Transmission Of Quantity-based Monetary Policy Through Heterogeneous Banks In China*

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Abstract

Different from the target rate oriented monetary policy in Western countries, China mainly relies on quantity-based instruments, which can induce funding imbalance within the banking system. Systematic reallocation of funds among banks constitutes a central part of the monetary policy transmission. This paper studies the reallocation of funds within the Chinese banking system and its effects on lending to the real economy. The substitution of funds injected by monetary policy for banks' positions on negotiable certificate of deposit (NCD) constitutes the main channel of monetary transmission within the banking system. State banks' apparent conservatism in lending prevents full substitution for interbank lending and impedes the reallocation of funds to non-state banks. Regarding the effects of the reallocation on the economy, we find that following a shift in state banks' positions on the NCD market from lending to borrowing, 1) state banks' use of funds increased, 2) non-state banks' lending growth and holding of excess reserves relative to state banks increased, 3) cities with more exposure to non-state bank lending experienced higher lending growth, and 4) the fraction of firms' borrowing from non-state banks increased.

Keywords: monetary policy transmission, quantity-based instruments, banks heterogeneity, interbank market.

JEL Codes: E02, E5, G21

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1 Introduction

Target rate oriented monetary instruments are prevalent in western countries such as the US, where interest rates on reserve balances (IORB), overnight reverse repos, and the discount window determine most banks' shadow costs of funds. In contrast, monetary policy in China over the last decade has largely relied on quantity-based instruments such as Medium-term Lending Facilities (MLF) and Required Reserve Ratio (RRR) cuts.[1] Specifically, MLF supplies funds to a predetermined subset of banks, mostly primary dealers (PD banks); RRR cuts, instead, effectively supply funds to all banks according to their deposit holdings rather than their needs for funding. Such practice results in systematic funding imbalances within the banking system, and the subsequent reallocation of funds among banks constitutes a crucial part of monetary policy transmission.

In this paper, we study how the reallocation of funds operate within the Chinese banking system and the resulting effects on the real economy. Specifically, we shed light on the roles of different types of banks and institutions in the reallocation process and their implications for the implementation of monetary policy and financial development. We begin our analysis with stylized facts about Chinese monetary policy and the banking system. First, the two major instruments for base money supply, RRR cuts and MLFs do not supply funds to banks according to their funding needs and are followed by systematic reallocation of funds among banks. Second, the Chinese banking system features considerable heterogeneity across banks. State banks, which are majority owned by the central government, are more conservative in lending and investment than non-state banks, because of their non-market objectives (Deng et al., 2011; Huang et al., 2020; Gao et al., 2020). Third, several interbank markets integrate the Chinese banking system, among which the newly developed NCD market is particularly active and a major channel of the reallocation. In addition, money market funds (MMFs) grew rapidly during our sample period and played an important role in determining the allocation of resources among banks.

Inspired by these facts, we build a simple model of the Chinese banking system. The model consists of state banks, non-state banks, and MMFs. Banks borrow and lend on the competitive interbank market and allocate funds between reserves and investment. MMFs make profits by lending to banks. State banks are conservative in the sense that compared to non-state banks, they have an additional aversion to investment in firms and interbank lending, but not to interbank borrowing. Through the lens of the model, we characterize the reallocation of funds following monetary policy operations through two forces. One is the substitution of funds injectd by monetary policy for banks' interbank positions. The other channel is the general equilibrium effect of the change in the interbank market rate on banks' asset allocation. State banks' conservatism prevents their

[1] Medium-term Lending Facilities provide banks with medium-term collateralized loans at monthly frequency. The maturity of the loans is typically one year.

"redundant" financial resources from being fully reallocated to other banks. As a result, when state banks are endowed with ample financial resources and lend on the interbank market, they hold more reserves and make less investments than non-state banks. However, when state banks are endowed with limited financial resources and borrow on the interbank market, they behave similarly to non-state banks. The model documents how the endowment of financial resources, that is, central bank funds and deposits, affects the eventual distribution of resources across banks. The model has implications for the implementation of monetary policy and financial liberalization.

Guided by the model, we conduct a series of empirical tests. We first characterize the substitution effect of expansionary monetary policy by examining how banks adjust their interbank borrowing/ lending when their central bank borrowing varies. To mitigate potential endogeneity concerns, we employ exogenous variation of primary dealers' central bank borrowing induced by MLF. We instrument a bank's central bank borrowing with the product of the aggregate liquidity supply by MLF and whether the bank is a primary dealer. This instrument is motivated by the observation that MLFs supply funds mostly to primary dealers, so only their central bank borrowing is substantially moved by MLFs.[2]

The 2SLS estimation results show the substitution effect is consistent with the model prediction in both direction and magnitude. First, in terms of the substitution of central bank borrowing for borrowing through NCD, the estimates for state banks[3] and non-state PD banks are -1.095 and -1.058 respectively, both of which are close to the model prediction -1. A further test shows no significant difference in this substitution across the two groups of banks. Second, in terms of the substitution of central bank borrowing for lending through NCD, the estimate for non-state PD banks is significantly higher than for state banks, by at least 29%. These findings lend support to the central model prediction that state banks' conservatism prevents full reallocation of funds when state banks lend on the interbank market. Meanwhile, we do not find evidence of the substitution effect on other relatively traditional interbank markets including interbank deposit, interbank placement, and repo.

We also investigate the reallocation of funds following RRR cuts. Our model predicts that after RRR cuts, the correlation between banks' interbank borrowing and deposits becomes more negative. On the one hand, banks with more deposits will see more liquidity injectd, which substitutes for more of their interbank borrowing. On the other hand, banks with more deposits tend to have fewer investment opportunities and increase investment less when the cost of funds decreases.

[2]The specification is similar in spirit to a difference-in-differences (DiD) framework or a Bartik instrument with exogenous shares (Autor et al., 2013; Goldsmith-Pinkham et al., 2020; Breuer, 2021; Borusyak et al., 2022), in which PD banks are treated but non-PD banks are not. The validity of the aggregate liquidity supply by MLFs as an IV relies on the assumption that the central bank chooses aggregate MLFs in response to the aggregate condition of the economy and the financial system, rather than cater to a subset of banks. This is consistent with the PBC's description that MLF is used to supply medium-term base money to the overall economy.

[3]All state banks are primary dealer.

Such difference in the GE effect further enhances the negative correlation.We test this prediction in a DiD framework using the two waves of RRR cuts during our sample period. For the first wave starting in 2015Q1, we do not observe a strong pattern regarding borrowing through NCD. The non-result likely originates from the fact that the NCD market was only introduced at the end of 2013 and not yet fully developed in 2015. For the second wave starting in 2018Q2, we find that the correlation between borrowing through NCD and deposits becomes more negative by around 10%. Similar to MLF, we do not observe that banks respond to the two waves of RRR cuts through traditional interbank markets.

To sum up, our analyses on MLF and RRR cuts illustrate three points. First, the substitution of funds injectd by monetary policy for banks' interbank positions transmits changes in monetary policy within the banking system. Second, state banks' conservatism prevents full reallocation of funds when state banks lend on the interbank market, but not when they borrow. Third, the NCD market plays a primary role in the reallocation of funds following monetary policy actions, whereas traditional interbank markets play minor roles.

A conventional view of the Chinese banking system is that state banks hold ample financial resources and provide funds to other banks. However, state banks began to systematically issue NCDs in 2018 and have become net issuers since 2019, suggesting that they were moving from the lending side on the interbank market to the borrowing side. A potential force driving this shift is a boom in MMFs in 2017 and 2018 that dampened state banks' deposit growth.[4] According to the model, this shift indicates an improvement in the reallocation of funds because state banks' conservatism prevent full substitution for interbank lending, but not for interbank borrowing. Consequently, the gap between banks' shadow costs of funds is closed: non-state banks make more investment and hold more excess reserves, whereas state banks make less investment and hold fewer excess reserves. Comparing the two periods before and after 2018, the second part of our empirical analysis assesses the effects of the reallocation mechanism on banks' asset allocation and the lending to the real economy.

We first shed light on banks' asset allocation. We find that before 2018, state banks have significantly lower utilization of funds than non-state banks. Specifically, as balance sheets expand, state banks keep 25.5% (23.2%) of the funds as excess reserves within one quarter (two quarters) whereas non-state banks only keep low excess reserves. However, since 2018, this difference shrinks dramatically and becomes insignificant as state banks keep only 16.3% (5.9%) of the funds as excess reserves within one quarter (two quarters). In terms of asset allocation, we find that state and non-state banks' lending growth and holding of excess reserves were stable before 2018, but afterwards, non-state banks' increased both by roughly 12% compared to state banks. These results suggest that when more resources are directed to non-state banks, the efficiency of the

[4] See 2.3 for more details.

banking system in terms of utilization of funds improves. MMFs and other similar investment vehicles may facilitate this process by attracting deposits from state banks and channel them to non-state banks.

In practice, due to various frictions, different banks are not perfect substitutes for borrowers. Hence, the distribution of financial resources across banks matters for borrowers. Therefore, the reallocation mechanism affects the lending to the real economy. We provide city- and firm-level evidence of this effect. At the city level, we construct a city's exposure to non-state banks by calculating the fraction of the numbers of non-state bank branches to the total number of branches of state and non-state banks. Although the fraction is admittedly a rough proxy of actual exposure, we still find sizable impacts of the reallocation mechanism on city-level lending in a DiD setting: if a city's fraction increases by one standard deviation, its lending growth increases by around 2% since 2018. At the firm level, we analyze the firms listed in National Equities Exchange and Quotations (NEEQ), because complete profiles of their borrowing are publicly available. Firms that borrow from both state and non-state banks, the share of borrowing from state banks increases by 4.3% since 2018 and the increase is significant for non-state-owned enterprises but not for state-owned ones.

Conceptually, the fact that state banks' positions on the interbank market have implications for the lending to the real economy hinges on both uneven monetary policy and interbank market frictions. If monetary policy injects funds according to banks' demand for funds and equalizes banks' shadow cost of funds, the interbank market should be irrelevant for the lending to the real economy. If monetary policy induces or fails to overcome funding imbalance but the interbank market is frictionless, reallocation of funds among banks will be complete and render the initial allocation of funds irrelevant. Therefore, our findings document the role of both uneven monetary policy and interbank market frictions.

The paper is organized as follows. The remainder of this section reviews the related literature. Section 2 provides necessary institutional background and highlights the stylized facts related to our analysis. Section 3 builds a simple model of the Chinese banking system. Section 4 gives a detailed description of the data we use. Section 5 characterizes the reallocation of funds following the two major quantity-based instruments. Section 6 investigates the effects of the reallocation mechanism on banks' asset allocation and the lending to the real economy. Section 7 concludes.

Related Literature Our paper is related to the large literature on the different transmission channels of monetary policy, such as the bank lending (Bernanke, 1983; Bernanke and Blinder, 1988, 1992; Kashyap and Stein, 1994) and balance sheet channel (Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Gertler and Kiyotaki, 2010; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). Recently, researchers have uncovered new channels through which monetary policy transmits and generates real effects, including interbank markets (Vari, 2020; Bianchi and Bigio, 2022; Eisenschmidt et al., 2022; Altavilla et al., 2022), banks' market power (Scharfstein and Sunderam, 2016; Drechsler et al., 2017; Xiao, 2020; Wang et al., 2022). Among the large literature, Bianchi and Bigio (2022), which also considers the interbank market and its impact on banks' asset allocation, is particularly relevant to our study. However, the funding imbalance and frictions in our paper originate from the monetary policy and the characteristics of Chinese banking system and are different from theirs.

Our paper also contributes to and builds on the growing literature of Chinese banking system and regulation. Chen et al. (2018) study the impact of China's monetary policy on shadow banking. Hachem and Song (2021) develop a model with interbank market power and liquidity regulation to study China's shadow banking activities. Chen et al. (2021) focuses on the role of China's NCD market for monetary policy transmission, but in a target-rate monetary policy framework. Fang et al. (2020) documents the collateral channel of monetary policy. They find that when a class of previously ineligible bonds in the interbank market became eligible collateral for financial institutions to borrow money from MLF in China, the yields of these bonds reduced by 42-62 basis points. Using loan-level data, Li et al. (2022) shows that China's implementation of Basel III in 2013 has reduced bank risk-taking, but less risk-taking results from lending to ostensibly low-risk but inefficient state-owned enterprises, leading to credit misallocation. Wang and Jin (2021) studies how interbank market frictions affect monetary policy transmission in China. They characterize the interbank market as more risk-averse big banks lending to less risk-averse small banks and ignore the nature of quantity-based monetary policy instruments.

Our paper makes three contributions to the literature. First, to the best of our knowledge, we are the first to consider the nature of China's major quantity-based monetary policy instruments and analyze their transmission within the banking system. Second, we highlight state banks' conservatism in lending and illustrate how it impedes reallocation of funds and further affects the lending to the real economy. Third, we uncover the impact of the specifics of the implementation of monetary policy on the allocation of financial resource in China.

2 Institutional Background and Stylized Facts

In this section, we detail the institutional background and document several stylized facts, which inform our modeling choices. We refer to Wang (2020); Huang et al. (2020); Amstad and He (2020); Sun (2020) for a more detailed description.

2.1 Monetary policy

During the period between 2002 and 2013, China saw a large influx of foreign exchange (FX) from current account surpluses and, in some years, even financial account surpluses. The accumulation of FX reserves by the People's Bank of China's (PBC) while at the same time keeping the Renminbi (RMB) exchange rate stable, resulted in a large influx of RMB liquidity in the economy. This passive form of base money supply in the form of funds outstanding for foreign exchange was so strong that PBC's monetary policy instruments were used to mainly sterilize FX inflows during this period.[5] Since 2013, the growth of funds outstanding for FX has been much slower, even negative in times. As a consequence, Chinese monetary policy became more dependent on PBC's active money supply, which is mainly implemented through quantity-based instruments. Table 2 presents an overview of the quantity-based instruments used extensively from 2013 to 2019 and Figure 1 plots the amount of base money supplied through these instruments. Among them, RRR cuts, MLF, and Pledged Supplementary Lending (PSL) dominate base money supply.

In September 2014, the PBC created MLF to supply medium-term base money to the economy. At the monthly frequency, MLF provides banks with loans, whose maturity is typically one year but can also be three or six months. As an exchange, banks need to provide as collateral high-quality bonds such as government bonds, central bank bills, policy financial bonds, and high-grade credit bonds. MLF targets commercial banks and policy banks that meet the requirements of macro-prudential management. Primary dealers are de facto the main counterparty of MLF. Although MLF supplies funds to a subset of banks, it is used as a flexible instrument to "maintain the overall stability and moderate growth of bank system liquidity and support reasonable growth of monetary credit", according to the PBC's description.[6]

Pledged Supplementary Lending (PSL), instead, is designed to provide collateralized loans to only three policy banks[7] and is basically more a fiscal than a pure monetary policy instrument, which is why we focus on RRR cuts and MLF.

The importance of the two instruments has been widely recognized. RRR cuts are considered the most effective policy instrument in supplying liquidity and signaling PBC's commitment to expansionary monetary policy. To prevent a liquidity crunch, PBC launched a wave of RRR cuts in 2015Q1 and another one in 2018Q2. The PBC reduced the required reserve ratio from 20% to 17% and from 17% to 13.5%, respectively. Figure 1 shows that the two waves successfully reduced

[5]For example, the RRR was raised from 7.5% in 2006 to 21% in 2011 despite the global financial crisis; central bank bills were issued to absorb commercial banks' excessive liquidity.

[6]On its official website, the PBC introduces MLF as follows: "To maintain the overall stability and moderate growth of bank system liquidity and support reasonable growth of monetary credit, the central bank needs to continuously enrich and improve the tool combination based on the term, subject, and purpose of liquidity demand, in order to further improve the flexibility, specificity, and effectiveness of regulation."

[7]In practice, PSL has been mainly used to fund policy banks' special loans for shanty-town renovation

money market rates. On the other hand, MLF is considered a more moderate and flexible way to control the liquidity in the banking system and the PBC can use it at the monthly frequency.

A common feature of the two instruments that is central to our analysis is that they do not inject funds to banks according to their needs. RRR cuts inject funds proportional to banks' deposits, so banks with a higher share of deposits in liabilities are injected with relatively more funds. MLF injects funds to only a subset of banks called primary dealers, which we discuss below. Consequently, banks will likely have different shadow costs of funds after policy interventions. In this sense, Chinese monetary policy as uneven. Uneven monetary policy results in systematic funding imbalance within the banking system, so the subsequent reallocation of funds among banks constitutes a crucial part of monetary policy transmission.

