacts with bank size and ownership structure. We classify the banks into two groups by the type of ownership structure: 1) state-controlled major banks and 2) city/regional commercial banks.

The results for the two groups vary greatly. The finding for major banks shows that a 1% increase in the proportion of green loans reduces bank credit risk by 1.1% at a 5% significance

level, indicating that green lending has a significant negative association with credit risk for these banks. Meanwhile, the city/regional banks generate a completely opposite result: for these banks, an increase in (relative) green lending in the year $t-1$ increases credit risk in the year t by 4.1% at a 1% significance level. The opposite result strongly suggests that city/regional level small banks do not have sufficient capacity to manage risks for green loans. Meanwhile, the state-controlled banks are better at implementing the Green Credit Policies, managing to do so while reducing credit risk. The outperformance of the state-controlled banks is attributable, in particular, to the introduction of mandatory disclosure of green lending in 2013.

Contributions: By tackling the question of how Chinese banks' credit risk relates to increases in green lending, we shed light on the differential implementation of the Green Credit Policy, with clear implications for policymakers (*see below*). In addition, this study contributes to understanding financial stability of the lending institutions and of the Chinese banking sector as a whole by addressing the question of whether sustainability integration in the form of green lending mitigates environmental risk exposures.

Policy Implications: Our results clearly show that the Green Credit Policy's effect on credit risk is not consistent across banks, and that, for two different key types of banks in China, the same Green Credit Policy actually has an opposite effect. This finding provides a compelling case for policymakers to tailor green finance policies according to banks' characteristics. Factors including ownership, size and capacity of the lending institution, expertise and knowledge in the newly emerged green finance sector, and regional differences have to be taken into account by policymakers in order to ensure continued financial stability for the lending institutions and for the banking sector as a whole. Guidelines and training on best practices could be implemented to help laggard banks to apply green credit policies appropriately.

Given the Chinese institutional context, where the ownership of regional banks by city and regional governments may also make them less integrated into central policymaking than the (central government-owned) major banks, it is important to set up mechanisms and networks for the large state-controlled banks to communicate and exchange information and expertise with the city/regional commercial banks. This could include sharing on industry expertise or environmental risk management, but could also extend to collaboration around innovative

banking activities, building (shared) green credit data analysis platforms, or setting up specialized green credit institutions. Even though the major banks are the ones that have been selected by policymakers to have a leading role in China's push to achieve a sustainable economy, this does not mean the smaller regional banks need to be left at a disadvantage.

1. Introduction

Banks' role in mobilizing financial resources and allocating them to productive investments makes them important contributors to economic growth and development. As such, bank lending to, and investment in, green assets is viewed as a crucial part of efforts to mitigate climate change by transitioning to a net-zero carbon economy. China's Green Credit Policy, implemented as early as 2007, established China as one of the pioneers in sustainable finance by attempting to strengthen banks' management of environmental exposures in areas such as pollution, energy consumption and climate change in their lending processes. This paper addresses the current lack of empirical studies examining China's Green Credit Policy with regard to its contribution to the solvency of individual banks and the resilience of the financial system as a whole.

Specifically, our analysis centres on credit risk and ownership structure at the bank level in China, and the interaction of Chinese green finance regulations with these bank level characteristics. We explore the potential linkages between the sustainability of a bank's lending practices and its financial performance, honing in on whether a bank's green lending affects its credit risk. Much of our focus is on whether the implementation of the Green Credit Policy depends on a given bank's ownership structure and size in the context of China's distinctive banking system and institutional setting.

Chinese green finance policies have served as an important starting motivation for this research. Among the most influential of these, and of most direct relevance to bank lending, is the so-called Green Credit Policy, introduced in 2007. This policy*, a joint effort by China's central bank, main financial regulator, and environmental protection agency, directs banks to incorporate environmental due diligence into lending.

In order to support and implement national green policies, the China Banking Association, the official umbrella group for the country's lenders, introduced the "*Guidelines on Corporate Social Responsibility for the Chinese Banking Sector*" in 2009. These encourage financial institutions to disclose green finance practices in their corporate social responsibility (CSR)

* Formally known as "the Opinion on Implementing Environmental Regulations and Managing Credit Risks". Jointly published by the State Environmental Protection Administration (SEPA), the People's Bank of China (PBOC), and the China Banking Regulatory Commission (CBRC).

reports. Since then, green finance disclosure and reporting have evolved from voluntary to mandatory in the wake of the “*Notice of the General Office of CBRC on the Submission of Green Credit Statistics Form and the Notice on the Submission of Green Credit Statistics Form*,” launched in 2013. Under the Notice, the 21 major banks of China, including three policy banks, five state-owned commercial banks, twelve joint-stock commercial banks and one postal savings bank are required to submit data on their green lending using green credit statistics forms (GCSF) to the China Banking Regulatory Commission (CBRC).

Despite the fact that green credit has become institutionalised in the Chinese legal system, and despite evidence from prior research (Harper Ho 2018) that the Green Credit Policy has indeed contributed to allocating funds to the green economic activities, the overall economic effects of green lending remain far from certain. What is the credit risk at the bank level associated with the increasing proportion of green lending? How do China’s green finance regulations affect financial stability for the lending institutions and for the financial sector as a whole? How does state ownership interact with green regulations in shaping a given bank’s risk performance? It is well established that credit risk at the level of individual banks affects financial and economic stability at a macroeconomic scale (Keeley 1990). The Chinese economy is reliant on bank lending, which represents the main source of financing, whereas capital markets play a limited role. And bank balance sheets are ballooning: according to the Institute for International Finance, China’s gross debt surged from 171 to 299 per cent of GDP from 2008 to 2018, with this rapid credit growth raising concerns about financial stability. In light of these vulnerabilities, and the significance of China to the global economy, it is particularly important to address the research gap and better understand these issues in China. Our research not only provides empirical evidence addressing these questions, but also looks at the implications for supervisors and policymakers.

Using a sample of 41 Chinese banks from 2007 to 2018, we examine how Chinese banks’ green lending actually affects credit risk, as measured by the rate of impaired loans, in the wake of the introduction of the Green Credit Policy in 2007. We use ordinary least-squares (OLS) regressions with robust standard errors clustered at the bank level and include year dummies to account for unknown factors in the market in a given year. We find that, in general, the lagged one-year effect of the green loan rate on credit risk is insignificant during the sample period for all sample banks. Drawing on the theory of relationship banking, we then further

investigate whether the impact of China's Green Credit Policy interacts with bank size and ownership structure. We classify the banks into two groups by the type of ownership structure: 1) state-controlled major banks and 2) city/regional commercial banks. The results for the two groups vary greatly. The finding for the former show that the proportion of green loans has a significant negative association with credit risk, indicating that the implementation of China's Green Credit Policy reduces credit risk for the state-controlled major banks. Meanwhile, the latter group generates a totally opposite result: the increase in the proportion of green loans in the year $t-1$ leads to higher credit risk in the year t , suggesting that the Green Credit Policy poses higher credit risk to the city/regional commercial banks. The state-controlled banks outperform the city/regional commercial banks in implementing the Green Credit Policies. And this outperformance is particularly attributed to the introduction of mandatory disclosure of green lending in 2013.

By tackling the question of how bank credit risk relates to increases in green lending, we aim to shed light on the implementation of the Green Credit Policy. The finding that the effect of green lending on credit risk for a given bank varies greatly depending on the state ownership structure and size could help policymakers to tailor green finance policies according to banks' characteristics. It also suggests that mechanisms and platforms for city/regional commercial banks to learn from state-controlled banks on risk management in green lending could be beneficial. In addition, this study contributes to understanding financial stability of the lending institutions and of the Chinese banking sector as a whole by addressing the question of whether sustainability integration in the form of green lending mitigates environmental risk exposures.

The remainder of the paper is organized as follows: Section 2 provides a review of the related literature. Section 3 presents a brief overview of the banking industry in China, and describes our sample, data, and empirical models. Section 4 reports the empirical results, followed with discussion in Section 5.

2. Literature review and hypothesis development

The purpose of this paper is to empirically examine how a Chinese bank's green lending affects its credit risk and whether this effect depends on the bank's ownership structure and size, following the introduction of the Green Credit Policy in 2007. We know that banks are as

vulnerable as other companies to environmental risks (Thompson and Cowton 2004), and that their performance is based on the financial health of their borrowers—in this case, the profitability of companies, as we focus on corporate loans. In light of this, we formulate our empirical hypotheses by first reviewing existing studies on the relationship between corporate environmental performance and financial performance.

According to the legitimacy theory, organisations need to consider the institutional environment in which they operate and the environmental pressures they face, and adjust their policies and performance accordingly. This serves not only for them to be perceived as legitimate to operate within social bounds and norms, but also to gain access to operational resources (Dowling and Pfeffer, 1975; de Villiers and Van Staden 2006). An overview of empirical research on firm environmental performance indicates a generally positive relationship between corporate environmental performance and corporate financial performance (Orlitzky and Benjamin 2001; Dixon-Fowler et al. 2013; Ambec and Lanoie 2008), as surviving firms with better environmental performance tend to have higher innovation and operational efficiency as well as strong organisational and management capabilities. Improved innovation, efficiency and organisational management may lead to competitive advantage and increase shareholder value. Nonetheless, there are some theoretical and empirical studies that instead support a negative relationship (Friedman 1970; White 1996; Climent and Soriano 2011) or suggest no significant relationship between the variables (Schaltegger and Figge 2000), as it is costly to improve environmental performance and these costs may exceed the financial gain derived from environmental activities. Recent studies find a U-shaped relationship between carbon emission performance and financial performance (Trumpp and Guenther 2015; Riillo 2017). More precisely, a higher level of environmental performance is associated with better financial performance, whereas a lower level of environmental performance is related with poor financial performance. Among green firms, better environmental performance tends to be associated with higher financial performance once a critical level of environmental performance is achieved. Bansal and Clelland (2004) find that firms with legitimate environmental policies and practices incur less idiosyncratic risk than firms without such policies. More recently, Jo, Kim, and Park (2014) find that good environmental, social and governance (ESG) corporate practices decrease the volatility of negative returns, as ESG efforts decrease the probability of negative events occurring (Krüger, 2015).

Fewer studies, however, focus on corporate social and environmental performance in China specifically. Drawing on institutional theory and a relational governance perspective, Xun (2013) shows that government-aimed corporate social performance (CSR) is positively related to firms' financial performance in China and argues that CSR is often used as a legitimisation tool and a discretionary means for engaging in the political process to interact with key legitimacy actors, i.e. the Chinese government, as a way to enhance firm performance. Mengze and Wei (2015) conduct a comparative analysis of environmental credit risk management among banks in the Asia-Pacific region and find that integration of standardized environmental risk assessment procedures into the credit rating process moderately reduces environmental risks of banks in China. Weber (2017) investigates the link between the sustainability performance of Chinese banks and their financial performance and finds a bi-directional causality between them.

Therefore, we could argue that a bank's financial risk is likely to be reduced by greater exposure to firms with higher environmental standards, controlling for the probability of expected financial misconduct. Given all of the above discussion, we posit:

H1. Bank green lending is negatively associated with its credit risk performance.

We also draw on the theory of relationship banking under asymmetric information: informed lenders can extract rents from lending to borrowers that are "informationally captured" because other lenders have insufficient information about them (Sharpe 1990; von Thadden 2004; Hauswald and Marquez 2006). In addition, Stomper (2006) uses a theoretical approach to analyse the relationship between industry expertise and bank credit risk and suggests that banks benefit from industry expertise when lending to borrowers in young industries with uncertain business conditions. Empirical evidence in China also suggests that, in the long and dynamic process, the success ratio of loans by commercial banks is based on the investment experience in the previous period (Li, Sui, and Lu 2012) and lenders gain from industry knowledge in their banking decisions (Kroszner and Strahan 2001).

After the introduction of China's Green Credit Policy in 2007, the state-controlled larger banks have developed internal systems and bank level guidelines including a database, measures and procedures to promote the development of green finance business (Bai, Faure, and Liu 2013). For example, in order to strengthen the management of environmental risk, the

Industrial and Commercial Bank of China (ICBC) established a database of clients' environmental risks in 2008, and determined the required actions and focal points in each step of green credit from due diligence, loan approval to fund distribution and post-loan management.[†] It has also developed the ICBC ESG Green Index (2017) and issued the management measures for classification of green credit to identify environmental impacts of its borrowers. In contrast to the state-controlled major banks that have established thorough internal green loan policies, guidelines, procedures, and due diligence requirements in the loan process, smaller commercial banks in cities and regions often lack comprehensive systems for environmental risk management or for transparency in green credit disclosure (Bai, Faure, and Liu 2013). Moreover, we also notice that training on environmental risk assessment for bank staff involved in is not adequate[‡]. The above literature discussed leads to our second hypothesis:

H2.1 For state-controlled major banks, bank green lending is negatively related to credit risk

H2.2 For smaller city/regional banks, bank green lending is positively related to credit risk

H2.3 The state-controlled major banks outperform the city/regional banks bank green

3. Data and Methodology

Green investments often have a long time to maturity, high capital intensity and relate to new goods for which a market might not yet exist (Elton, Edwin and Gruber 1982; Criscuolo and Menon 2015). These characteristics also mean it should be easier to investigate the long-term relation between banks' green investments—focusing on green lending, in our analysis—and bank level financial performance. We run OLS regressions to estimate whether banks with a higher level of green loans are less risky than those with lower level of green loans. Year dummies are included to account for shocks in the market in a given year. The standard errors are clustered at the bank level.