2.2 The Banking System

Banks dominate the Chinese financial system. As of 2017, banking institutions' total assets amounted to 252 trillion RMB and accounted for 95% of all financial institutions' total assets. At that time, China's banking industry consisted of over 4000 commercial banks, including 6 state banks, 12 joint-stock commercial banks, 134 urban commercial banks, many rural commercial banks, private banks, and foreign subsidiary banks.

The 6 state banks are majority-owned by the central government and have similar business models.[8] Due to their large coverage of bank branches, state banks have considerable advantage in taking deposits at low deposit rates and focus on traditional financial intermediation between depositors and borrowers. Joint-stock banks are held mainly by non-state entities. Although joint-stock banks are not completely privately owned, the government holds significantly smaller stakes in them than in the state banks. Urban commercial banks and large rural commercial banks were formerly owned by local governments. During the 2000s, they were transformed into joint-stock banks, in which the local governments became the main but not necessarily dominant shareholders.

In addition to size differences, state and non-state banks also differ substantially in their objectives. Different from executives of non-state banks who are rewarded with pecuniary benefits according to banks' profitability, executives of state banks are essentially government officials and rewarded with promotion to higher positions in the government (Deng et al., 2011; Huang et al., 2020; Gao et al., 2020).[9] In addition to facilitating economic growth, maintaining the stability of the financial system is also one of their primary tasks. Hence, if lending becomes nonperforming or at-risk, the responsible executive in a state bank will be punished more harshly than that in a

[8] They include Big 4 state banks and two minor one. The Big 4 are the Industrial & Commercial Bank of China (ICBC), the China Construction Bank (CCB), the Bank of China (BoC), and the Agricultural Bank of China (ABC). The other two are the Bank of Communications and Postal Savings Bank of China.

[9] State banks' core executives are appointed, removed and re-assigned by the Organization Department of the CCP.

non-state bank. As shown in Figure 2, state banks have lower loan rates, lower non-performing loan ratios, and lower returns on bond investment. These observations suggest that state banks are more conservative in their investment than non-state banks. Such conservatism could be efficient if it reflects that the central government presses state banks to consider financial stability in addition to profitability. It could also be inefficient if it results from poor corporate governance.

As mentioned before, primary dealers play important roles in the current monetary policy framework. Similar to their counterparts in the U.S., primary dealers in China are trading counterparties of the PBC in its implementation of monetary policy. Primary dealers are selected by the PBC every year. As of 2022, the 49 primary dealers consist of 2 policy banks, 6 state banks, 39 non-state banks, and 2 security companies.

2.3 Interbank Markets

Since the implementation of Chinese monetary policy frequently induces systematic funding imbalance within the banking system, interbank markets that reallocate funds among banks and mitigate the imbalance are crucial to the efficient transmission of monetary policy. Traditionally, banks borrow and lend in three ways: interbank deposits, interbank placements, and repos. Throughout the paper, we term the three jointly as traditional interbank borrowing & lending. Figure 3 demonstrates traditional interbank borrowing & lending of different types of banks during the period from 2013 to 2019. Here we focus on banks with complete annual data from 2013 to 2019, so that bank entry and exit do not play a role. Traditional interbank borrowing & lending has been large and stable for an extended period of time. Notably, many banks, especially state banks, are heavily engaged in both borrowing and lending. We interpret this fact as an indication of large banks intermediating between banks and having market power. Because of search frictions and convenience, large banks can exploit substantial bid-ask spreads on these traditional interbank markets.

In addition to traditional interbank markets, NCDs were introduced at the end of 2013. An NCD is a non-secured, fixed-term certificate of deposit issued by depository institutions on the interbank market. The maturities of NCDs typically range from one to twelve months, with twelve months being the most popular. The NCD market is considered competitive because NCDs are tradable and have excellent secondary market liquidity (Amstad and He, 2020). As shown in Figure 4, since its inception in December 2013, the NCD market grew rapidly, reaching 10.7 trillion RMB by the end of 2019. At the very beginning, state banks were the biggest holders, but were later overtaken by rural commercial banks and mutual funds broadly defined including money market funds and wealth management products, which we will discuss in more detail below. On the issuance side, joint-stock and urban commercial banks are always the main issuers. Notably, state banks began to systematically issue NCDs in 2018 and have become net issuers in 2019. This latter fact seems at odds with the typical view that state banks have ample resources and provide funds for other banks.

Since the shift in state banks' interbank positions is crucial in our analysis, it is helpful to discuss the underlying forces. According to media coverage, decreasing growth in deposits was the primary force pushing state banks from the lending side on the NCD market to the borrowing side. What caused decreasing growth in deposits at that time? We speculate that money market funds and other similar money market products may play an important role.[10,11] In addition to reducing commercial banks' market power in deposits, MMFs help depositors circumvent the tight ceiling on deposit rates and facilitate interest rate liberalization. Figure 5 demonstrates the growth of banks' deposits and MMFs' total AUM since 2015m2. To assess the correlation between MMFs growth and banks' deposits in our sample period, we regress monthly year-over-year change in banks' deposits ($\Delta deposit\_yoy$) on that in MMFs' total AUM (Δmmf_yoy_t):

$$\Delta deposit\_yoy_{i,t} = \alpha + \beta \Delta mmf\_yoy_t + u_{i,t}. \tag{1}$$

Table 3 shows the results. Column (1) and (2) focus on the Big 4 state banks. The coefficient is -22% for the period up to 2019m12 and -27% for the period up to 2022m4. In Column (3) and (4), the coefficients for other banks are not significantly different from 0. This evidence is consistent with the idea that MMFs attracted deposits mainly from state banks. Notably, as shown in Figure 5, in the 18 months from 2017m1 to 2018m7, MMFs' total AUM ballooned from 3.6 trillion RMB to 8.6 trillion RMB. According to a back-of-envelop calculation using the estimates in Table 3, this boom in MMFs depressed the four big state banks' deposit growth by more than one trillion RMB. Complementary to our study, using proprietary data from a leading Chinese FinTech company, Buchak et al. (2021) provide causal evidence that MMFs attract deposits from households by offering more competitive interest rates.

3 A Simple Model of Chinese Banking System

Informed by these stylized fact, we now build a simple model of the Chinese banking system with an interbank market. We use the model to characterize the reallocation of funds injecting of

[10] Since its inception in 2003, the Chinese money market funds industry has witnessed rapid growth. As of Dec 2019, the total assets under management (AUM) of money market funds in China reached 7.1 trillion RMB and accounted for almost half of all funds. In 2022, the size further increased to 11 trillion RMB, making China's money market funds industry the world's second-large after the United States.

[11] Commercial banks and security companies in China issue an enormous number of wealth management products (WMPs) that raise money from individuals and institutions and make financial investment. A large fraction of WMPs channel funds through money markets and behave effectively like MMFs. Due to data availability, we cannot shed much light on WMPs. However, it is very likely that the impact of MMFs on the financial system we show is amplified by WMPs in practice.

funds into the banking system by the monetary authority and derive testable implications regarding interbank transactions and investments in the real economy.

The model consists of N_s symmetric state banks, N_{ns} non-state banks, and MMFs. The subscript "j" is used to denote all banks, "s" denotes state banks, and "i" non-state banks. There are two dates, 0 and 1. At date 0, banks borrow and lend on the interbank market and invest in firms. MMFs cannot invest in firms but can make profits by lending to banks on the interbank market. To focus on the transmission within the banking system, we assume MMFs are endowed with cash W that they fully lend to banks. At date 1, banks receive cash flows from firms and repay their loans. All players are risk neutral and do not discount future cash flows. The interbank market is competitive and all players take the interbank rate as given.

3.1 Setup

Table 1 sketches bank j's balance sheet at date 0.[12] Banks have three sources of funding. Deposits d_j and central bank borrowing m_j are exogenous to banks. Specifically, as a way to implement its monetary policy, the central bank injects funds to or withdraws funds from banks by changing central bank borrowing. For simplicity, we assume banks pay no interest on deposits and central bank borrowing. The third source is borrowing on the interbank market, which we denote by b_j.

On the asset side, banks must hold at least a fraction ρ of their deposits as cash. The central bank sets ρ as the required reserve ratio. Hence, banks' cash consists of required reserves ρd_j and excess reserves x_j. For the rest of their funds, banks can choose to lend to other banks on the interbank market and invest in firms, whose amounts are denoted by l_j and k_j respectively. Therefore, bank j faces the following budget constraint at date 0

$$\begin{aligned} \rho d_j + x_j + l_j + k_j &= d_j + m_j + b_j \\ \Leftrightarrow x_j + k_j + l_j - b_j &= (1-\rho)\, d_j + m_j. \end{aligned} \tag{2}$$

We refer to $e_j \triangleq (1-\rho)\, d_j + m_j$ as bank j's endowed funds, which are exogenous to banks. Without loss of generality, we assume banks do not borrow and lend at the same time. That is, either $l_j > 0 = b_j$ or $l_j = 0 < b_j$.

Non-state banks only care about their expected profits. Given the balance sheet at date 0, a non-state bank i's expected utility at date 1 is

$$[\rho d_i + x_i + \gamma(x_i)] + [R_k k_i - \eta\,(k_i)] + R_{IB}\,(l_i - b_i) - d_i - m_i. \tag{3}$$

By holding cash $\rho d_i + x_i$, the non-state bank earns 0 interest but earns the liquidity value of excess

[12] We assume 0 equity for simplicity.

Table 1: A bank's balance sheet at date 0.

Asset		Liability	
Required reserves	ρd_j	Deposit	d_j
Excess reserves	x_j	CB borrowing	m_j
IB lending	l_j	IB borrowing	b_j
Investment	k_j	Equity	0

reserve, $\gamma(x_i)$, where $\gamma(\cdot)$ is increasing and concave. By making an investment k_i, the non-state bank receives an expected payment of $R_k k_i - \eta(k_i)$ from firms, where $\eta(k_i)$ is increasing and convex in k_i, implying a decreasing return on investment. This property could originate from market power of banks on its local lending market, resulting in a downward-sloping demand curve for loans. The interbank rate, or the expected return of interbank lending, is denoted by R_{IB}. Hence, the non-state bank i receives $R_{IB}(l_i - b_i)$ for its position on the interbank market. $\gamma(\cdot)$, R_k, and $\eta(\cdot)$ are exogenously given, while R_{IB} is determined in equilibrium. Non-state banks pick (x_i, k_i, l_i, b_i) to maximize equation (3) subject to equation (2). Hence, the following first-order conditions characterize their equilibrium choices:

$$\begin{cases} 1 + \gamma'(x_i) = R_{IB}, \\ R_k - \eta'(k_i) = R_{IB}. \end{cases} \tag{4}$$

Since non-state banks borrow and lend at the rate of R_{IB} on the interbank market, their marginal benefit of holding excess reserves and of investments must be equal to R_{IB}.

On the other hand, state banks also care about the safety of their investment. Different from executives of non-state banks who are rewarded with pecuniary benefits according to banks' profitability, executives of state banks are essentially government officials and rewarded with promotion to higher positions in the government (Deng et al., 2011; Huang et al., 2020; Gao et al., 2020). In addition to facilitating economic growth, helping the central government maintain the stability of the financial system is also one of their primary tasks. Hence, if lending becomes nonperforming or at-risk, the responsible executive in a state bank will be punished more harshly than an executive in a non-state bank. To capture the concern for the safety of investment, we assume that state banks are similar to non-state banks except that they have an additional aversion $\delta_f(l_s)$ to interbank lending and $\delta_k(k_s)$ to investing in firms, where $\delta_f(\cdot)$ and $\delta_k(\cdot)$ are increasing and convex. Specifically, a state bank's expected utility at date 1 is

$$[\rho d_s + x_s + \gamma(x_s)] + [R_k k_s - \eta(k_s) - \delta_k(k_s)] + \left[R_{IB}(l_s - b_s) - \delta_f(l_s)\right] - d_s - m_s. \tag{5}$$

Hence, their equilibrium choices are characterized by the following first-order conditions:

$$\begin{cases} 1+\gamma'(x_s) = R_{IB} - \delta_f'(l_s)\cdot \mathbf{1}\{l_s>0\}, \\ R_k - \eta'(k_s) - \delta_k'(k_s) = R_{IB} - \delta_f'(l_s)\cdot \mathbf{1}\{l_s>0\}. \end{cases} \tag{6}$$

If state banks lend on the interbank market, their marginal benefit of holding excess reserves and that of investment must be equal to the interbank rate minus the derivative of their aversion to interbank lending. However, if state banks borrow on the interbank market, their aversion plays no role.

Given that we assume that banks have the same investment opportunity set $R_k k - \eta(k)$ and liquidity value $\gamma(x)$, we can alternatively interpret banks as bank branches. In this sense, the numbers of banks N_s and N_{ns} stand for the size of the state and the non-state banking sectors, respectively.

3.2 Parameterized Equilibrium

We assume the following parameterization of the model to solve for the equilibrium choices of banks explicitly:

- liquidity value: $\gamma(x) = \gamma x\left(\bar{x} - \frac{1}{2}x\right)$;
- the expected payoff of investment: $R_k k - \eta(k) = R_k - \frac{1}{2}\eta k^2$;
- state banks' aversion: $\delta_k(k) = \frac{1}{2}\delta_k k^2$, $\delta_f(f) = \frac{1}{2}\delta_f f^2$.

Here, $\gamma\bar{x}$ is sufficiently large so that banks all hold excess reserves in equilibrium. Applying the parameterization to banks' first-order conditions and budget constraints, we obtain Proposition 1.

Proposition 1. *Given the interbank rate R_{IB}, banks' equilibrium investment, excess reserves, and net interbank borrowing are given by:*

- *For non-state banks,*

$$k_i = \frac{R_k - R_{IB}}{\eta},$$
$$x_i = \bar{x} - \frac{R_{IB}-1}{\gamma},$$
$$b_i - l_i = k_i + x_i - (1-\rho)\,d_i - m_i.$$

- *For state banks,*

$$k_s = \frac{R_k - R_{IB}}{\eta + \delta_k} + \frac{\delta_f}{\eta + \delta_k} l_s \cdot \mathbf{1}\{l_s > 0\},$$
$$x_s = \bar{x} - \frac{R_{IB} - 1}{\gamma} + \frac{\delta_f}{\gamma} l_s \cdot \mathbf{1}\{l_s > 0\},$$
$$b_s - l_s = k_s + x_s - (1-\rho)\, d_s - m_s.$$

The last step is to pin down the interbank rate R_{IB} by imposing market clearing in the interbank market:

$$N_s\,(b_s - l_s) + \sum_{i=1}^{N_{ns}} (b_i - l_i) = W.$$

Denote the total deposits and total central bank borrowing of state banks by:

$$(D_s, M_s) = (N_s d_s, N_s m_s)$$

and those of non-state banks by:

$$(D_{ns}, M_{ns}) = \left(\sum_{i=1}^{N_{ns}} d_i, \sum_{i=1}^{N_{ns}} m_i\right).$$

Proposition 2. *Let R^1_{IB} be the solution to the following equation:*

$$N_s\left(\frac{R_k - R^1_{IB}}{\eta + \delta_k} + \bar{x} - \frac{R^1_{IB} - 1}{\gamma}\right) + \left(1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}\right) N_{ns}\left(\frac{R_k - R^1_{IB}}{\eta} + \bar{x} - \frac{R^1_{IB} - 1}{\gamma}\right)$$
$$= (1-\rho)\, D_s + M_s + \left(1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}\right)\left[(1-\rho)\, D_{ns} + M_{ns} + W\right]$$

and R^2_{IB} be the solution to:

$$N_s\left(\frac{R_k - R^2_{IB}}{\eta + \delta_k} + \bar{x} - \frac{R^2_{IB} - 1}{\gamma}\right) + N_{ns}\left(\frac{R_k - R^2_{IB}}{\eta} + \bar{x} - \frac{R^2_{IB} - 1}{\gamma}\right) = (1-\rho)\, D_s + M_s + (1-\rho)\, D_{ns} + M_{ns} + W.$$

- *If $\frac{R_k - R^2_{IB}}{\eta + \delta_k} + \bar{x} - \frac{R^2_{IB} - 1}{\gamma} < (1-\rho)\, d_s + m_s$, the equilibrium interbank rate is $R^*_{IB} = R^1_{IB}$.*
- *If $\frac{R_k - R^2_{IB}}{\eta + \delta_k} + \bar{x} - \frac{R^2_{IB} - 1}{\gamma} \geq (1-\rho)\, d_s + m_s$, the equilibrium interbank rate is $R^*_{IB} = R^2_{IB}$.*

To pin down the interbank rate, we need to figure out whether state banks lend or borrow on the interbank market. Proposition 2 follows the simple intuition that if state banks' endowed funds are more than the sum of their investment and excess reserves implied by Proposition 1, they will lend on the interbank market; in that case, state banks' equilibrium investment and excess reserves depend not only on the interbank rate but also on their interbank lending.