[†] Industrial & Commercial Bank OF China, 2018 Corporate Social Responsibility Report 47-50. <http://v.icbc.com.cn/userfiles/Resources/ICBCLTD/download/2019/2018csrCN.pdf>

[‡] During the process of manual data collection, we hardly find bank level green lending guidance or management information in the annual reports and CSR reports for the city/regional commercial banks.

3.1. *Sample selection*

The Chinese banking system is composed of four basic bodies: the central bank, the supervisory authority, policy banks and commercial banks. The Chinese government is the sole owner of the policy banks and has controlling stakes in the state-owned commercial banks and national joint-stock commercial banks. In addition, the Chinese banking sector also includes more than one hundred city commercial banks and thousands of small credit cooperatives and rural financial institutions. While the major commercial banks account for more than half of total assets in the Chinese banking sector, city and regional commercial banks do hold nearly a third— 31.2% of total assets, to be precise[§].

After the introduction of China's Green Credit Policy in 2007, the major commercial banks started to voluntarily disclose green finance in their annual reports and CSR reports. City/regional commercial banks have reported their green finance information since 2009 under the "*Guidelines on Corporate Social Responsibility for the Chinese Banking Sector*". In 2013, the China Banking Regulatory Commission (CBRC), the country's bank supervisor, launched the "*Notice of the General Office of CBRC on the Submission of Green Credit Statistics Form*" and the "*Notice on the Submission of Green Credit Statistics Form*". These two documents form the Green Credit Statistics System (GCSS). Accordingly, banking institutions are required to categorize their green credit portfolios into two categories: (i) lending to the production and manufacturing of three "strategic emerging sectors" and (ii) lending to projects and services that save energy and contribute to environmental protection. The size of Chinese banks' green credit portfolios has grown steadily. The most prominent sectors for green lending have been green transportation, renewable and clean energy, industrial energy efficiency, water conservation and environmental protection projects, both in terms of volume of loans and in terms of growth of lending. In addition, the 21 major banks in China, including all 3 policy banks, 5 state-owned commercial banks, and 12 national joint-stock commercial banks, as well as the Postal Savings Bank of China, are required to report green credit statistics every six months.

We manually collect green loan information from individual banks' annual reports and ESG reports from a total of 41 Chinese banks for the period 2007-2018. We classify our sample into

[§] Financial Times, November 8, 2019, "China's small lenders suffer bank runs as economy slows"

two groups depends on ownership structure: 1) state-controlled major banks and 2) city/regional commercial banks. The former group includes policy banks, state-owned commercial banks, national joint-stock commercial banks and the postal saving bank, all of which are either solely owned or largely controlled by the central government. The latter group consists of city or rural commercial banks, scattered throughout the country and owned by local governments and urban firms. Table 1 reports the number of banks by type. Our sample includes 18 city commercial banks, 11 joint-stock commercial banks, 5 state-owned commercial banks, 3 rural commercial banks, 3 policy banks, and 1 postal saving bank. Our panel data is unbalanced as many city commercial banks and rural commercial banks are not required to fill and submit the green credit statistics forms (GCSF) to the CBRC. Appendix 1 reports bank names in our sample list.

3.2. Variable measurements

Variable of interest

Our variable of interest in this study is the proportion of green lending at the bank level. Specifically, we measure it as the ratio of the amount of green loans on a bank's balance sheet to the amount of total loans at that bank, for a given bank i at a given time t .

$$GreenLoan_{i,t} = \frac{Green\ loan_{i,t}}{Total\ loan_{i,t}}$$

Figure 1 shows the trend for banks' green lending, for the state-owned major banks group and city/regional commercial banks group, from 2007 to 2018. In general, the proportion of green lending in the two types of banks has increased in parallel during the sample period. For the major banks, green lending grown from 5% of total lending in 2007 to almost 10% in 2018, with two sharp rises occurring around 2008 and 2014, a year after two major green credit regulations were issued. For city/regional banks, which are not required to submit green loan information but nonetheless started, in some cases, to report green credit information from 2009, the upward trend in the proportion of green lending does not exhibit any apparent policy effect. Figure 2 illustrates developments in green lending by the different specific types of banks. This figure suggests that the policy banks' green lending is most heavily affected by regulations and policies. Joint-stock commercial bank and state-owned commercial bank green loans have grown smoothly and steadily, without any sharp movements. It is also worth

noting that rural commercial banks only started to disclose green loan information around 2016, so there is little data available about that category of banks.

Dependent variable

The dependent variable is bank level credit risk, which is the risk of an economic loss from the failure of borrowers to fulfil their contractual obligations (Jorion 2003). In accordance with Ahmad and Ariff (2007), credit risk is measured by the ratio of the amount of impaired loan to the total gross amount of loans, for a given bank i at a given time t . The impaired loan is considered to be one of the best measures of problem loans. because there is objective evidence of impairment (i.e. a loss event) and that loss event affects the estimated future cash flows.

$$CreditRisk_{i,t} = \frac{Impaired\ loan_{i,t}}{Grossloan_{i,t}}$$

Control variables

Following the previous literature, we control for several bank characteristics that can be expected to affect a bank's credit risk. Control variables include size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The definitions of each variable for hypothesis testing are shown in Table 2.

First, the log of total assets is used to measure bank size. Fisher, Gueyie and Ortiz (2002) and Hassan et al. (1994) find that bank size is significantly, negatively related to the credit risk of U.S. banks. Fisher, Gueyie and Ortiz (2002) also suggest that leverage is significantly and positively related to bank credit risk in Canada and Mexico. We define leverage as the ratio of total liabilities to total assets. Total deposits are considered to be a stable source of funding (Ivashina and Scharfstein 2010). Bank lending relies more on core deposits, which need to be controlled in analysing loan performance. We control for loan deposit rate which is the rate of total loans to total deposits. Cummins and Sommer (1995) and Galloway et al. (1997) find a negative relationship between the capital asset ratio of a bank and its credit risk. Regulatory capital is the ratio of Tier 1 capital to total loans. Efficiency is measured as the ratio of earning assets to total assets. Loan loss provision is calculated as loan-loss provisions divided by total loans. Funding cost is the sum of interest expense and non-interest expense divided by total

assets. The loan-deposit rate is defined as total loans divided by time deposits. Spread is measured as the difference between two ratios: that of total interest income to total earning assets, and that of total interest expense to total interest-bearing liabilities.

We use non-interest income rate to characterise the operating performance of the banks. *Non-interest income rate* indicates bank income diversity. It is the ratio of non-interest income to total income, and it is controlled to capture non-interest performance (Laeven and Levine 2009). Many have argued that bank governance is significantly associated with performance, as it captures unobserved bank characteristics. Laeven & Levine (2009) find that banks with higher controlling shareholder ownership are riskier. We use bank ownership structure, *ownership*, to control the diversity of ownership. All above financial information is obtained from the Bankscope database.

3.3. Regression

We use OLS with robust standard errors clustered at the bank level to test the lagged one-year effect of green lending on credit risk, over the sample period of 2007-2018. Following the previous empirical and theoretical literature, notably Sharpe's (1963) capital-asset pricing model (CAPM) and Hamada's (1972) contribution on bank risk and leverage, the baseline model is specified in equation (1):

$$CreditRisk_{i,t} = \beta_1 Greenloan_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 Efficiency_{i,t-1} + \beta_4 Leverage_{i,t-1} + \beta_5 LoanLoss_{i,t-1} + \beta_6 FundingCost_{i,t-1} + \beta_7 Capital_{i,t-1} + \beta_8 Spread_{i,t-1} + \beta_9 Loan/Deposit_{i,t-1} + YearFE + \varepsilon_{i,t} \quad (1)$$

Here, $CreditRisk_{i,t}$ is the impaired loan rate observed for bank i in year t . $Greenloan$ is the actual proportion of green loans for bank i in year $t - 1$. The above-mentioned control variables are all included in the regression. $YearFE$ is included to account for common shocks in the market in a given year. $\varepsilon_{i,t}$ is the error term.

We then include a dummy variable $StateBank$. It is equal to 1 if it is a state-controlled major banks and 0 otherwise in equation (2). An interaction term $Greenloan_{i,t-1} \times StateBank$ is also included to test whether green loan effect on bank credit risk depends on the size and ownership and whether the state-controlled banks outperform the small city/regional banks.

Statebanks is a dummy variable. It is equal to 1 if it is a State-controlled major banks, and 0 otherwise.

$$\begin{aligned} CreditRisk_{i,t} = & \beta_1 Greenloan_{t-1} \times StateBank + \beta_2 Statebank + \beta_3 Greenloan_{i,t-1} + \\ & \beta_4 Size_{i,t-1} + \beta_5 Efficiency_{i,t-1} + \beta_6 Leverage_{i,t-1} + \beta_7 LoanLoss_{i,t-1} + \beta_8 FundingCost_{i,t-1} + \\ & \beta_9 Capital_{i,t-1} + \beta_{10} Spread_{i,t-1} + \beta_{11} Loan/Deposit_{i,t-1} + YearFE + \varepsilon_{i,t} \end{aligned} \quad (2)$$

4. Data and Methodology

Descriptive summary statistics are presented in Table 3. Columns (1) and (2) report the mean of bank characteristics for state-controlled major banks and for city/regional smaller banks respectively, and columns (3) and (4) illustrate the standard deviation. It is apparent that the average major bank is larger not only in terms of total assets than the average city/regional bank, but also has a higher proportion of green lending, a higher deposit rate, and higher funding costs. Moreover, the distributions of those variables are more volatile for the group of major banks than for the group of city/regional commercial banks. However, the mean values for leverage and loan-loss provision are higher for the smaller bank group than for the large banks, and their distributions are more volatile. The summary statistics suggest that the group of state-owned major banks exhibits different characteristics to the group of smaller banks, indicating that we should test the effect of green lending on credit risk separately for those two groups. The correlations between the independent and dependent variables can be found in Table 4.

Our main results are presented in Table 5. Column (1) shows the results for all banks across both groups, and columns (2) and (3) show our results for the group of state-owned major banks and the group of city/regional smaller banks, respectively. The coefficient estimate of the green loan variable is 0.366 for all banks, but it is not statistically significant. This finding would seem to suggest that the implementation of China's Green Credit Policy has had a negligible effect on the financial stability of the financial sector as a whole. However, when we split banks into the two groups by ownership structure, the results vary greatly. The finding for the group of state-owned major banks shows that a 1% increase in the proportion of green loans reduces bank credit risk by 1.096 at a 5% significance level, indicating that green lending has a significant negative association with credit risk for these banks. Meanwhile, the group of smaller city/regional banks generates a totally opposite result: for these banks, an increase in

(relative) green lending in the year $t-1$ leads to higher credit risk in the year t , suggesting that city/regional level small banks do not have sufficient capacity to manage risks for green loans. These results clearly support our hypothesis that the effect of banks' green lending on credit risk varies by ownership structure and size: while the proportion of green lending is negatively associated with credit risk for state-controlled major banks, it is positively related to credit risk for city/regional commercial banks. This finding is consistent with (Laeven and Levine 2009), who find that the same policy has different impacts on bank risk depending on a given bank's governance structure.

Table 6 present the effect of green loan on credit risk for the interaction term $Greenloan \times StateBank$. Columns (1), (2) and (3) show the estimates for the whole sample period 2007-2018, pre and post the introduction of mandatory green lending disclosure for the state-controlled major banks in 2013, respectively. We find that , in supporting to $H2.1$ and $H2.2$, the coefficient on the interaction term $Greenloan \times StateBank$ is negative and significant (-0.038, $p < 0.01$) for the whole sample period. And this outperformance of the state-controlled banks is attributed to the mandatory disclosure requirement of green lending in 2013. The findings suggest that the implementation of the Green Credit Policy depends on a given bank's ownership structure and size in the context of China's distinctive banking system and institutional setting. This size and ownership effect provide additional supporting evidence for the link between the sustainability of a bank's lending practices and its financial performance.