3.3 The Effects of Monetary Policy

In general, monetary policy affects a bank j's interbank position via two channels. First, monetary policy directly changes bank j's endowment of funds $(1-\rho)\,d_j + m_j$, and bank j responds to this change by adjusting its interbank position in the opposite direction, i.e.,

$$\frac{\partial\left(b_j - l_j\right)}{\partial\left[(1-\rho)\,d_j + m_j\right]} < 0.$$

This effect originates from the substitution between endowed funds and interbank positions and we refer to it as the substitution effect. Second, monetary policy moves the interbank rate and thus changes bank j's asset allocation. A loser (tighter) policy decreases (increases) the interbank rate. As a response, bank j increases (decreases) investment and excess reserves, which entails an adjustment in its interbank position, i.e.,

$$\frac{\partial\left(b_j - l_j\right)}{\partial R_{IB}} < 0.$$

We refer to this channel as the general equilibrium (GE) effect. Notably, due to their conservatism, state banks are affected by the GE effect to a lesser extent. Hence, their interbank positions are less responsive to the interbank rate than non-state banks.

Proposition 3. *State banks' interbank positions are less sensitive to the interbank rate than non-state banks:*

$$\left|\frac{\partial\left(b_i - l_i\right)}{\partial R_{IB}}\right| > \left|\frac{\partial\left(b_s - l_s\right)}{\partial R_{IB}}\right|.$$

3.4 Implications

Next, we derive implications for the transmission of monetary policy and its real effects. These implications serve two purposes. The first is to shed light on the transmission mechanism and the second is to guide our empirical design. Therefore, we focus on implications that we can test with our data. The first two implications concern the cross-sectional variation in banks' responses to Chinese uneven monetary policies through the substitution effect and the general equilibrium effect. Due to data availability, we focus on implications on banks' interbank borrowing. The last two implications concern the real effects of monetary policy. For any term z, let Δz represent its intertemporal change in z.

3.4.1 Medium-term Lending Facility

MLFs inject funds only to PD banks through central bank borrowing. Since PD banks contain all state banks and some non-state banks, we categorize banks into three groups: state banks, non-state PD (nspd) bank, and non-PD (npd) banks. Banks in the same group have the same intertemporal change in net interbank borrowing. We denote the change for each group by by $\Delta(b_s - l_s)$, $\Delta\left(b_{nspd} - l_{nspd}\right)$ and $\Delta\left(b_{npd} - l_{npd}\right)$, respectively.

Our first implication concerns how the change in MLF transmit from PD banks to other banks through the substitution effect.

Implication 1. *Consider banks that borrow on the interbank market. The substitution of endowed funds for interbank borrowing is the same for state banks and non-state PD banks:*

$$\frac{\partial \Delta b_s}{\partial \Delta e_s} = \frac{\partial \Delta b_{nspd}}{\partial \Delta e_{nspd}} = -1.$$

Consider banks that lend on the interbank market. The substitution of endowed funds for interbank lending is smaller for state banks than for non-state PD banks:

$$\frac{\partial \Delta l_s}{\partial \Delta e_s} < \frac{\partial \Delta l_{nspd}}{\partial \Delta e_{nspd}} = 1.$$

Banks' excess reserves and investment depend only on the interbank rate. Given the interbank rate, an increase in a bank's endowed funds induces a one-to-one decrease in its interbank borrowing. Hence, the substitution of central bank borrowing for interbank borrowing is -1 for all PDs. However, when state banks lend on the interbank market, their aversion to interbank lending is increasing in the amount of lending, so an increase in their endowed funds induces an increase in their interbank lending that is less than one-to-one. Hence, the substitution of central bank borrowing for interbank lending is smaller for state banks than for non-state PD banks. This point is crucial because it implies that state banks' conservatism prevents full reallocation of funds when state banks lend on the interbank market, but not when they borrow on the interbank market.

3.4.2 Required Reserve Ratio cuts

RRR cuts essentially inject funds to banks proportional to their deposits. To characterize this effect, we examine the relationship between banks' interbank borrowing and deposits.

Implication 2. *Suppose that banks with higher deposits are affected by the GE effect to a lesser extent. Absent other monetary policy shocks, interbank borrowing is more negatively correlated* *with deposits following RRR cuts. That is, for any two banks j_1 and j_2,*

$$\Delta \frac{b_{j_1} - b_{j_2}}{d_{j_1} - d_{j_2}} \Big/ \Delta\rho > 1.$$

Implication 2 states the negative correlation between interbank borrowing and deposits becomes stronger after RRR cuts. Consider any two banks j_1 and j_2 and suppose that j_1 has higher deposits than j_2. Then

$$\Delta \frac{b_{j_1} - b_{j_2}}{d_{j_1} - d_{j_2}} = \Delta\rho + \Delta R_{IB} \frac{\text{diff in GE}}{d_{j_1} - d_{j_2}}.$$

When j_1 and j_2 are equally affected by the GE effect (e.g., two non-state banks), only the substitution effect is operative. A lower ρ implies a stronger substitution between deposits and interbank borrowing, so interbank borrowing becomes more negatively correlated with deposits. When they are differently affected by the GE effect, the difference is also reflected in the correlation. Since RRR cuts result in lower interbank rates, banks that are less affected by the GE effect will increase their investment by less, which reduces their demand for funds. Hence, if banks with higher deposits are less affected by the GE effect, the difference in the GE effect makes the negative correlation between interbank borrowing and deposits stronger than implied by the substitution effect alone. For example, state banks have higher deposits and are also less affected by the GE effect due to conservatism.

3.4.3 Banks' Asset Allocation

Motivated by the fact that state banks move from the lending side on the NCD market to the borrowing side, we consider two scenarios. In Scenario 1, state banks are endowed with ample deposits so that they lend on the interbank market. In Scenario 2, state banks are endowed with limited deposits (probably due to the rise of MMFs), so that they borrow on the interbank market. In the two scenarios, the total available funds

$$(1-\rho)D_s + M_s + (1-\rho)D_{ns} + M_{ns} + W,$$

are the same.

Implication 3 concerns the intensive margin of banks' asset allocation by examining banks' asset allocation at the margin when their balance sheets expand. In Scenario 1, state banks' conservatism plays a role. Hence, as balance sheets expand, state banks allocate more to excess reserves or have lower utilization of funds than non-state banks. In Scenario 2, all banks follow the same allocation strategy.

Implication 3. *Given the interbank rate, as balance sheets expand, state banks allocate more (the* *same) to excess reserves or have lower (the same) utilization of funds than non-state banks in Scenario 1 (2). That is,*

$$\frac{\Delta x_s^1}{\Delta L_s^1} - \frac{\Delta x_i^1}{\Delta L_i^1} > 0 = \frac{\Delta x_s^2}{\Delta L_s^2} - \frac{\Delta x_i^2}{\Delta L_i^2},$$

where $L = m + (1-\rho)\,d + b$ represents the total liabilities less required reserves.

Further, Implication 4 concerns the level of banks' asset allocation, taking both intensive and extensive margin into account. In Scenario 1, state banks have ample endowed funds. However, due to state banks' aversion to interbank lending, the funds are not fully reallocated to non-state banks and stay on state banks' balance sheet. In Scenario 2, endowed funds are fully reallocated. The indicator of such full reallocation is that all banks have the same marginal shadow cost of investment and excess reserves. As a result, compared to Scenario 1, state banks have lower investment and excess reserves in Scenario 2, while non-state banks have larger investment and excess reserves. Comparing the lending of state and non-state banks in the two scenarios, Implication 4 uncovers the effects of the reallocation mechanism on the lending to the real economy.

Implication 4. *Compared with Scenario 1, state banks have smaller investment and excess reserves in Scenario 2, whereas non-state banks have greater ones. That is,*

$$k_i^2 - k_i^1 > 0 > k_s^2 - k_s^1,$$
$$x_i^2 - x_i^1 > 0 > x_s^2 - x_s^1.$$

3.4.4 Monetary Policy Implementation

Our last implication sheds light on the impact of money policy on aggregate lending. In Scenario 1, state banks' conservatism restrains their investment and also impedes resources from being reallocated to non-state banks. Therefore, injecting funds to non-state banks results in a higher total investment than injecting funds to state banks. In Scenario 2, state banks' conservatism plays no role, and no distributional consequences arise from injecting funds to any type of bank.

Implication 5. *Regarding the aggregate impact of monetary policy,*

- *in Scenario 1, injecting funds to non-state banks results in a higher total investment than injecting funds to state banks, i.e.,*

$$\frac{dTI^1}{d\left[(1-\rho)\,D_s + M_s\right]} < \frac{dTI^1}{d\left[(1-\rho)\,D_{ns} + M_{ns}\right]};$$

- *in Scenario 2, the identity of the banks that receive liquidity does not matter, i.e.,*

$$\frac{dTI^2}{d\left[(1-\rho)D_s+M_s\right]}=\frac{dTI^2}{d\left[(1-\rho)D_{ns}+M_{ns}\right]}.$$

4 Data And Summary Statistics

We now detail our data sources and provide summary statistics.

4.1 Data sources

We construct a bank-level dataset at the quarterly frequency from 2013Q4 to 2019Q4, which covers the period from the emergence of NCD until the outbreak of COVID-19. Quarterly bank balance sheet and income statement data are collected from the Wind database. Due to regulation, publicly listed banks and banks that intend to issue bonds on the interbank markets are required to disclose audited financial statements at a regular frequency. These disclosures can be found on banks' official website or on the National Interbank Funding Center. Disclosed bank information includes total assets, total liabilities, central bank borrowing, various interbank borrowing and lending, reserves, loans, financial investments, deposits, and ROA.

Data on NCD issuance are from the Wind database, which collects the information from the National Interbank Funding Center. For each NCD issued, we have information on issue volume, issuer bank, issuer credit rating, issue rate, issue date and term. We also obtain monthly NCD holdings and NCD outstanding balances aggregated at the bank-type level from the Shanghai Clearing House.

In terms of economy-wide data, GDP growth rates are from the PBC. Interbank market rates such as Shibor and R007 are from the National Interbank Funding Center. The total AUM of money market funds are collected from the Asset Management Association of China (AMAC). City level data such as lending, GDP, and population are from China City Statistical Yearbook. Data on firms listed in National Equities Exchange and Quotations (NEEQ) are from their annual reports.

4.2 Summary Statistics

Table 4 reports the summary statistics of banks' quarterly financial information. Banks are divided into three groups: state-owned banks (SOB), Non-state PD banks (NSPD) and non-PD banks (NPD). The sizes of banks across the three groups differ significantly. State banks have an average asset holdings of RMB 17,346.7 billion, which is about 6 (132) times larger than that for NSPD

(NPD). We scale other financial variables by banks' total assets in the previous quarter. NCD outstanding is the outstanding NCD balance issued by a bank at quarter end. IB net borrowing is a bank's interbank borrowing minus lending. Interbank lending is calculated as the sum of interbank deposits, interbank placement and repos on the asset side, and interbank borrowing is the sum of those on the liability side. CB borrowing is the balance of central bank borrowing. Excess reserves are calculated as total reserves minus the product of deposits and Required Reserve Ratios. Investment consists of loans and financial investment, where financial investment includes bonds, mutual funds, and account receivable investments. Liquid ratio is calculated as the percentage of liquid asset to total asset, where liquid assets include reserves and net repo assets.

Across the three groups, NSPDs have the highest relative level of NCD outstanding, which on average accounts for 8% of their total assets. This suggests that NSPDs engage most actively in NCD issuance. SOBs' NCD outstanding accounts for only 0.4% of their total assets on average, as SOBs rarely issued NCD until 2018. Among NPDs, urban commercial banks heavily rely on funding from the NCD market, but rural commercial banks do not. Taken together, NPDs' NCD outstanding on average accounts for about 5% of their total assets. Similar to NCD outstanding, NSPDs have the highest ratio of IB net borrowing and CB borrowing to total assets, while NPDs have the lowest ones. Compared to NSPDs and NPDs, SOBs have the highest deposits, excess reserves, ROA, and liquidity ratios, but lowest investment ratios. Overall, these patterns are consistent with the stylized facts we reported earlier.

5 Monetary Policy Transmission

As discussed before, Chinese uneven monetary policy implementation results in funding imbalance within the banking system and the transmission depends heavily on the reallocation of funds across banks. This section characterizes how the reallocation operates by testing the first two implications of Section 3.4. In Section 5.1 and Section 5.2, we exploit MLF to examine the substitution of allocated funds for interbank positions, which is central in the transmission of quantity-based monetary policy. In Section 5.3, we analyze the reallocation following RRR cuts.

5.1 MLF: substitution for IB borrowing

This subsection focuses on the substitution of banks' central bank borrowing for interbank borrowing. The first part of Implication 1 suggests that this substitution is one-to-one for all banks. To bring this prediction to the data, we estimate the following regression:

$$\Delta Y_{i,t} = \alpha_i + \lambda_t + \beta_1 \Delta cb\_borrow_{i,t} + \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}, \quad . \tag{7}$$

where the dependent variable $\Delta Y_{i,t}$ is the quarterly change in either NCD outstanding or IB net borrowing of bank i at time t. $\Delta cb\_borrow_{i,t}$ is the quarterly change in central bank borrowing. We include the following variables as controls:

- the lagged central bank borrowing $cb\_borrow_{i,t-1}$;
- deposit controls $D_{i,t} = \{RRR\_cut_t, RRR\_cut_t \times deposit_{i,t}, \Delta deposit_{i,t}\}$, where RRR_cut_t equals 1 if the Required Reserve Ratio falls at time t, $deposit_{i,t}$ is bank i's deposits at time t scaled by total asset in the last period, and $\Delta deposit_{i,t}$ is its quarterly change;
- fundamental controls $X_{i,t} = \{\Delta r_t, \Delta r_t \times NSB_i, NSB_i, GDPg_t, ROA_{i,t-1}, LIQ_{i,t-1}\}$, where Δr_t is the change in the interbank rate measured by the 3-month Shibor rate, NSB_i equals 1 if bank i is a non-state bank, $GDPg_t$ is the year-over-year GDP growth rate, $ROA_{i,t-1}$ and $LIQ_{i,t-1}$ are the lagged ROA and liquidity ratio, respectively;
- bank fixed effects and year fixed effects.

Since NCD was introduced recently and banks adopted it gradually over time, for each bank, we include the quarters since the first time that its NCD outstanding is greater than both 1 billion RMB and 0.1% of its total assets. We cluster standard errors by banks.

The substitution effect predicts a negative coefficient on $\Delta cb\_borrow_{i,t}$ in equation (7). However, other forces may also affect the correlation between interbank borrowing and central bank borrowing. Two potential sources of endogeneity exists. One is omitted variables such as banks' idiosyncratic demand for funds and the other is reverse causality in that banks adjust central bank borrowing in response to its actions on the interbank markets. To mitigate the endogeneity concerns, we instrument $\Delta cb\_borrow_{i,t}$ by the product of $PD_{i,t}$ and ΔMLF_t, where $PD_{i,t}$ is a dummy variable that equals 1 if a bank is a primary dealer (PD) at time t and ΔMLF_t is the quarterly change in the aggregate liquidity supply by MLF. This instrument is motivated by the observation that MLF supplies funds almost exclusively to primary dealers, so only their central bank borrowing responds to MLF. The specification is similar in spirit to a DiD framework or a Bartik instrument with exogenous shares (Autor et al., 2013; Goldsmith-Pinkham et al., 2020; Breuer, 2021; Borusyak et al., 2022), where PD banks are treated but non-PD banks are not. The validity of the aggregate liquidity supply by MLF as an instrument relies on the assumption that the central bank chooses aggregate MLF in response to the aggregate condition of the economy and the financial system, rather than cater to a subset of banks. This condition is consistent with the PBC's description that MLF is used to supply medium-term base money to "maintain the overall stability and moderate growth of bank system liquidity and support reasonable growth of monetary credit." The aggregate liquidity supply by MLF is unlikely correlated with the omitted idiosyncratic shocks to a bank's demand for funds and also helps mitigate the reverse causality concern that banks adjust central bank borrowing to the condition of interbank markets.