In interpreting these results from a conceptual perspective, we follow relationship banking theory (Sharpe 1990; von Thadden 2004; Hauswald and Marquez 2006), which posits that informed lenders can extract rents from lending to borrowers that are "informationally captured" because other lenders have insufficient information about them. The strong negative association between green lending and bank credit risk for state-controlled major banks can be attributed to the fact that large banks benefit from industry expertise and knowledge in green loan underwriting, as well as sound internal mechanisms of environmental credit risk management (Harper Ho 2018). Empirical evidence also suggests that the success of bank lending depends on investment experience (Li, Sui, and Lu 2012) and industry knowledge (Kroszner and Strahan 2001). An explanation for the positive effect of green lending on credit risk for city/regional commercial banks is that they have more limited industry expertise, and

more limited capacity in green finance and environmental risk management (Bai, Faure, and Liu 2013).

5. Robustness tests

We performed a series of robustness tests. We first test the green lending effect using Generalized Least Squares (GLS) regression due to the concern about heteroskedasticity. Table 7 report the GLS regression results. Columns (1), (2) and (3) show the estimates for the whole sample, the state-controlled major banks and the interaction term, respectively. We obtained identical, statistically significant estimates for the state-controlled groups reported in Table 5. The negative coefficient of the interaction term $Greenloan \times StateBank$. is also significant, but at a 10% significance level.

Compared to the main findings used lagged green lending ratio, we then conduct a simultaneous regression on credit risk for the whole sample period, pre and post the introduction of mandatory green lending disclosure in 2013. The results (Table 8) are consistent with the one-year lagged tests for the whole and subsample periods. The findings enhance our mains results by showing that the green lending effect on credit risk for the state-controlled major banks during the same year period.

Next, we excluded three policy banks in our test as they are less profit driven. The results are reported in Table 9. We obtained identical, statistically significant estimates to those reported in table 7.

6. Discussion and policy implications

Although China's Green Credit Policy established the country as one of the pioneers of sustainable finance by getting banks to introduce and scale up green lending, there have so far been few analyses of its success. This paper addresses the current lack of empirical studies examining the Green Credit Policy with regard to its impact on financial stability for lending institutions and for the banking sector as a whole. The empirical evidence this study provides can help policymakers adjust the implementation of climate-related regulations and offers guidance to industry practitioners who wish to mitigate environmental risks in sustainable investing.

Our results shed light on the Green Credit Policy from many angles. One finding is that we do not document a significant association between bank green lending and risk performance across the banking sector as a whole; rather, credit risk varies greatly by bank ownership structure and size. This result implies that the Green Credit Policy's effect on credit risk is not consistent across banks. In other words, a blanket green lending policy may not be very effective, but rather may require more tailoring to specific bank characteristics.

This view is reinforced by our most important finding: that while an increase in the proportion of green lending reduces credit risk for state-owned major banks, it actually increases credit risks for smaller city/regional commercial banks. For two different groups of banks that differ by size and ownership structure, the same Green Credit Policy actually has an opposite effect. This result suggests that, compared to their large peers, city/regional level commercial banks have more limited capacity and industry expertise, and less developed risk management systems, all of which may contribute to the economic losses they are experiencing in green lending. Their ownership by city and regional governments may also make them less integrated into central policymaking than the (central government-owned) major banks, which have a leading role in China's push to achieve a sustainable economy.

Thus, our findings serve to highlight the challenges in implementing the Green Credit Policy. The large discrepancy between the two groups of banks makes it all the more important for the government to adjust the implementation standards for green finance policies in accordance with regional economic status and bank structure. Factors including ownership, size and capacity of the lending institution, expertise and knowledge in the newly emerged green finance sector, and regional differences have to be taken into account by policymakers in order to ensure continued financial stability for the lending institutions and for the banking sector as a whole. Guidelines and training on best practices could be implemented to help laggard banks to apply green credit policies appropriately.

Given the Chinese institutional context, it is equally important to set up mechanisms and networks for the large state-controlled banks to communicate and exchange information and expertise with the city/regional commercial banks. This could include sharing on industry expertise or environmental risk management, but could also extend to collaboration around innovative banking activities, building (shared) green credit data analysis platforms, or setting up specialized green credit institutions.

After all, a systemic shift to sustainable lending requires industry-wide expertise, capacity, and risk management. Without mechanisms to access sufficient knowledge or expertise on green finance, or without the right tools to assess environmental risks and opportunities, smaller regional Chinese banks may suffer further deterioration of their credit risk under coercive institutional pressure to blindly increase the proportion of green lending.

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Table 1 Bank Green Loan Data: 41 banks green loan data from 2007 to 2018

Bank Type	State-controlled major banks	No. banks
City commercial bank	No	18
Joint-stock commercial bank	Yes	11
State-owned commercial bank	Yes	5
Rural commercial bank	No	3
Policy bank	Yes	3
postal saving	Yes	1
Total		41