Since non-PD banks are not exposed to ΔMLF_t, the estimated $\hat{\beta}_1$ captures the average substitution of PD banks in the estimation. Panel A of Table 5 reports the results of model (7) when NCD outstanding is the dependent variable. As indicated by the F-statistics in the first stage, weak instruments are not a concern. For Column (1) and (2), we include only state banks and non-PD banks, so $\hat{\beta}_1$ is the estimate of state banks' substitution. The OLS estimate is not significantly different from 0, whereas the 2SLS estimate is close to -1 and significantly negative at the 1% level, consistent with Implication 2. In Column (3) and (4), we include only non-state PD banks and non-PD banks, and the estimates of non-state PD banks' substitution are very close to state banks'. As mentioned earlier, the OLS estimate could potentially be biased due to omitted variables. Among potential omitted variables, the most common one is banks' idiosyncratic demand for funds, which moves NCD issuance and central bank borrowing in the same direction. Omitted variables therefore attenuate the negative association induced by the substitution effect. The aggregate liquidity supply by MLF as an IV ameliorates this concern, allowing us to document the substitution effect.

Panel B of Table 5 shows the results for IB net borrowing. We observe significantly negative OLS estimates of $\hat{\beta}_1$ but insignificant 2SLS estimates. This pattern is different from that in Panel A of Table 5 but consistent with the previous discussion concerning the difference between the NCD market and traditional interbank markets. The NCD market is competitive, liquid, and thus used to accommodate various shocks. This feature makes NCD issuance responsive to other shocks such as banks' idiosyncratic demand for funds. In contrast, in traditional interbank markets, banks have market power due to information frictions and convenience. Hence, banks are more likely adjust other balance sheet items in response to traditional interbank markets. The OLS estimates in Panel B capture this reverse causality and thus imply a strong negative correlation compared to the 2SLS estimates.

According to Implication 2, state banks and non-state PD banks have the same substitution of central bank borrowing for interbank borrowing. To test the difference between them, we estimate the following equation in the sample consisting of all PD banks:

$$\begin{aligned}\Delta Y_{i,t} =& \alpha_i + \lambda_t + \beta_0 \Delta cb\_borrow_{i,t} \times NSB_i + \beta_1 \Delta cb\_borrow_{i,t} \\ &+ \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}. \end{aligned} \tag{8}$$

In addition to the regressors in equation (7), equation (8) includes $\Delta cb\_borrow_{i,t} \times NSB_i$, the product of the change in central bank borrowing with the non-state dummy. The coefficient β_0 captures the difference substitution patterns between state and non-state banks. We instrument $\Delta cb\_borrow_{i,t}$ and $\Delta cb\_borrow_{i,t} \times NSB_i$ by ΔMLF_t and $\Delta MLF_t \times NSB_i$. We again cluster standard errors by bank. Table 6 shows that the OLS and 2SLS estimates of β_0 are not significantly different from 0 for both NCD outstanding and interbank net borrowing as dependent variable.

Taken together, the results in Tables 5 and 6 suggest that banks respond to the liquidity supply by MLF mainly through NCDs, whereas traditional interbank borrowing and lending play insignificant roles. The estimated magnitude of the substitution of central borrowing for NCD outstanding is close to the model prediction and does not differ significantly between state and non-state banks.

5.2 MLF: Substitution for Interbank Lending

The second part of Implication 1 states that the substitution of central bank borrowing for interbank lending is stronger for non-state PD banks than for state banks. This point is crucial because it implies that state banks' conservatism prevents full reallocation of funds when state banks lend on the interbank market. This subsection tests this implication.

The unavailability of granular bank-level NCD holding data imposes the first challenge for testing this implication. Instead, we must resort to the monthly NCD holding data that are aggregated at the bank type level published by the Shanghai Clearing House. Specifically, we can observe the total monthly NCD holding of state banks (SOB), joint stock banks (JSB), urban commercial banks (UCB), rural commercial banks (RCB), and other banks, respectively. Given the small cross section and the short sample period, we resort to a monthly frequency for statistical power. The second challenge is that only the total central bank borrowing of the Big 4 state banks and that of all non-state banks are available at a monthly frequency, so we cannot exactly match banks' interbank lending and central bank borrowing, which may lead to biased estimates.

Empirically, we estimate the following model:

$$\begin{aligned}\Delta NCD\_holding_{i,t} =& \alpha_i + \lambda_t + \beta_0 \Delta cb\_borrow_{i,t} \times NSB_i + \beta_1 \Delta cb\_borrow_{i,t} \\ &+ \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}.\end{aligned} \tag{9}$$

Model (9) is similar to model (8) except that the dependent variable is the monthly change in NCD holdings, $\Delta NCD\_holding_{i,t}$. The coefficient β_0 captures the difference between state and non-state banks in the substitution for interbank lending. We still instrument $\Delta cb\_borrow_{i,t}$ and $\Delta cb\_borrow_{i,t} \times NSB_i$ by ΔMLF_t and $\Delta MLF_t \times NSB_i$.

For state banks, we match the total central bank borrowing of the Big 4 state banks with the total NCD holding of state banks. Note that state banks consist of the Big 4 and two smaller banks, which are all PD banks. Effectively, the levels and the variation of state banks' central bank borrowing are underreported, resulting in state banks' substitution being systematically overestimated or biased towards $+\infty$. For non-state PD banks, we match the total central bank borrowing of non-state banks with the total NCD holding of joint stock banks and urban commercial banks.

Ideally, for the total NCD holding, we include only the NCD holdings of all non-state PD banks and not that of any non-PD bank. Non-PD banks are only affected by the GE effect that leads to a negative correlation between banks' NCD holding and the aggregate liquidity supply by MLF. Including non-PD banks' NCD holding in the estimation will not only add noise but also attenuate the estimate of non-state banks' substitution. In light of this consideration, we include only joint stock banks (JSB) and urban commercial banks (UCB), because most banks of other types are not primary dealers.[13] It is worth noting that non-state PD banks' substitution is systematically underestimated or biased towards 0 because we exclude primary dealers among rural commercial banks (RCB) and other banks and include some non-PD banks. Due to imperfect matching, $\hat{\beta}_0$ is biased towards 0, which makes it harder to reject the null hypothesis of no difference.

Table 7 reports the estimates of equation (9). Again, the instruments are not weak. Columns (1) and (2) test the difference in substitution for NCD holding between state banks and non-state PD banks. The OLS estimate of β_0 is 0.294 and significantly positive at the 1% level, whereas the 2SLS estimate is 0.289 and significantly positive at the 5% level. As discussed earlier, state banks' substitution is systematically overestimated, whereas non-state PD banks' substitution is systematically underestimated. The estimates suggest that non-state PD banks' substitution for NCD holding is stronger than the substitution for state banks' by at least 29%.

As a comparison, we also estimate model (9) using as the dependent variable the monthly NCD outstanding at the bank type level (also published by Shanghai Clearing House). In Columns (3) and (4) of Table 7, both OLS and 2SLS estimates suggest no significant difference exists between state banks and non-state PD banks in their substitution for outstanding NCD. This finding is consistent with the results in Table 6, which are estimated using bank-level quarterly NCD outstanding.

5.3 RRR Cuts

In this subsection, we characterize the reallocation of funds following RRR cuts. In our sample period, two waves of RRR cuts occurred, one starting in 2015Q1 and the other starting in 2018Q2. According to Implication 2, after RRR cuts, interbank borrowing will be more negatively correlated with deposits because of a stronger substitution of deposits for interbank borrowing; if banks with higher deposits are affected by the GE effect to a smaller extent, then the GE effect further enhance the negative correlation.

To test this implication, we study the two waves as two separate events and adopt a DiD framework, in which RRR cuts are the shocks and a bank's deposit determines the magnitude of the

[13] According to the Wind Database, in 2019, 11 of 12 joint stock banks, 18 of 121 urban commercial banks, 5 of 1581 rural commercial banks, and 4 of 59 other banks are primary dealers.

treatment. Specifically, we estimate the following model:

$$Y_{i,t} = \lambda_t + \beta_1 RRR\_cut_t \times deposit_{i,t} + \beta_2 deposit_{i,t} + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}. \quad (10)$$

Here, the dependent variable $Y_{i,t}$ is either NCD outstanding or interbank net borrowing. RRR_cut_t is a dummy variable that equals 1 for quarters with cuts in RRR. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control for other monetary policy shocks. Fundamental controls are the same as in equation (7). To eliminate the influence of banks' entry and exit, we include only banks with observations right before the two waves of RRR cuts. We cluster standard errors at the bank level.

Many factors potentially affect the relationship between banks' interbank borrowing and deposits. Valid inference requires that this relationship is stable before a wave of RRR cuts comes into effect and that the relationship had stayed stable absent the wave of RRR cuts, which is of course untestable. To test for parallel trends before the RRR cuts, we replace RRR_cut_t in model (10) with quarter dummy variables $Q_{\tau,t}$ that equals 1 if $t = \tau$ and estimate the following model:

$$\begin{aligned} Y_{i,t} =& \lambda_t + \sum_{\tau=-4}^{-2} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \sum_{\tau=0}^{5} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \beta_2 deposit_{i,t} \\ &+ \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}. \end{aligned} \quad (11)$$

For each wave of RRR cuts, the quarter of the first cut is labeled quarter 0. Model (11) includes four quarters before the wave and six quarters since the start of the wave and uses as the benchmark quarter -1, the quarter right before the wave. To the extent we find parallel trend before the shock, our identifying assumption then becomes that absent the shock, the relationship had stayed stable.

For the first wave of RRR cuts, which started in 2015Q1, we do not observe any strong and clear pattern regarding either NCD outstanding or interbank net borrowing before or after the start of the wave. The unresponsiveness of interbank net borrowing is not surprising in light of our previous finding that traditional interbank borrowing & lending are fairly insensitive to policy shocks. The unresponsiveness of NCD outstanding is likely due to the fact that the NCD market was only established recently and still not fully liquid. As shown by Figure 4, by the end of 2015Q3, the size of the NCD market was about 2.5 trillion RMB, which was quite small compared to its later levels. In addition, many banks were granted the permission to issue NCDs only during 2014 and 2015. Moreover, learning how to use NCD efficiently might also take time. Therefore, we relegate the results regarding the first wave of RRR cuts to Appendix C.

For the second wave of RRR cuts, we label 2018Q2 as quarter 0. Panel A of Figure 6 plots the estimates of $\beta_{1,\tau}$ and their 95% confidence intervals with NCD outstanding being the dependent variable. In the four quarters leading up to 2018Q2, the estimates of $\beta_{1,\tau}$ are economically and statistically not different from 0, which suggests a stable relationship between NCD outstanding and deposits before the start of the second wave. Starting in 2018Q2, the estimates of $\beta_{1,\tau}$ become significantly negative, building up for three quarters and staying negative for five quarters, consistent with the prediction of Implication 2.

Panel B of Figure 6 plots the estimates of $\beta_{1,\tau}$ with interbank net borrowing as dependent variable. No clear pattern emerges and for most of the ten quarters around 2018Q2, the estimates are not significantly different from zero. Therefore, similar to the earlier results regarding MLF and the first wave of RRR cuts, we do not observe any clear cut reaction in interbank net borrowing.

We confirm these results in Table 8. To ensure the robustness of the results, we consider the time windows including 3 quarters before the treatment and 1, 2, or 3 quarters afterwards. The first three columns report the estimates for NCD outstanding. The estimates of β_1 range from -9% to -11% across various windows and are significantly negative at the 1% level. Since this wave of cuts reduced all banks' RRR by 3.5%, the substitution effect alone implies a coefficient of -3.5% if banks correctly anticipated the eventual size of this wave of RRR cuts. Hence, the point estimates close to -9% are relatively large and likely reflect difference in the GE effect across banks as well.

State banks and banks in less developed areas tend to have higher deposits than other banks. To some extent, their high deposits result from a relatively lack of investment opportunities, so they do not expand balance sheets through other sources of funding. As shown in Table 4, state banks and non-PD banks have higher deposits and lower investments than non-state PD banks. By and large, banks with higher deposits tend to be less aggressive in investment. When RRR cuts lower the interbank rate, all banks increase investment, but banks with higher deposits respond less aggressively, which results in lower interbank borrowing. Such difference in the GE effect further enhances the negative correlation between deposits and interbank borrowing.

The key to our DiD analysis is that the relationship between banks' interbank borrowing and deposits absent RRR cuts is fully determined by our model. As a robustness check, we add fixed effects to account for a potentially nonlinear relationship between them. Specifically, we divide banks into ten deciles based on their deposits in 2018Q1, the quarter right before the second wave, and add decile fixed effects. Figure 11 and Table 14 in Appendix C show the estimation results of the model with decile fixed effects, which are qualitatively similar to those in Figure 6 and Table 8.

6 Bank's Lending to the Real Economy

In the previous section, we provide empirical evidence for the reallocation mechanism proposed by the model. According to the model, in Scenario 1, in which state banks are endowed with ample funds and lend on the interbank market, their conservatism impedes the reallocation of funds to non-state banks, whereas in Scenario 2, in which state banks are endowed with limited funds and borrow on the interbank market, their conservatism plays no role, and the efficiency of monetary policy transmission improves. Next, we assess the effects of the reallocation mechanism on banks' asset allocation and the lending to the real economy.

Figure 4 shows that state banks began to systematically issue NCDs in 2018 and have become net issuers since 2019, suggesting that they were moving from the lending side of the interbank market to the borrowing side. Table 3 and Figure 5 indicate that a boom in MMFs in 2017 and 2018 that dampened state banks' deposit growth could be a driving force behind this change.[14] Mapping this shift to our model, we interpret the periods before and since 2018 as Scenarios 1 and 2, respectively. Our empirical strategy is then to test Implications 3 and 4 by comparing the two subsamples before and after 2018.

6.1 Banks' asset allocation

Concerning banks' use of funds, Implication 3 states that an expansion in banks balance sheets results in state banks allocating more resources to excess reserves than non-state banks in Scenario 1, whereas all banks follow the same allocation strategy in Scenario 2. We test Implication 3 by examining how banks' excess reserves change when their balance sheets expand. Specifically, we estimate the following model (12)

$$\Delta xreserve_{i,t} = \alpha_i + \lambda_t + \beta_1 \Delta assest_{i,t} + \beta_2 \Delta asset_{i,t} \times NSB_i + \gamma X_{i,t} + u_{i,t}. \tag{12}$$

Here, the dependent variable $\Delta xreserve_{i,t}$ is the change in excess reserves scaled by lagged total assets of bank i at time t over the subsequent one or two quarters, respectively. We calculate excess reserves as cash holdings minus the product of RRR and deposits.[15] $\Delta asset_{i,t}$ is the quarterly change in total assets scaled by lagged total assets. The product of $\Delta asset_{i,t}$ and NSB_i is included to capture the difference between state and non-state banks. Fundamental controls $X_{i,t}$ are the same as in equation (7). We also control for bank fixed effects and quarter fixed effects. Standard errors are clustered by banks. We run the regressions in the full sample and the two subsamples before and since 2018.

Columns (1) to (3) report the results for the one quarter change, $\Delta xreserve_{i,t}$. Column (1) shows that in the full sample, non-state banks have a significantly lower tendency to allocate resources to

[14] Buchak et al. (2021) provide causal evidence that MMFs in China attract households' deposits from banks by offering more competitive interest rates.

[15] We find that for the quarter right before a RRR cut, banks may hold reserves according to the post-cut RRR rather than the actual RRR in that quarter. This inconsistency can be detected at year ends for some banks because they disclosed the RRR they used in their annual reports. So far, we have not been able to systematically correct the inconsistency. Consequently, banks' excess reserves are underestimated and appear to be negative in some cases.

excess reserves than state banks. Following a one unit increase in total assets, non-state banks tend to allocate 22.6% less to excess reserves than state banks. Columns (2) and (3) show the difference between the two types of banks shrinks from 25.5% to 10.7% and becomes much less significant across the two subsamples. This pattern becomes sharper if we look at $\Delta xreserve_{i,t}$ in a longer window of two quarters. Before 2018, state banks keep 23.2% as excess reserves even over the subsequent two quarters, but they keep only 5.9% since 2018. Hence, the difference between the two types of banks almost vanishes.