Figure 1 Chinese Bank Green Loan Trend by type 2007-2018

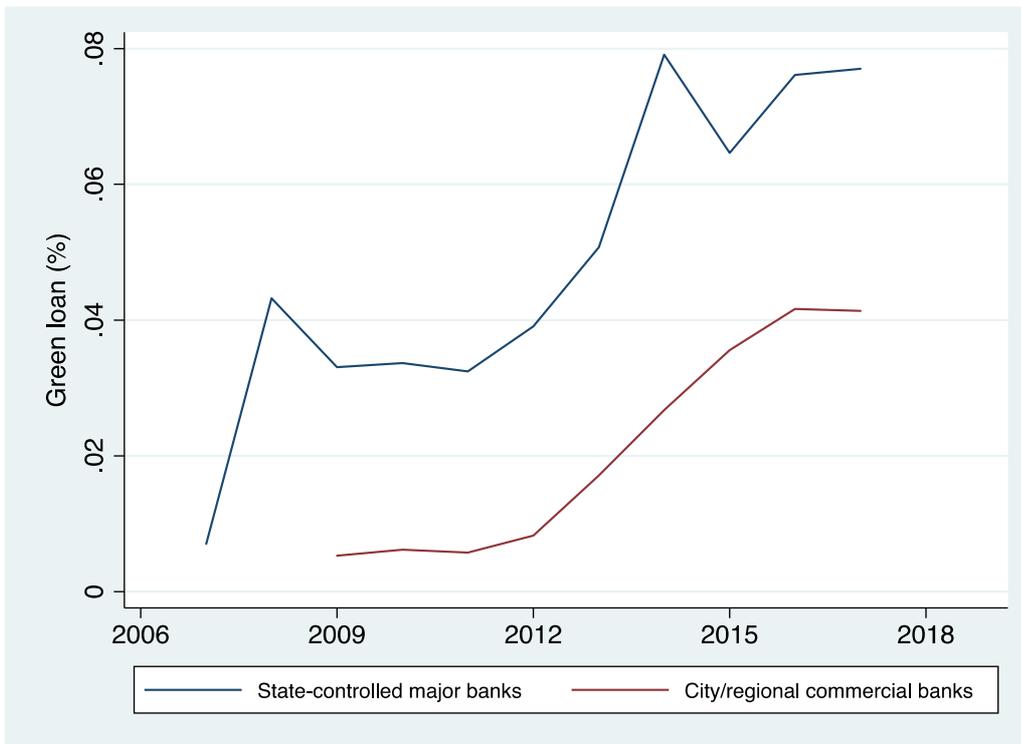


Figure 2 Chinese Bank Green Loan Trend by Type 2007-2018

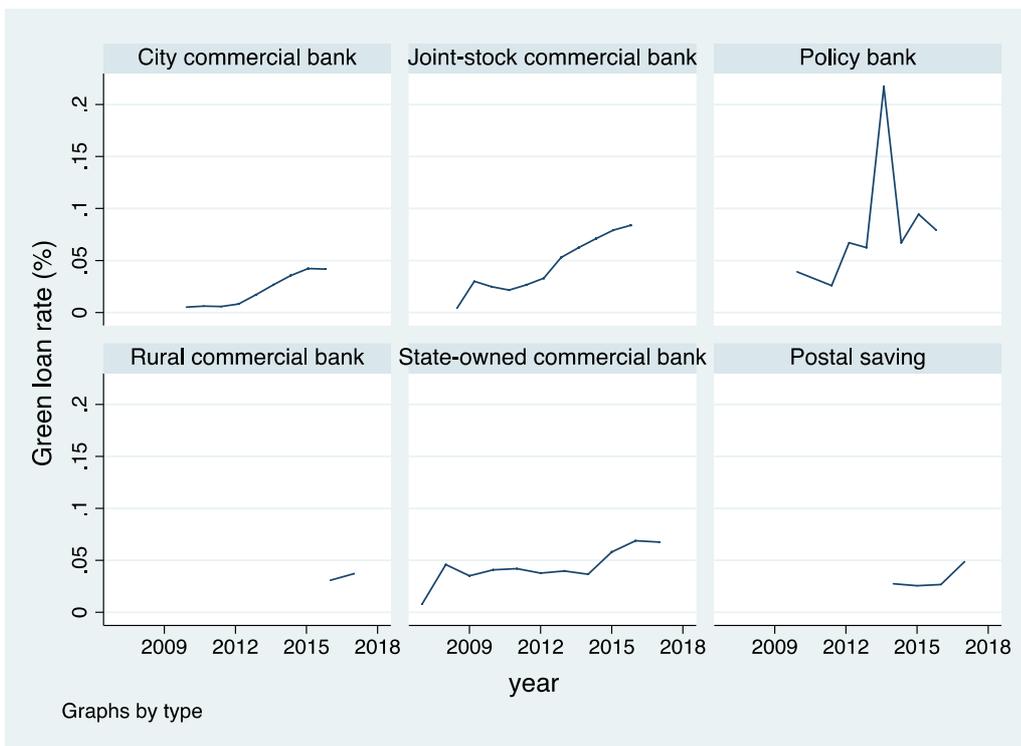


Table 2 Variable definitions

Variable	Definitions
Credit risk (%)	Impaired loans/gross loans
Log(asset)	Log of total assets
Green lending (%)	Green loans/total loans
Efficiency (%)	Earning assets/total assets
Leverage (%)	Total liabilities/total assets
Loan loss provision (%)	Loan loss provisions/total loans
Funding cost (%)	(Interest expense + non-interest expense)/total assets
Regulatory capital (%)	Tier 1 capital/total loans
Spread (%)	(total interest income/total earning assets) - (total interest expense/total interest-bearing liabilities)
Loan deposit rate (%)	Total loans/time deposits

Table 3 Summary statistics

Variable	Mean		Std	
	State-controlled major banks (1)	City/regional banks (2)	State-controlled major banks (3)	City/regional banks (4)
Log(asset)	13.528	11.295	0.890	0.734
Green lending (%)	0.057	0.033	0.089	0.032
Credit risk (%)	1.285	1.173	0.597	0.406
Efficiency (%)	0.855	0.864	0.050	0.043
Leverage (%)	0.937	0.938	0.020	0.031
Loan loss provision (%)	0.009	0.011	0.005	0.006
Funding cost (%)	0.0310	0.0307	0.0054	0.0046
Regulatory capital (%)	0.124	0.173	0.021	0.038
Spread (%)	-2.369	-2.568	0.676	0.473
loan/asset (%)	0.846	0.427	0.875	0.068

Table 4 Variable Correlation

	Credit risk (%)	Green lending (%)	Efficiency (%)	Leverage (%)	Loan loss provision (%)	Funding cost (%)	Regulatory capital (%)	Spread (%)	Log(asset)	loan/asset (%)
Credit risk (%)	1									
Green lending (%)	0.048	1								
Efficiency (%)	-0.134	0.196	1							
Leverage (%)	-0.089	-0.088	0.380	1						
Loan loss provision (%)	0.281	0.173	0.221	-0.064	1					
Funding cost (%)	-0.271	-0.070	0.113	0.302	-0.060	1				
Regulatory capital (%)	0.020	0.091	0.186	-0.124	0.397	0.005	1			
Spread (%)	0.336	-0.078	-0.398	-0.066	-0.098	-0.800	-0.229	1		
Log(asset)	0.175	0.204	-0.237	-0.280	-0.265	-0.244	-0.508	0.330	1	
loan/asset (%)	-0.134	0.176	0.335	-0.130	-0.228	-0.045	-0.396	-0.108	0.390	1