Concerning the level of banks' asset allocation, Implication 4 states that moving from Scenario 1 to Scenario 2, non-state banks have a higher growth in lending and excess reserves than state banks. We test this implication in a DiD framework. Specifically, we estimate the following model using a yearly sample of banks:

$$log\left(Y_{i,t}\right) = \beta_1 \left(after_t \text{ or } NCD\_outstanding\_SOB_t\right) \times NSB_i + \alpha_i + \lambda_t + u_{i,t}. \quad (13)$$

Here, the dependent variable $log\left(Y_{i,t}\right)$ is either the log of loans ($log\left(loan_{i,t}\right)$) or the log of relative excess reserve ($log\left(rxreserve_{i,t}\right)$) of bank i in year t. We calculate relative excess reserve as the ratio of reserves to required reserves.[16] $after_t$ is a dummy variable that equals 1 since the year 2018. $NCD\_outstanding\_SOB_t$ is the total of state banks' NCD outstanding in year t, which is a direct measure for the shift from Scenario 1 to 2. We also control bank fixed effects and year fixed effects. We cluster standard errors at the bank level. Implication 4 predicts the coefficient β_1 is positive.

To test the parallel trend assumption, we replace $after_t$ in equation (13) with year dummies. We look at years from 2013 to 2020 and use the year 2017 as benchmark. Figure 7 reports the estimates of β_1. We see in Panel A that in the five years leading up to 2018, the difference in lending between state and non-state banks is stable. However, since 2018, non-state banks experienced significantly higher growth. This pattern coincides with the increase in state banks' NCD outstanding, which increased dramatically since 2018. Relative excess reserves in Panel B follow a similar pattern.

Table 10 reports the estimation results of equation (13) using the yearly sample from 2016 to 2019. Column (1) and (2) show that with the log of bank loans being the dependent variable, the estimates of β_1 are significantly positive at the 1% level for both specifications of equation (13). The economic magnitude of the effect is large. Column (1) suggests that since 2018, non-state banks' lending growth increased by 12.5% compared to state banks'. Column (2) suggests that as state banks increase NCD outstanding by 1 trillion RMB, non-state banks' lending growth relative to state banks increased by 9.5%. We want to stress that in this setting, state banks' NCD

[16] As discussed in Footnote 15, excess reserves are underestimated and appear to be negative in some cases. Taking the log of excess reserves will result in some observations being dropped. Hence, we use relative excess reserves instead.

outstanding just serves as an indicator of state banks' funding condition and does not drive the difference in lending growth. Column (3) and (4) show the results for the log of relative excess reserve. Similar to bank loans, non-state banks' growth in relative excess reserve was on average 12.6% higher than for state banks since 2018, and as state banks increase NCD outstanding by 1 trillion RMB, non-state banks' growth relative to state banks increased by 6.3%.

In general, it is hard to evaluate the overall efficiency of the banking system from an ex-ante perspective. However, systematically holding large excess reserves is a likely indication of inefficiency. With respect to this indicator, Table 9 suggests that when more resources are directed to non-state banks, the utilization of funds in the banking system improves. As we have discussed in Section 2.3, MMFs and other similar investment vehicles may contribute to this improvement by attracting deposits from state banks and channel them to non-state banks. Table 10 suggests that state banks' funding conditions are informative about bank lending. This result is consistent with the model intuition that the endowment of financial resources such as central bank funds and deposits affects the eventual distribution of financial resources across banks.

6.2 City-level lending

In practice, banks usually have different customer bases due to informational and operational frictions, so different banks are not perfect substitutes for borrowers. Hence, the eventual distribution of financial resources across banks matters for borrowers. Through this channel, the reallocation mechanism affects the lending to the real economy. In this subsection, we provide city-level evidence for this effect. The previous analysis on banks' asset allocation implies that as state banks moved to the borrowing side of the interbank market in 2018, non-state banks' lending grew faster than state banks'. A further implication is that cities with more exposure to non-state banks should witness higher lending growth since 2018.

We obtain cities' lending and other information from China City Statistical Yearbook. As a first step, we need to construct a measure for cities' exposure to non-state banks. For each city, we only have data on aggregate lending. However, the list of all bank branches and their locations are public. Therefore, we resort to the numbers of bank branches in a city to measure banks' influence and use the fraction of non-state bank branches in a city to measure the city's exposure to non-state banks. Specifically, we focuses on branches of state banks, joint-stock banks, and urban commercial banks, because their branches are active in lending, whereas many branches of rural commercial banks and other banks mainly take deposits. Hence, we use data in year t to measure a city's exposure to non-state banks in year t as follows:

$$fraction_{city} \triangleq \frac{\#JSB_{city} + \#UCB_{city}}{\#JSB_{city} + \#UCB_{city} + \#SOB_{city}}. \tag{14}$$

We adopt a DiD framework and estimate the following model using a yearly sample of cities:

$$\begin{aligned} log\left(lending_{city,t}\right) =& \beta_1 \left(after_t \text{ or } NCD\_outstanding\_SOB_t\right) \times fraction_{city} \\ &+ \beta_2 fraction_{city} + \alpha_{province} + \lambda_t + \gamma CX_{city,t} + u_{city,t}. \end{aligned} \tag{15}$$

Here the dependent variable is the log of a city's lending in year t. $after_t$ is a dummy variable that equals 1 since 2018. $NCD\_outstanding\_SOB_t$ is the total of state banks' NCD outstanding in year t. To account for endogenous changes in bank branches, we fix $fraction_{city}$ right before the start of our the sample period. Fundamental controls at the city level $CX_{i,t}$ include the log of GDP ($log\left(GDP_{city,t}\right)$), the log of population ($log\left(population_{city,t}\right)$), the primary sector GDP share ($primary\_sector_{city,t}$), and the secondary sector GDP share ($secondary\_sector_{city,t}$). We also include province fixed effects and year fixed effects. Standard errors are clustered at the city level.

To test the parallel trend assumption, we replace $after_t$ in equation (15) with year dummies. With $fraction_{city}$ calculated using data in 2012, we look at years from 2013 to 2020 and use the year 2017 as omitted category. Figure 8 reports the estimates of β_1. In the five years leading up to 2018, the correlation between the log of a city's lending and the fraction of non-state banks is stable, so the parallel trend assumption is likely to hold. In the three years since 2018, the correlation becomes significantly more positive, indicating that cities with more exposure to non-state banks experienced higher growth in lending since 2018.

Table 11 shows the estimation results of equation (15) using a yearly sample from 2016 to 2019. Columns (1) and (2) report the estimates when $fraction_{city}$ is calculated using data in 2012. The significantly positive estimates of β_1 imply that since 2018, when state banks began to borrow on the NCD market, cities with more exposure to non-state banks have significantly higher growth in lending than others. As shown in Columns (3) and (4), the results are robust if we calculate $fraction_{city}$ using data from 2015 instead. Since the standard deviation of $fraction_{city}$ in 2012 (2015) is 0.096 (0.11), the point estimate of 0.23 (0.163) in Column (1) ((3)) implies that if a city's exposure as measured by $fraction_{city}$ increases by one standard deviation, its lending growth increases by 2.2% (1.8%). Even though $fraction_{city}$ is only a crude proxy for a city's exposure to non-state banks, our estimates still implies sizable impacts of the reallocation mechanism on city-level lending.

6.3 Firm-level Lending

Finally, we provide firm-level evidence suggesting that the reallocation mechanism affects the lending to the real economy. A corollary of Implication 4 is that firms that borrow both from state and non-state banks should receive higher fractions of lending from non-state banks since 2018.

We test this prediction using the sample of firms listed in the National Equities Exchange and

Quotations (NEEQ) system. NEEQ is a stock exchange for small and medium-sized enterprises (SMEs) and requires firms to fully disclose their borrowing activities.[17] We focus on loans granted after 2013 by state banks, joint stock banks, urban commercial banks, and rural commercial banks. We use a firm's average daily balance (ADB) of loans to characterize its overall borrowing in a period. To measure loan composition, we calculate the fraction of the average daily balance of loans from non-state banks to that from non-state and state banks as follows:

$$NSB\_Fraction_{i,t} \triangleq \frac{\text{firm } i\text{'s ADB of loans from NSBs in period } t}{\text{firm } i\text{'s ADB of loans from NSBs and SOBs in period } t}. \tag{16}$$

We restrict the sample to firms whose ADBs of loans from state banks and non-state banks both exceed 25 million RMB in at least one quarter by the end of 2016. We impose this restriction for two reasons. First, the loan composition of firms that actively borrow from both state and non-state banks is a better indicator for the change in loan supply from state and non-state banks than that of other firms. Second, including only firms with large amounts of loans helps to avoid the influence of policies targeted directly to SMEs. In our sample period, the PBC had various policies to funnel loans to SMEs.[18] Meanwhile, news reports suggest that to control their risk exposure to SMEs, banks reduce loans to SMEs that do not qualify as SME loans. The selected firms' total ADB accounts for 47% of all firms'.

We estimate the following model using a yearly sample of firms:

$$NSB\_Fraction_{i,t} = \alpha_i + \beta_1(after_t \text{ or } NCD\_outstanding\_SOB_t) + u_{i,t}. \tag{17}$$

We add firm fixed effects and cluster standard errors at the firm level. Similar to our previous analyses, we replace $after_t$ in model (17) with year dummies. We look at years from 2014 to 2020 and use the year 2017 as omitted category. Figure 9 reports the estimates of β_1. $NSB\_Fraction_{i,t}$ is stable in the four years leading up to 2018, but increases significantly in the three years since 2018. Figure 9 suggests that there is no significant time trend before 2018.

Table 12 shows the estimation results. The first two columns report the estimates for all eligible firms. The estimate in Column (1) suggests that the fraction of loans from non-state banks increases by 4.3% since 2018. The estimate in Column (2) suggests that as state banks increase NCD outstanding by 1 trillion RMB, the fraction of loans from non-state banks as measured by $NSB\_Fraction_{i,t}$ increases by roughly 3.5% since 2018. Both estimates are significantly positive at the 1% level. Column (3) to (6) show the results for the sample of non-state-owned enterprises

[17] The main board of the Chinese stock market does not require full disclosure of borrowing activities, so for firms listed there, we do not have access to a complete profile of their borrowing activities.

[18] A bank's loan to a firm qualifies as a SME loan if the firm has a total credit line smaller than 10 million RMB with the bank.

(non-SOEs) and the sample of state-owned enterprises (SOEs). The estimates regarding SOEs in Column (5) and (6) are not significantly different from 0, suggesting that the increase mainly comes from non-SOEs. However, this could also be due to the smaller sample size for SOEs in NEEQ.

7 Conclusion

We document several stylized facts about the conduct of monetary policy in China and the Chinese banking system and informed by the facts, we build a simple model characterizing the reallocation mechanism following quantity-based monetary policy instruments through the Chinese banking system. We document the existence of two forces driving the reallocation of funds after monetary policy interventions. One is the substitution effect: Banks substitute funds injectd by monetary policy for interbank borrowing and lending. The other is the general equilibrium effect: Monetary policy moves the interbank market rate and further affects banks' asset allocation. State banks are conservative in investment in firms and lending to other banks, which impedes the monetary policy transmission mechanism when state banks have ample resources and lend on the interbank market.

Empirically, we test the model's implications using data in the period from 2013 to 2019. We show that while state and non-state PD banks have a similar degree of substitution of central bank borrowing for interbank borrowing, non-state PD banks have a stronger substitution of central bank borrowing for interbank lending. The substitution effect operates through the NCD market, but not through other relatively traditional interbank markets. Employing a shift in state banks' positions on the NCD market, we find that the reallocation mechanism has considerable effects on banks' asset allocation and the lending to the real economy. Our analysis demonstrates that the endowment of financial resources affects the distribution of resources across banks and ultimately in the real economy. To improve the efficiency of the monetary transmission mechanism and the eventual allocation of financial resources, monetary policy instruments should be designed to avoid and eliminate funding imbalances within the banking system. Facilitating financial liberalization, e.g. through MMFs, could be one step towards that goal.

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Appendix

A Tables and Figures

Table 2: PBC monetary policy instruments

This table lists the quantity based instruments used extensively by PBC from 2013 to 2019. The purpose, liquidity receivers, terms, types of collaterals, balance by September 2022 (in trillion RMB) of the instruments are also presented.

		Purpose	Liquidity receivers	Term	Collateral	Balance in 2022.9
MLF	Medium-term lending Facility	Supply base money over the medium term	banks that meet the requirements of macro-prudential management	3-12 months	High-quality bonds	4.55 tn
PSL	Pledged supplementary lending	Provide fund for rural and urban development	Policy banks	Normally > 3 years	High-quality bonds and loans	2.65 tn
Re-lending		Support agriculture, small enterprises in the private sector, and loans related to green causes, technology innovation, pension and logistics	All banks			2.35 tn
Re-discount		Support commercial activities in important industries, especially agriculture, small and medium enterprises, and the private sector	All banks		Commercial drafts	0.54 tn
RRP	Open market operation through reverse repo	Provide short term liquidity for financial institutions	Primary dealers	7-14 days	Treasury bonds	0.97 tn
CB FX holding	Central bank foreign exchange holding	Sustain FX reserve and exchange rate, provide RMB liquidity	Primary dealers			21.31 tn
RRR	Required Reserve ratios in both RMB and FX	Supply base money through RRR cut	All banks			12.34 tn
SLF	Standing lending facility	Discount window liquidity upon request	All banks		High-quality bonds and loans	0 tn
TMLF	Targeted medium term lending facility	Provide medium -term liquidity to support private sector and SMEs	Primary dealers	1-3 years		0 tn

Table 3: Deposits and money market funds

This table estimates the impact of MMF growth on deposit as follows,

$$\Delta deposit\_yoy_{i,t} = \alpha + \beta \Delta mmf\_yoy_t + u_{i,t},$$

where Δmmf_yoy_t and $\Delta deposit\_yoy_{i,t}$ are the year -over-year change in MMF' total AUM and the deposit of bank i at month t respectively. Samples are divided to the four big state banks including the Industrial & Commercial Bank of China (ICBC), the China Construction Bank (CCB), the Bank of China (BoC), and the Agricultural Bank of China (ABC), and other banks separately. Estimations are run over two sample periods, both of which starts from December 2013 and ends by December 2019 or April 2022, respectively.

	Big 4		Others	
	(1)	(2)	(3)	(4)
	Up to 2019m12	Up to 2022m4	Up to 2019m12	Up to 2022m4
Δmmf_yoy_t	-0.224***	-0.266*	0.097	0.116
	(0.074)	(0.135)	(0.120)	(0.154)
Constant	4.431***	5.378***	9.958***	10.862***
	(0.136)	(0.222)	(0.220)	(0.254)
Observations	47	75	47	75
R-squared	0.169	0.050	0.014	0.008

Table 4: Descriptive statistics

This table shows the summary statistics of banks' quarterly financial information from 2013Q4-2019Q4. Banks are categorized into three groups as state-owned banks (SOB), Non-state PD banks (NSPD) and non-PD banks (NPD). Assets are banks' total assets at ends of quarters, and other balance sheet variables are scaled by assets. NCD outstanding is the outstanding NCD balance issued by a bank by a quarter end. IB net borrowing is a bank's interbank borrowing minus lending. Interbank lending is calculated as the sum of interbank deposits, interbank placement and repos on the asset side, and interbank borrowing is the sum of those on the liability side. CB borrowing is the balance of central bank borrowing. Excess reserves are calculated as total reserves minus the products of deposits and required reserve ratios. Investment consists of loans and financial investment, where financial investment includes bond, mutual fund, and account receivable investments. Liquid ratio is calculated as the percentage of liquid asset to total asset, where liquid assets include reserves and net repo assets.