Table 5 The baseline results of bank green lending effect on credit risk

This table reports the results of OLS regressions. The control variables are bank characteristics including size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The dependent variable is bank credit risk. All variables are defined in Table 2. In this analysis, we employ a lagged one-year structure of research design, where the credit risk in year t is hypothesized to be affected by firm characteristics and green lending in the previous year $t - 1$. Columns (1), (2) and (3) show the estimates for all sample banks, the group of state-owned major banks, and the group of city/regional smaller banks, respectively. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Credit risk		
	All sample	State-controlled Major banks	City/regional banks
Green lending (lagged)	0.001 (0.30)	-0.011** (-2.07)	0.047*** (3.35)
Efficiency	-0.040** (-2.53)	-0.018 (-1.24)	-0.081** (-2.64)
Leverage	0.011 (0.18)	-0.009 (-0.14)	0.016 (0.13)
Loan loss provision	0.183** (2.36)	0.366** (2.34)	-0.035 (-0.49)
Funding cost	0.041 (0.21)	0.080 (0.40)	0.114 (0.40)
Regulatory capital	-0.000 (-0.01)	0.030 (1.20)	-0.011 (-0.25)
Spread	0.000 (0.15)	-0.000 (-0.31)	0.002 (0.62)
Log(asset)	-0.001 (-0.49)	-0.002** (-2.35)	-0.002 (-0.08)
loan/asset	0.001 (1.31)	0.002 (1.69)	0.001 (1.34)
Constant	0.033 (0.57)	0.013 (0.22)	0.051 (0.41)
Year FE	YES	YES	YES
SE Cluster(firm)	YES	YES	YES
R square	0.542	0.662	0.599
Obs	163	109	54

Table 6 The green lending effect on credit risk for the state-controlled major banks pre and post the introduction of mandatory green lending disclosure

This table reports the results of OLS regressions. The control variables are bank characteristics including size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The dependent variable is bank credit risk. All variables are defined in Table 2. In this analysis, we employ a lagged one-year structure of research design, where the credit risk in year t is hypothesized to be affected by firm characteristics and green lending in the previous year $t - 1$. The interaction term is Green loan \times State-controlled major banks. The variable of State-controlled major banks is a dummy variable. It is equal to 1 if it is a State-controlled major banks, and 0 otherwise. Columns (1), (2) and (3) show the estimates for the whole sample period 2007-2018, pre and post the introduction of mandatory green lending disclosure for the stated-controlled major banks in 2013, respectively. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Credit risk		
	2007-2018 (1)	2013-2018 (2)	2007-2013 (3)
Green lending (lagged) \times State controlled major banks	-0.038*** (-2.85)	-0.033** (-2.42)	1.673 (1.04)
State controlled major banks	0.001 (0.98)	0.004** (2.35)	-0.022 (-1.41)
Green lending (lagged)	0.036** (2.63)	0.032** (2.25)	-1.708 (-1.06)
Efficiency	-0.044*** (-3.02)	-0.017 (-0.86)	0.020 (0.30)
Leverage	0.016 (0.27)	-0.014 (-0.25)	0.300 (1.31)
Loan loss provision	0.162* (1.89)	0.048 (0.86)	0.703 (1.73)
Funding cost	-0.017 (-0.07)	-0.148 (-0.56)	0.331 (1.15)
Regulatory capital	0.001 (0.05)	0.000 (0.02)	0.108 (1.55)
Spread	-0.001 (-0.27)	0.000 (0.06)	-0.001 (-0.37)
Log(asset)	-0.001 (-0.49)	-0.002 (-1.46)	0.040 (1.31)
loan/asset	0.001 (0.96)	-0.000 (-0.51)	0.006* (1.90)
Constant	0.031 (0.52)	0.046 (0.79)	-0.382 (-1.33)
Year FE	YES	YES	YES
SE Cluster(firm)	YES	YES	YES
R square	0.563	0.419	0.876
Obs	163	112	36

Table 7 The GLS estimate of the green lending effect on credit risk

This table reports the results of GLS regressions. The control variables are bank characteristics including size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The dependent variable is bank credit risk. All variables are defined in Table 2. In this analysis, we employ a lagged one-year structure of research design, where the credit risk in year t is hypothesized to be affected by firm characteristics and green lending in the previous year $t - 1$. The interaction term is Green loan \times State-controlled major banks. The variable of State-controlled major banks is a dummy variable. It is equal to 1 if it is a State-controlled major banks, and 0 otherwise. Columns (1), (2) and (3) show the estimates for the whole sample, the state-controlled major banks and the interaction term, respectively. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Credit risk		
	(1)	(2)	(3)
Green lending (lagged) \times State controlled major banks			-0.020* (-1.80)
State controlled major banks			0.000 (0.14)
Green lending (lagged)	0.004 (0.92)	-0.011** (-2.07)	0.023** (1.97)
Efficiency	-0.010 (-0.75)	-0.018 (-1.24)	-0.018 (-1.48)
Leverage	-0.009 (-0.31)	-0.009 (-0.14)	-0.013 (-0.35)
Loan loss provision	0.188*** (2.58)	0.366** (2.34)	0.168** (2.30)
Funding cost	0.281 (1.61)	0.080 (0.40)	0.217 (1.05)
Regulatory capital	-0.013 (-1.01)	0.030 (1.20)	-0.010 (-0.82)
Spread	0.002 (1.41)	-0.000 (-0.31)	0.001 (0.83)
Log(asset)	-0.002*** (-3.25)	-0.002** (-2.35)	-0.002*** (-3.16)
loan/asset	0.001 (1.15)	0.002* (1.69)	0.001 (0.96)
Constant	0.026 (0.99)	0.013 (0.22)	0.036 (0.96)
Year FE	YES	YES	YES
SE Cluster(firm)	YES	YES	YES
Obs	163	109	163

Table 8 The simultaneous regression result of green lending effect on credit risk pre and post the introduction of mandatory green lending disclosure

This table reports the results of OLS regressions. The control variables are bank characteristics including size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The dependent variable is bank credit risk. All variables are defined in Table 2. The interaction term is Green loan×State-controlled major banks. The variable of State-controlled major banks is a dummy variable. It is equal to 1 if it is a State-controlled major banks, and 0 otherwise. Columns (1), (2) and (3) show the estimates for the whole sample period 2007-2018, pre and post the introduction of mandatory green lending disclosure for the stated-controlled major banks in 2013, respectively. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Credit risk		
	2007-2018 (1)	2013-2018 (2)	2007-2013 (3)
Green lending × State controlled major banks	-0.036** (-2.69)	-0.031** (-2.22)	1.377 (0.93)
State controlled major banks	0.000 (0.09)	0.003* (1.72)	-0.018 (-1.28)
Green lending	0.035** (2.56)	0.031** (2.16)	-1.428 (-0.96)
Efficiency	-0.057*** (-2.76)	-0.019 (-1.08)	-0.037 (-0.44)
Leverage	0.038 (1.23)	-0.003 (-0.12)	0.303 (1.36)
Loan loss provision	0.202** (2.14)	0.077 (1.40)	0.574 (1.05)
Funding cost	0.128 (0.66)	0.039 (0.18)	0.565 (1.33)
Regulatory capital	0.006 (0.36)	0.004 (0.22)	0.103 (1.72)
Spread	-0.000 (-0.27)	0.001 (0.51)	0.003 (1.26)
Log(asset)	0.001 (0.95)	-0.001 (-0.64)	0.009 (0.81)
loan/asset	0.001 (1.55)	-0.000 (-0.05)	0.005* (1.81)
Constant	0.014 (0.61)	0.026 (1.47)	-0.307 (-1.29)
Year FE	YES	YES	YES
SE Cluster(firm)	YES	YES	YES
R square	0.629	0.504	0.900
Obs	163	112	36