	N	mean	sd	p25	Median	p75
Panel A: State						
Assets (billion yuan)	139	17346.76	6446.03	9932.88	18349.49	22209.78
NCD outstanding/assets (%)	139	.38	.81	0	.04	.3
IB net borrowing/assets (%)	139	3.45	4.68	.82	3.41	5.41
CB borrowing/assets (%)	139	1.77	1.89	0	1.47	2.53
Deposits/assets (%)	139	75.65	8.29	72.02	75.9	79.24
Excess reserve/assets (%)	139	.94	.93	.2	.98	1.53
Investment/assets (%)	139	77.91	3.48	75.98	78.04	80.53
ROA (%)	139	.68	.32	.37	.64	.92
Liquid ratio (%)	139	14.46	3.16	12.23	14.33	16.38
Panel B: Non-state PD (NSPD)						
Assets (billion yuan)	426	2637.88	2143.85	657.31	2016.62	4357.33
NCD outstanding/assets (%)	426	8.23	4.84	4.71	8.56	11.42
IB net borrowing/assets (%)	426	10.07	7.6	5.31	9.41	14.59
CB borrowing/assets (%)	426	2.24	2.06	.29	1.69	3.93
Deposits/assets (%)	426	61.74	7.37	56.71	61.41	66.43
Excess reserve/assets (%)	426	.66	1.11	-.06	.41	1.1
Investment/assets (%)	423	81.79	7.31	78.66	83.67	86.55
ROA (%)	426	.58	.27	.34	.56	.77
Liquid ratio (%)	426	10.11	5.76	6.35	8.56	11.39
Panel C: Non-PD (NPD)						
Assets (billion yuan)	1948	131.55	205.94	24.05	60.64	150.05
NCD outstanding/assets (%)	1948	5.2	6.55	0	2.04	9.02
IB net borrowing/assets (%)	1948	2.25	9.7	-3.39	1.64	7.87
CB borrowing/assets (%)	1948	1.04	1.76	0	.45	1.35
Deposits/assets (%)	1946	74.72	11.69	66.88	75.22	83.22
Excess reserve/assets (%)	1946	.93	2.55	-.44	.63	1.76
Investment/assets (%)	1920	79.93	8.55	75.77	80.81	85.48
ROA (%)	1947	.56	.34	.32	.53	.77
Liquid ratio (%)	1948	9.1	5.48	6.01	9.1	12.07

Table 5: The substitution of CB borrowing for IB borrowing

This table shows the substitution of central bank borrowing for interbank borrowing estimated by the model,

$$\Delta Y_{i,t} = \alpha_i + \lambda_t + \beta_1 \Delta cb\_borrow_{i,t} + \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here the dependent variable $\Delta Y_{i,t}$ is the quarterly change in either NCD outstanding or IB net borrowing of bank i at time t. $\Delta cb\_borrow_{i,t}$ is the quarterly change in central bank borrowing. In 2SLS estimation, $\Delta cb\_borrow_{i,t}$ is instrumented by the product of $PD_{i,t}$ and ΔMLF_t. In addition to bank fixed effects and year fixed effects, we include the lagged central borrowing $cb\_borrow_{i,t-1}$, deposit controls $D_{i,t} = \{RRR\_cut_t, RRR\_cut_t \times deposit_{i,t}, \Delta deposit_{i,t}\}$, and fundamental controls $X_{i,t} = \{\Delta r_t, \Delta r_t \times NSB_i, NSB_i, GDPg_t, ROA_{i,t-1}, LIQ_{i,t-1}\}$. For each bank, we include the quarters since the first time that its NCD outstanding is greater than both 1 billion RMB and 0.1% of its total assets. Standard errors are clustered by banks.

Panel A: $NCD\_outstanding_{i,t}$				
	(1)	(2)	(3)	(4)
	OLS	2SLS	OLS	2SLS
	SOB+NPD	SOB+NPD	NSPD+NPD	NSPD+NPD
$\Delta cb\_borrow_{i,t}$	-0.060	-1.095***	-0.107	-1.058**
	(0.115)	(0.335)	(0.088)	(0.464)
$cb\_borrow_{i,t-1}$	0.014	-0.548**	0.046	-0.297
	(0.112)	(0.248)	(0.072)	(0.197)
Deposit controls	Y	Y	Y	Y
Fundamental Controls	Y	Y	Y	Y
Bank FE & Year FE	Y	Y	Y	Y
Observations	1,270	1,270	1,618	1,618
R-squared	0.126		0.111	
Instruments' F-statistics		25.22		16.36
Panel B: $IB\_netborrow_{i,t}$				
	(1)	(2)	(3)	(4)
	OLS	2SLS	OLS	2SLS
	SOB+NPD	SOB+NPD	NSPD+NPD	NSPD+NPD
$\Delta cb\_borrow_{i,t}$	-0.776***	-0.524	-0.733***	0.101
	(0.241)	(0.527)	(0.180)	(0.945)
$cb\_borrow_{i,t-1}$	-0.239	-0.102	-0.099	0.202
	(0.147)	(0.330)	(0.095)	(0.365)
Deposit controls	Y	Y	Y	Y
Fundamental Controls	Y	Y	Y	Y
Bank FE & Year FE	Y	Y	Y	Y
Observations	1,270	1,270	1,618	1,618
R-squared	0.172		0.173	
Instruments' F-statistics		25.22		16.36

Table 6: The difference in the substitution for IB borrowing

This table shows the difference in the substitution of central bank borrowing for interbank borrowing estimated by the model,

$$\Delta Y_{i,t} = .\alpha_i + \lambda_t + \beta_0 \Delta cb\_borrow_{i,t} \times NSB_i + \beta_1 \Delta cb\_borrow_{i,t} + \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here the dependent variable $\Delta Y_{i,t}$ is the quarterly change in either NCD outstanding or IB net borrowing of bank i at time t. In 2SLS estimation, $\Delta cb\_borrow_{i,t}$ and $\Delta cb\_borrow_{i,t} \times NSB_i$ are instrumented by ΔMLF_t and $\Delta MLF_t \times NSB_i$. In addition to bank fixed effects and year fixed effects, we include the lagged central borrowing $cb\_borrow_{i,t-1}$, deposit controls $D_{i,t} = \{RRR\_cut_t, RRR\_cut_t \times deposit_{i,t}, \Delta deposit_{i,t}\}$, and fundamental controls $X_{i,t} = \{\Delta r_t, \Delta r_t \times NSB_i, NSB_i, GDPg_t, ROA_{i,t-1}, LIQ_{i,t-1}\}$. For each bank, we include the quarters since the first time that its NCD outstanding is greater than both 1 billion RMB and 0.1% of its total assets. Standard errors are clustered by banks.

	$NCD\_outstanding_{i,t}$		$IB\_netborrow_{i,t}$	
	(1)	(2)	(3)	(4)
	SOB+NSPD OLS	SOB+NSPD 2SLS	SOB+NSPD OLS	SOB+NSPD 2SLS
$\Delta cb\_borrow_{i,t}$	-0.277**	-0.443*	-0.644**	-0.605
	(0.133)	(0.263)	(0.301)	(0.426)
$\Delta cb\_borrow_{i,t} \times NSB_i$	-0.012	0.295	-0.014	0.284
	(0.163)	(0.289)	(0.341)	(0.727)
$cb\_borrow_{i,t-1}$	-0.112	-0.085	0.023	0.089
	(0.094)	(0.104)	(0.135)	(0.160)
Deposit controls	Y	Y	Y	Y
Fundamental Controls	Y	Y	Y	Y
Bank FE & Year FE	Y	Y	Y	Y
Observations	456	456	456	456
R-squared	0.132		0.256	
Instruments' F-statistics		69.30/26.87		69.30/26.87

Table 7: The difference in the substitution for NCD holding & outstanding

This table shows difference in the substitution of central bank borrowing for NCD holding & outstanding estimated by the model,

$$\Delta Y_{i,t} = .\alpha_i + \lambda_t + \beta_0 \Delta cb\_borrow_{i,t} \times NSB_i + \beta_1 \Delta cb\_borrow_{i,t} + \beta_2 cb\_borrow_{i,t-1} + \kappa D_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here the dependent variable $\Delta Y_{i,t}$ is the monthly change in either NCD holding or NCD outstanding of bank type i at time t. In 2SLS estimation, $\Delta cb\_borrow_{i,t}$ and $\Delta cb\_borrow_{i,t} \times NSB_i$ are instrumented by ΔMLF_t and $\Delta MLF_t \times NSB_i$. In addition to bank-type fixed effects and year fixed effects, we include the lagged central borrowing $cb\_borrow_{i,t-1}$, deposit controls $D_{i,t} = \{RRR\_cut_t, RRR\_cut_t \times deposit_{i,t}, \Delta deposit_{i,t}\}$, and fundamental controls $X_{i,t} = \{\Delta r_t, \Delta r_t \times NSB_i, NSB_i, GDPg_t\}$.

	$NCD\_holding_{i,t}$		$NCD\_outstanding_{i,t}$	
	(1)	(2)	(3)	(4)
	OLS	2SLS	OLS	2SLS
$\Delta cb\_borrow_{i,t}$	-0.062	-0.098	-0.076	-0.083
	(0.076)	(0.082)	(0.163)	(0.177)
$\Delta cb\_borrow_{i,t} \times NSB_i$	0.294***	0.289**	-0.053	0.131
	(0.100)	(0.112)	(0.215)	(0.242)
$cb\_borrow_{i,t-1}$	0.010	0.009	-0.134***	-0.130***
	(0.015)	(0.015)	(0.033)	(0.031)
Deposit controls	Y	Y	Y	Y
Fundamental Controls	Y	Y	Y	Y
Bank-type FE & Year FE	Y	Y	Y	Y
Observations	124	124	124	124
R-squared	0.271	0.267	0.249	0.239
Instruments' F-statistics		100.98/84.83		100.98/84.83

Table 8: The second wave of RRR cuts

This table estimates the effect of the second wave of RRR cuts on the correlation between deposits and interbank borrowing by estimating the following model

$$Y_{i,t} = \lambda_t + \beta_1 RRR\_cut_t \times deposit_{i,t} + \beta_2 deposit_{i,t} + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here, the dependent variable $Y_{i,t}$ is either NCD outstanding or IB net borrowing. RRR_cut_t is a dummy variable that equals 1 for quarters in a wave of RRR cuts. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. Fundamental controls are the same as in model (7). Quarter fixed effects are included. Different time windows are used test the robustness of the result. For example, Column (1) is labeled as "3+1" as we include 3 quarters before and 1 quarter after the RRR cut. We include only banks with observations right before the wave to make samples balanced. Standard errors are all clustered by banks.

	$NCD\_outstanding_{i,t}$			$IB\_netborrow_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
	3+1	3+2	3+3	3+1	3+2	3+3
$RRR\_cut_t \times deposit_{i,t}$	-0.090***	-0.093***	-0.110***	-0.006	-0.001	0.025
	(0.025)	(0.025)	(0.027)	(0.039)	(0.033)	(0.035)
$deposit_{i,t}$	-0.364***	-0.362***	-0.362***	-0.471***	-0.473***	-0.475***
	(0.041)	(0.040)	(0.039)	(0.058)	(0.058)	(0.057)
$cb\_borrow_{i,t}$	-0.904***	-0.877***	-0.855***	-0.386	-0.413*	-0.415*
	(0.171)	(0.160)	(0.151)	(0.260)	(0.242)	(0.223)
NSB_i	4.074***	4.067***	4.267***	-4.018***	-4.036***	-3.989***
	(0.849)	(0.832)	(0.839)	(0.949)	(0.923)	(0.802)
$\Delta r_t \times NSB_i$	0.192	0.368	0.518*	0.517	-0.095	-0.162
	(0.642)	(0.318)	(0.288)	(0.857)	(0.474)	(0.465)
$ROA_{i,t-1}$	-3.519**	-4.056***	-4.268***	-2.245	-2.188	-1.376
	(1.532)	(1.382)	(1.308)	(2.458)	(2.468)	(2.316)
$LIQ_{i,t-1}$	0.152*	0.145*	0.151**	-0.562***	-0.560***	-0.548***
	(0.082)	(0.077)	(0.076)	(0.100)	(0.097)	(0.089)
Quarter FE	Y	Y	Y	Y	Y	Y
Observations	562	702	843	562	702	843
R-squared	0.457	0.469	0.480	0.496	0.501	0.498

Table 9: Banks' utilization of funds

This table examines banks' utilization of funds when their balance sheets expand by estimating the following model

$$\Delta xreserve_{i,t} = \alpha_i + \lambda_t + \beta_1 \Delta assest_{i,t} + \beta_2 \Delta asset_{i,t} \times NSB_i + \gamma X_{i,t} + u_{i,t}.$$

Here, the dependent variable $\Delta xreserve_{i,t}$ is the change in excess reserves scaled by lagged total assets of bank i at time t in either one quarter or two quarters. Excess reserves are calculated as cash holdings minus the product of Required Reserve Ratios and deposits. $\Delta asset_{i,t}$ is the quarterly change in total assets scaled by lagged total assets. The product of $\Delta asset_{i,t}$ and NSB_i is included to capture the difference between state and non-state banks. Fundamental controls $X_{i,t}$ are the same as in model (7). We also control bank fixed effects and quarter fixed effects. Standard errors are clustered by banks. We run the regressions in the full sample and the two subsamples that are before and since 2018 respectively.

	$\Delta xreserve_{i,t}$ in one quarter			$\Delta xreserve_{i,t}$ in two quarters		
	(1)	(2)	(3)	(4)	(5)	(6)
	Full	Before 2018	Since 2018	Full	Before 2018	Since 2018
$\Delta assest_{i,t}$	0.262***	0.279***	0.163**	0.179***	0.232***	0.059*
	(0.033)	(0.026)	(0.076)	(0.046)	(0.048)	(0.030)
$\Delta assest_{i,t} \times NSB_i$	-0.226***	-0.255***	-0.107	-0.164***	-0.221***	-0.039
	(0.033)	(0.026)	(0.075)	(0.046)	(0.048)	(0.029)
$\Delta r_t \times NSB_i$	-0.192	-0.302**	0.481	-0.580**	-0.442**	-0.627
	(0.127)	(0.151)	(0.292)	(0.226)	(0.188)	(0.493)
$ROA_{i,t-1}$	-0.037	-0.029***	-0.348	-0.653*	-0.302	-0.663
	(0.024)	(0.010)	(0.461)	(0.394)	(0.617)	(0.437)
$LIQ_{i,t-1}$	-0.101***	-0.090***	-0.224***	-0.115***	-0.102***	-0.237***
	(0.020)	(0.022)	(0.055)	(0.022)	(0.028)	(0.044)
Bank FE	Y	Y	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y	Y	Y
Observations	2,488	1,100	1,388	2,332	1,015	1,317
R-squared	0.179	0.189	0.226	0.146	0.134	0.194

Table 10: The level of banks' asset allocation

This table examines the change in banks' asset allocation by estimating the following model using a yearly sample from 2016 to 2019

$$log\left(Y_{i,t}\right) = \beta_1 \left(after_t \text{ or } NCD\_outstanding\_SOB_t\right) \times NSB_i + \alpha_i + \lambda_t + u_{i,t}.$$

Here, $log\left(Y_{i,t}\right)$ is either the log of loans ($log\left(loan_{i,t}\right)$) or the log of relative excess reserve ($log\left(rxreserve_{i,t}\right)$) of bank i in year t. Relative excess reserve is calculated as the ratio of reserves to required reserves. $after_t$ is a dummy variable that equals 1 since the year 2018. $NCD\_outstanding\_SOB_t$ is the total of state banks' NCD outstanding at year t, which is a direct measure for the shift from Scenario 1 to 2. We also control bank fixed effects and year fixed effects. Standard errors are clustered by banks.

	$log\left(loan_{i,t}\right)$		$log\left(rxreserve_{i,t}\right)$	
	(1)	(2)	(3)	(4)
$after_t \times NSB_i$	0.125***		0.126***	
	(0.028)		(0.035)	
$NCD\_outstanding\_SOB_t \times NSB_i$		0.095***		0.063***
		(0.021)		(0.024)
Bank FE & Year FE	Y	Y	Y	Y
Observations	2,225	2,225	2,214	2,214
R-squared	0.985	0.985	0.602	0.602

Table 11: City-level lending

This table examines city-level lending by estimating the following model using a yearly sample from 2016 to 2019

$$log\left(lending_{city,t}\right) = \beta_1 \left(after_t \text{ or } NCD\_outstanding\_SOB_t\right) \times fraction_{city} + \beta_2 fraction_{city} + \alpha_{province} + \lambda_t + \gamma CX_{city,t} + u_{city,t}$$

Here $log\left(lending_{city,t}\right)$ is the log of a city's lending in year t. $after_t$ is a dummy variable that equals 1 since the year 2018. $NCD\_outstanding\_SOB_t$ is the total of state banks' NCD outstanding in year t. To account for endogenous changes in bank branches, we stick to the fraction, $fraction_{city}$, in a year before the sample period. City fundamental controls $CX_{i,t}$ includes the log of GDP ($log\left(GDP_{city,t}\right)$), the log of population ($log\left(population_{city,t}\right)$), the primary sector GDP share ($primary\_sector_{city,t}$), and the secondary sector GDP share ($secondary\_sector_{city,t}$). We control province fixed effects and year fixed effects. Standard errors are clustered by cities.

	$fraction_{city}$ in 2012		$fraction_{city}$ in 2015	
	(1)	(2)	(3)	(4)
$after_t \times fraction_{city}$	0.230**		0.163**	
	(0.104)		(0.072)	
$NCD\_outstanding\_SOB_t \times fraction_{city}$		0.220**		0.185***
		(0.104)		(0.065)
$fraction_{city}$	0.932***	0.897***	1.374***	1.327***
	(0.262)	(0.268)	(0.240)	(0.244)
$log\left(GDP_{city,t}\right)$	1.152***	1.152***	1.085***	1.085***
	(0.048)	(0.048)	(0.048)	(0.047)
$log\left(population_{city,t}\right)$	-0.130**	-0.131**	-0.096*	-0.097*
	(0.053)	(0.053)	(0.052)	(0.052)
$primary\_sector_{city,t}$	-1.578***	-1.581***	-1.273**	-1.279***
	(0.501)	(0.501)	(0.492)	(0.492)
$secondary\_sector_{city,t}$	-2.582***	-2.586***	-2.444***	-2.453***
	(0.250)	(0.251)	(0.233)	(0.234)
Province FE & Year FE	Y	Y	Y	Y
Observations	1,131	1,131	1,131	1,131
R-squared	0.939	0.939	0.942	0.942

Table 12: Firm-level lending

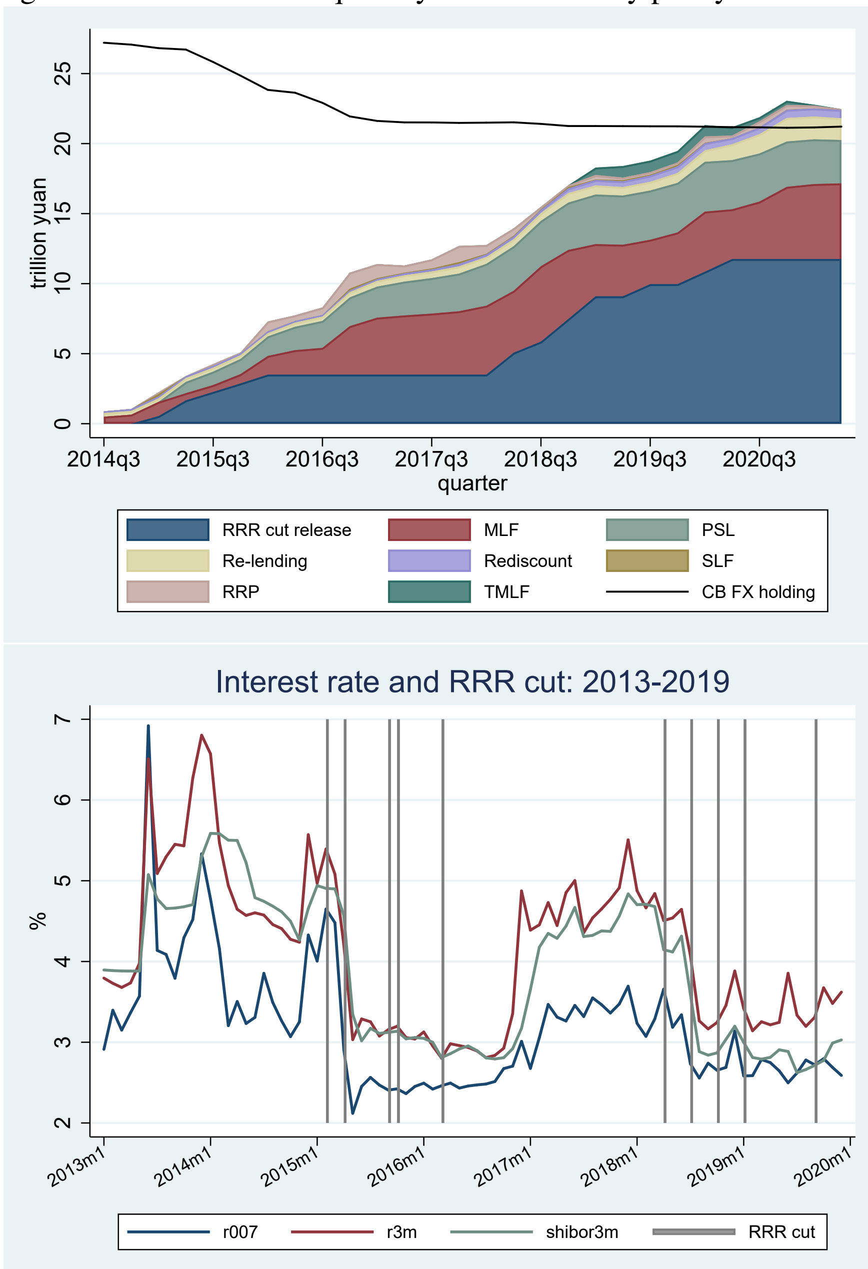
This table examines firms' loan composition by estimating the following model using a yearly sample from 2016 to 2019

$$NSB\_Fraction_{i,t} = \alpha_i + \beta_1(after_t \text{ or } NCD\_outstanding\_SOB_t) + u_{i,t}.$$

Here $NSB\_Fraction_{i,t}$ is the fraction of the average daily balance of loans from non-state banks to that from non-state and state banks, as defined by Equation (16). $after_t$ is a dummy variable that equals 1 since the year 2018. $NCD\_outstanding\_SOB_t$ is the total of state banks' NCD outstanding in year t. We control firm fixed effects. Standard errors are clustered by firms.

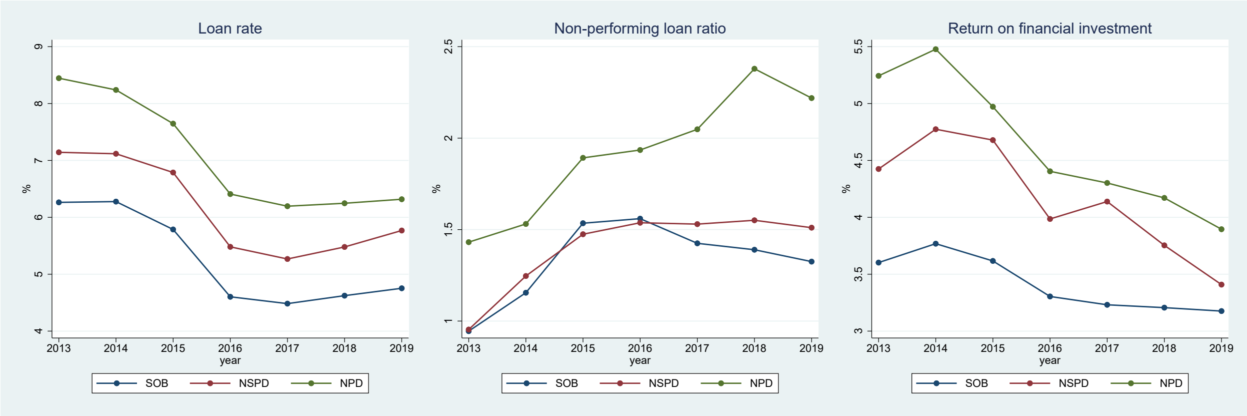
	(1)	(2)	(3)	(4)	(5)	(6)
	Full	Full	Non-SOE	Non-SOE	SOE	SOE
$after_t$	0.043***		0.040***		0.055	
	(0.009)		(0.010)		(0.034)	
$NCD\_outstanding\_SOB_t$		0.035***		0.034***		0.044
		(0.007)		(0.008)		(0.029)
Firm FE	Y	Y	Y	Y	Y	Y
Observations	2,213	2,213	1,966	1,966	197	197
R-squared	0.785	0.785	0.789	0.790	0.740	0.741

Figure 1: The volumes of quantity-based monetary policy instruments



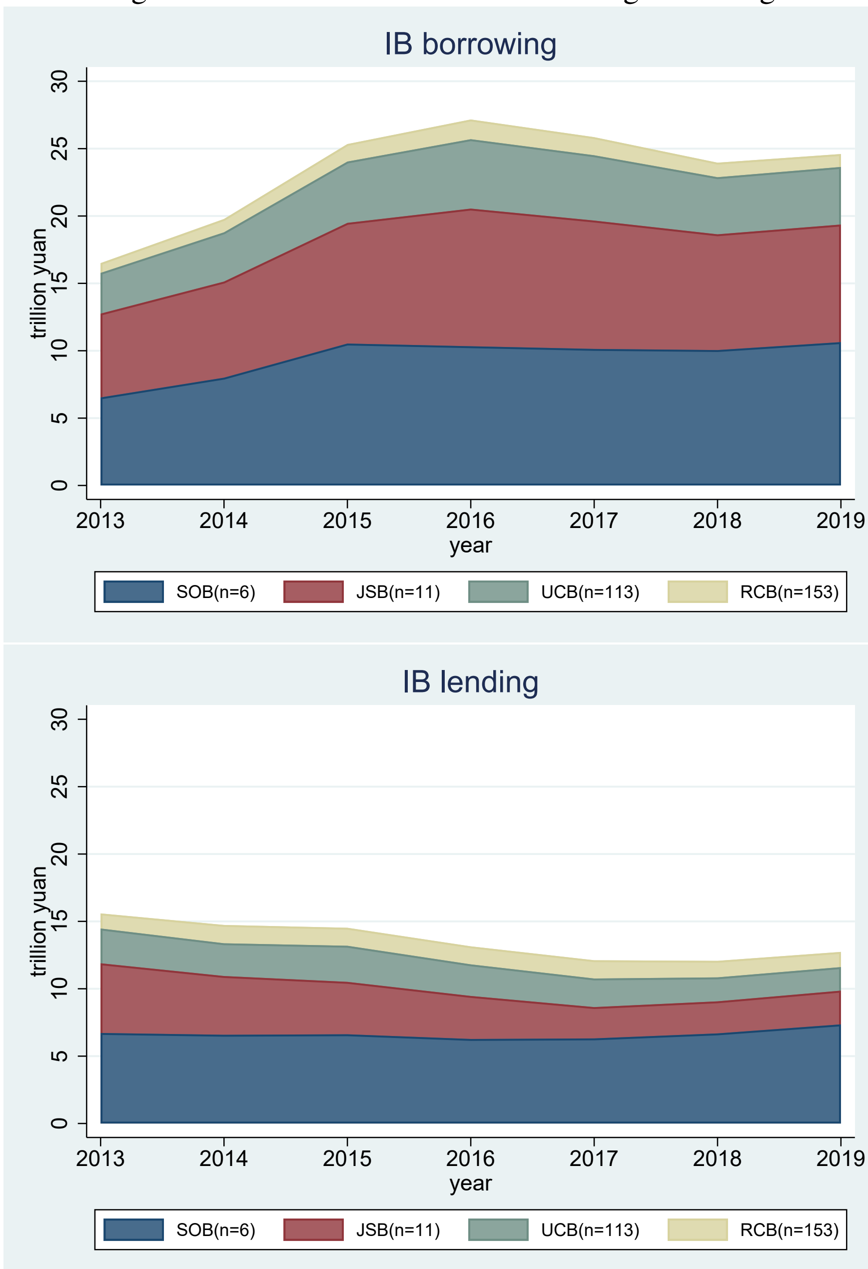
The first panel shows the quarterly amount of base money supplied through monetary policy instruments from 2014Q3 to 2021Q2. Liquidity injectd by RRR cut is estimated by using aggregate deposits times the percentage of RRR cut, and we set 2014Q3 as the base period (RRR cut inject balance equals 0). RRP and MLF quarterly balance is backed out using PBC open market operation announcements. Data comes from PBC website. The second panel shows the time series of monthly average 7-day and 3-month repo rate (R007, R3M) and 3-month SHIBOR rate (Shibor3M) from 2013M1 to 2019M12. The shaded area marks the months when RRR cut happens.

Figure 2: Banks' investment styles



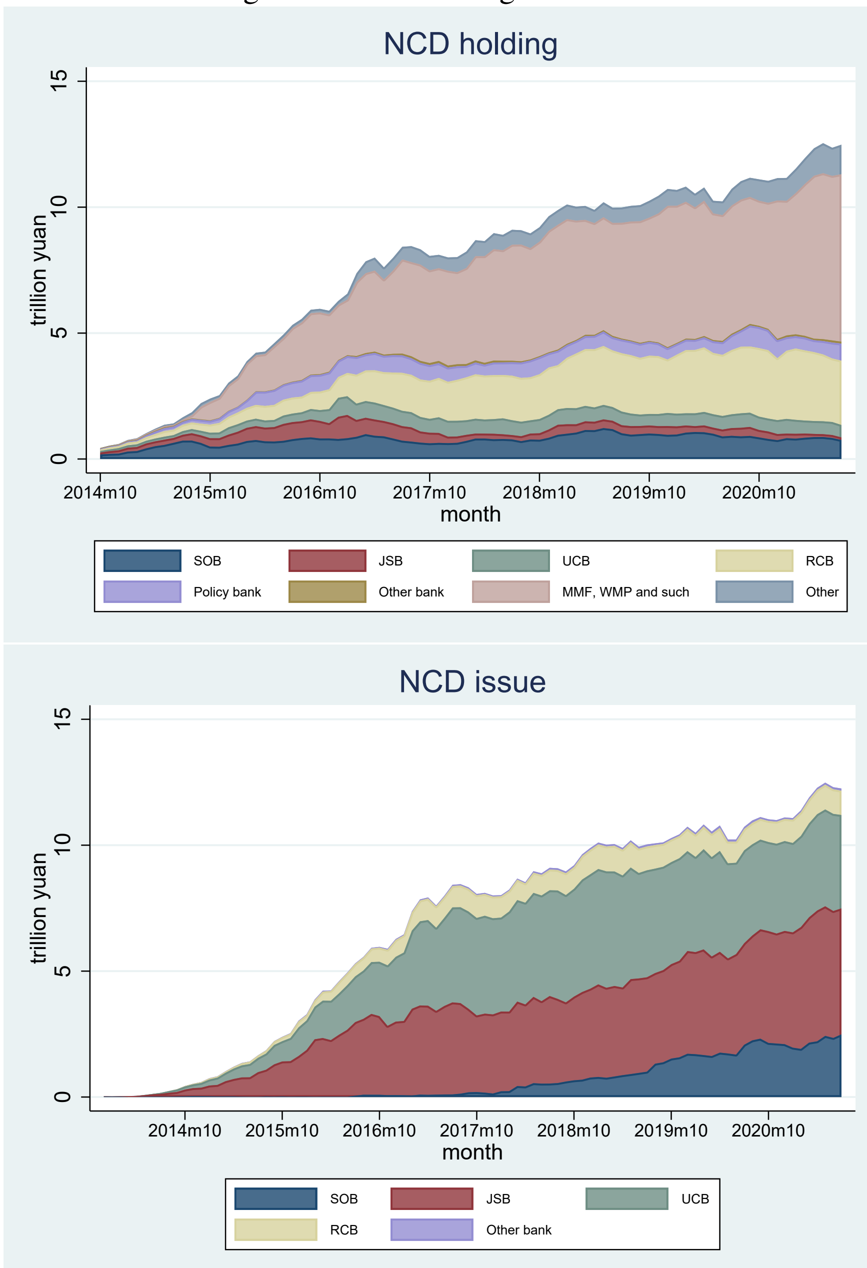
This figure plots the yearly average of loan rate, non-performing loan ratio, and return on financial investments of different bank groups from 2013-2019. Banks are grouped into state-owned banks (SOB), non-state primary dealer banks (NSPD) and non primary dealer banks (NPD). Loan rates (return of financial investment) are calculated using annual interest income from loan (financial investment) scaled by the average of loan (financial investments) balance at year start and year end. Non-performing loan ratio is directly collected from bank annual reports.