Table 9 The green lending effect on credit risk for the state-controlled major banks pre and post the introduction of mandatory green lending disclosure

This table reports the results of OLS regressions. The control variables are bank characteristics including size, management efficiency, leverage, loan-loss provision, funding cost, regulatory capital, spread and loan deposit rate. The dependent variable is bank credit risk. All variables are defined in Table 2. In this analysis, we employ a lagged one-year structure of research design, where the credit risk in year t is hypothesized to be affected by firm characteristics and green lending in the previous year $t - 1$. The interaction term is Green loan \times State-controlled major banks. The variable of State-controlled major banks is a dummy variable. It is equal to 1 if it is a State-controlled major banks, and 0 otherwise. Columns (1), (2) and (3) show the estimates for the whole sample period 2007-2018, pre and post the introduction of mandatory green lending disclosure for the stated-controlled major banks in 2013, respectively. *, **, and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Credit risk		
	2007-2018	2013-2018	2007-2013
Green lending (lagged) \times State controlled major banks	-0.037** (-2.70)	-0.032** (-2.14)	1.673 (1.04)
State controlled major banks	0.001 (0.97)	0.005*** (2.81)	-0.022 (-1.41)
Green lending (lagged)	0.037** (2.61)	0.034** (2.23)	-1.708 (-1.06)
Efficiency	-0.053*** (-3.27)	-0.022 (-0.94)	0.020 (0.30)
Leverage	0.060 (1.47)	0.048 (1.09)	0.300 (1.31)
Loan loss provision	0.167* (1.84)	0.041 (0.71)	0.703 (1.73)
Funding cost	-0.076 (-0.30)	-0.256 (-1.05)	0.331 (1.15)
Regulatory capital	0.019 (0.87)	0.027 (1.11)	0.108 (1.55)
Spread	-0.001 (-0.53)	-0.001 (-0.45)	-0.001 (-0.37)
Log(asset)	0.011 (0.89)	0.017 (1.64)	0.040 (1.31)
loan/asset	0.001 (0.88)	-0.001 (-0.91)	0.006* (1.90)
Constant	-0.010 (-0.25)	-0.016 (-0.44)	-0.382 (-1.33)
Year FE	YES	YES	YES
SE Cluster(firm)	YES	YES	YES
R square	0.560	0.424	0.876
Obs	159	108	36

Appendix 1 Chinese bank sample list

Bank name	Bank type	State-controlled Major banks
BANK of BEIJING CO LTD	City commercial bank	No
BANK of CHENGDU CO LTD	City commercial bank	No
BANK of CHONGQING	City commercial bank	No
BANK of GANSU	City commercial bank	No
BANK of GUIYANG CO LTD	City commercial bank	No
BANK of HANGZHOU CO LTD	City commercial bank	No
BANK of JIANGSU CO LTD	City commercial bank	No
BANK of JINZHOU CO LTD	City commercial bank	No
BANK of NANJING	City commercial bank	No
BANK of NINGBO	City commercial bank	No
BANK of QINGDAO CO LTD	City commercial bank	No
BANK of SHANGHAI	City commercial bank	No
BANK of TIANJIN	City commercial bank	No
BANK of ZHENGZHOU CO., LTD.	City commercial bank	No
HARBIN BANK	City commercial bank	No
HUIZHANG BANK CO LTD	City commercial bank	No
JIANGXI BANK CO LTD	City commercial bank	No
ZHONGYUAN BANK CO LTD	City commercial bank	No
CHONGQING RURAL COMMERCIAL BANK	Rural commercial bank	No
JIANGSU CHANGSHU RURAL COMMERCIAL BANK CO., LTD	Rural commercial bank	No
WUXI RURAL COMMERCIAL BANK CO.LTD	Rural commercial bank	No
CHINA BOHAI BANK	Joint-stock commercial bank	Yes
CHINA CITIC BANK CORPORATION LIMITED	Joint-stock commercial bank	Yes
CHINA EVERBRIGHT BANK COMPANY LIMITED	Joint-stock commercial bank	Yes
CHINA GUANGFA BANK CO LTD	Joint-stock commercial bank	Yes
CHINA MERCHANTS BANK CO LTD	Joint-stock commercial bank	Yes
CHINA MINSHENG BANKING CORPORATION	Joint-stock commercial bank	Yes
CHINA ZHESHANG BANK CO LTD	Joint-stock commercial bank	Yes
HUA XIA BANK CO., LIMITED	Joint-stock commercial bank	Yes
INDUSTRIAL BANK CO LTD	Joint-stock commercial bank	Yes
PING AN BANK	Joint-stock commercial bank	Yes
SHANGHAI PUDONG DEVELOPMENT BANK	Joint-stock commercial bank	Yes
AGRICULTURAL DEVELOPMENT BANK of CHINA	Policy bank	Yes
CHINA DEVELOPMENT BANK CORPORATION	Policy bank	Yes
EXPORT-IMPORT BANK of CHINA - CHINA EXIMBANK	Policy bank	Yes
AGRICULTURAL BANK of CHINA LIMITED	State-owned commercial bank	Yes
BANK of CHINA LIMITED	State-owned commercial bank	Yes
BANK of COMMUNICATIONS CO. LTD	State-owned commercial bank	Yes
CHINA CONSTRUCTION BANK CORPORATION JOINT STOCK COMPANY	State-owned commercial bank	Yes
INDUSTRIAL & COMMERCIAL BANK of CHINA (THE) - ICBC	State-owned commercial bank	Yes
POSTAL SAVINGS BANK of CHINA CO LTD	Postal saving	Yes