Figure 3: Traditional interbank borrowing & lending



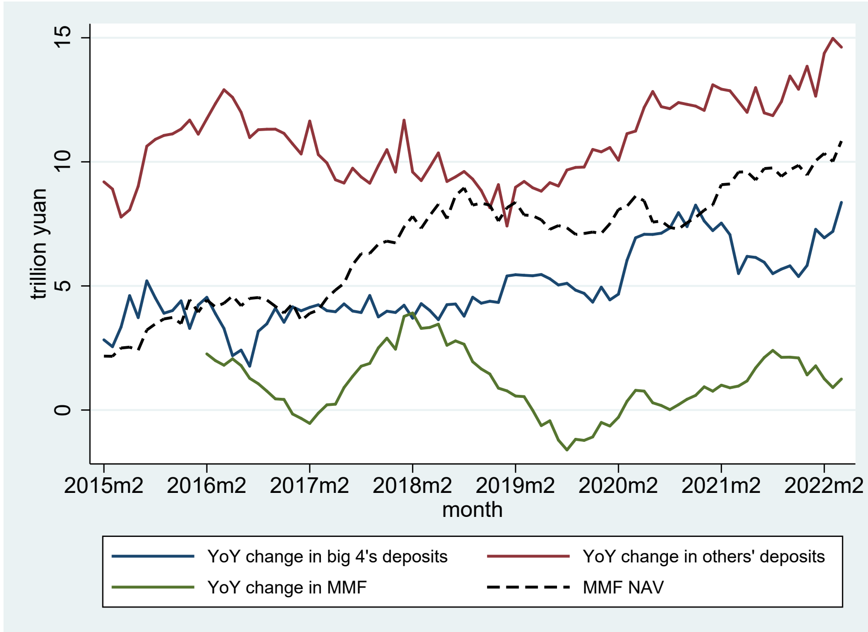
This figure plots traditional interbank borrowing & lending of different types of banks during the period from 2013 to 2019. Banks are grouped into state-owned banks (SOB), joint-stock banks (JSB), urban commercial banks (UCB) and rural commercial banks (RCB). We include only banks with complete annual data from 2013 to 2019 and reports the number of banks in each groups.

Figure 4: NCD holding & issuance



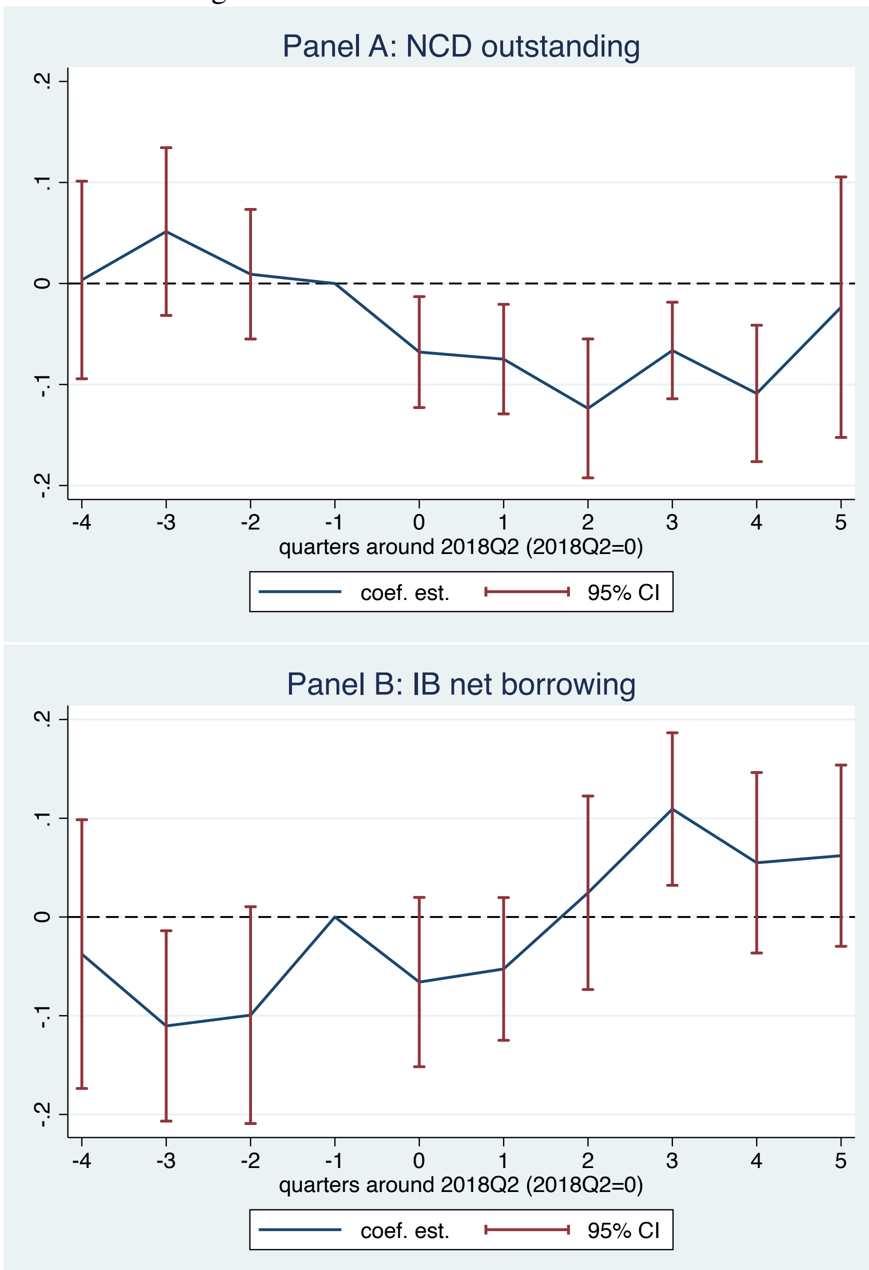
The first panel shows the monthly volume of NCD holding by different type of investors from October 2014 to July 2021. Banks are grouped into state-owned banks (SOB), joint-stock banks (JSB), urban commercial banks (UCB) and rural commercial banks (RCB), policy banks and other banks. The second panel shows the monthly volume of NCD balance by different type of issuing banks from December 2013 to July 2021. NCD balance is calculated as the total volume of NCD outstanding at the end of each month.

Figure 5: Deposits and money market funds



This figure shows the growth of banks' deposits and MMFs' total AUM from February 2015 to April 2022. Aggregate bank deposit data comes from PBC. MMF data comes from Asset Management Association of China.

Figure 6: The second wave of RRR cuts

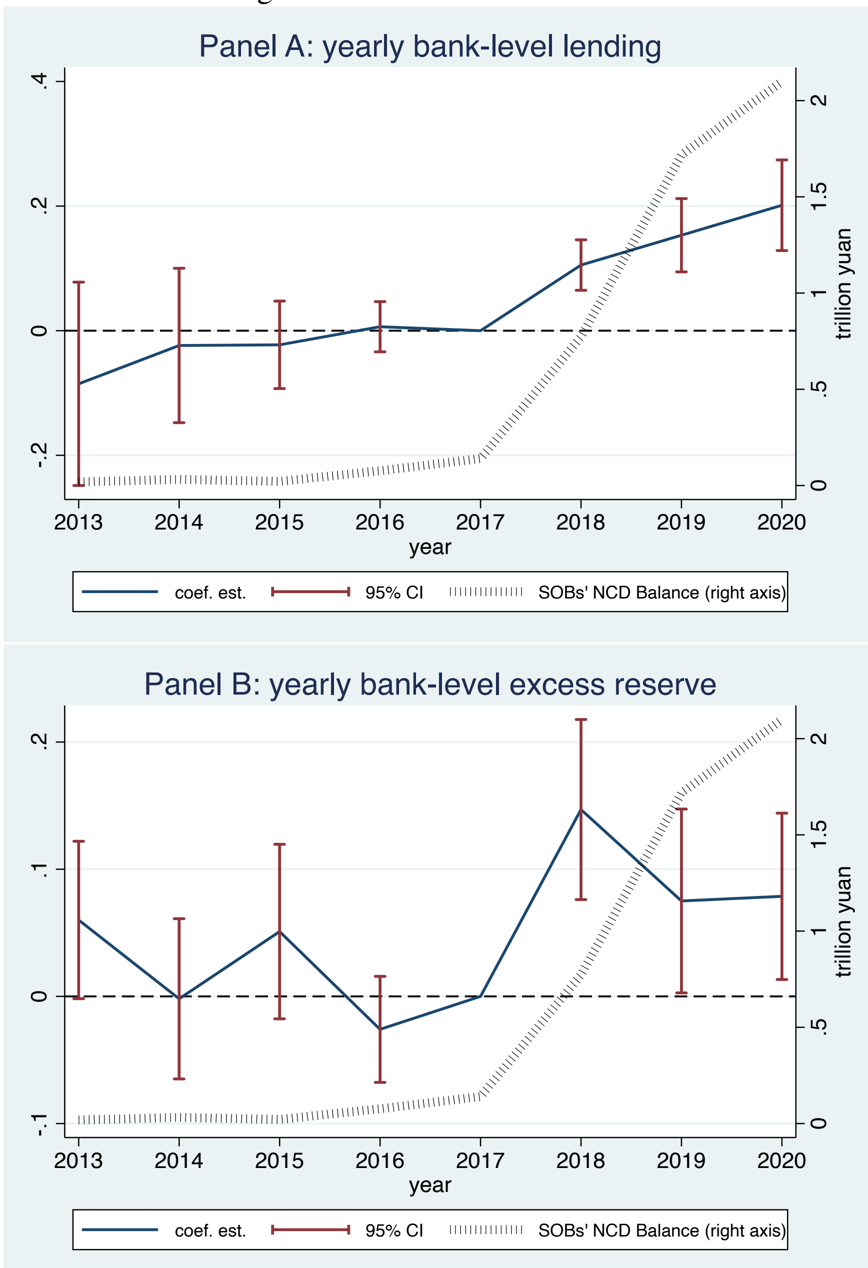


Panel A (B) plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$
\begin{aligned}
Y_{i,t} =& \lambda_t + \sum_{\tau=-4}^{-2} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \sum_{\tau=0}^{5} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \beta_2 deposit_{i,t} \\
& + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}
\end{aligned}
$$

with NCD outstanding (IB net borrowing) being the dependent variable for the wave of RRR cuts starting in 2018Q2. $Q_{\tau,t}$ is the quarter dummy variable that equals 1 if $t = \tau$. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. $X_{i,t}$ are fundamental controls. 2018Q2 is labeled as Quarter 0. Four quarters before the wave and six quarters in the wave are included in the regression. The quarter right before the wave, Quarter -1, is used as the benchmark.

Figure 7: Banks' asset allocation

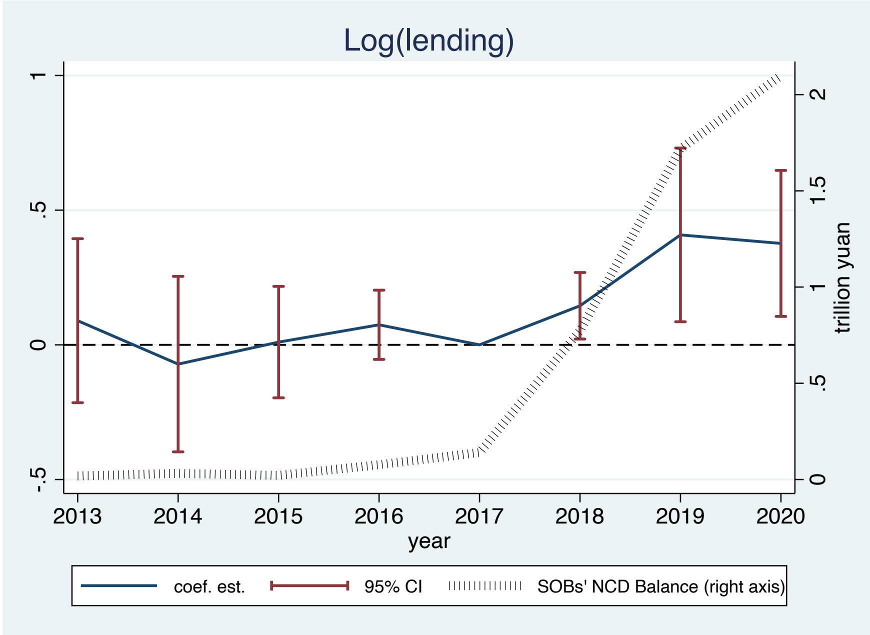


Panel A (B) plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$log\left(Y_{i,t}\right) = \sum_{\tau=2013}^{2016} \beta_{1,\tau} Y_{\tau,t} \times NSB_i + \sum_{\tau=2018}^{2020} \beta_{1,\tau} Y_{\tau,t} \times NSB_i + \alpha_i + \lambda_t + u_{i,t}.$$

$log\left(Y_{i,t}\right)$ is the log of loans (the log of relative excess reserve). $Y_{\tau,t}$ is the year dummy variable that equals 1 if $t = \tau$. Relative excess reserve is calculated as the ratio of reserves to required reserves. We use the year 2017 as the benchmark and control bank fixed effects and year fixed effects. Standard errors are clustered by banks.

Figure 8: City-level lending

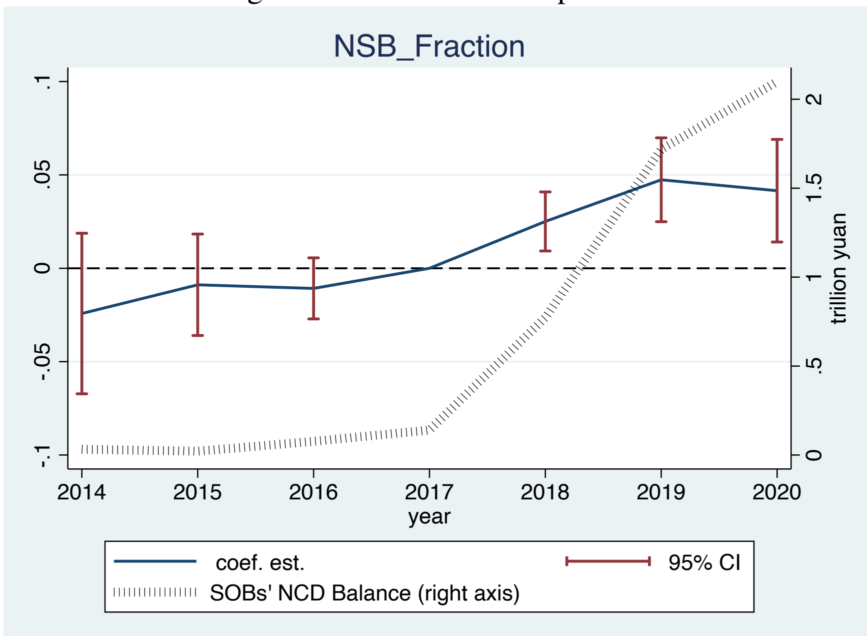


This figure plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$log\left(lending_{city,t}\right) = \sum_{\tau=2013}^{2016} \beta_{1,\tau} Y_{\tau,t} \times fraction_{city} + \sum_{\tau=2018}^{2020} \beta_{1,\tau} Y_{\tau,t} \times fraction_{city} + \beta_2 fraction_{city} + \alpha_{province} + \lambda_t + \gamma CX_{city,t} + u_{city,t}.$$

$log\left(lending_{city,t}\right)$ is the log of a city's lending in year t. $Y_{\tau,t}$ is the year dummy variable that equals 1 if $t = \tau$. $fraction_{city}$ is calculated using data in 2012. City fundamental controls $CX_{i,t}$ includes the log of GDP ($log\left(GDP_{city,t}\right)$), the log of population ($log\left(population_{city,t}\right)$), the primary sector GDP share ($primary\_sector_{city,t}$), and the secondary sector GDP share ($secondary\_sector_{city,t}$). We use the year 2017 as the benchmark and control bank fixed effects and year fixed effects. Standard errors are clustered by cities.

Figure 9: Firms' loan composition



This figure plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$NSB\_Fraction_{i,t} = \sum_{\tau=2014}^{2016} \beta_{1,\tau} Y_{\tau,t} + \sum_{\tau=2018}^{2020} \beta_{1,\tau} Y_{\tau,t} + \alpha_i + u_{i,t}.$$

$NSB\_Fraction_{i,t}$ is the fraction of the average daily balance of loans from non-state banks to that from non-state and state banks, as defined by Equation (16). $Y_{\tau,t}$ is the year dummy variable that equals 1 if $t = \tau$. We use the year 2017 as the benchmark and control firm fixed effects. Standard errors are clustered by firms.

B Proofs

Proof of Proposition 2

If state banks borrow on the interbank market, i.e., $b_s \geq 0 = l_s$, then the interbank market clearing implies that the interbank rate is equal to R_{IB}^2. This is indeed the equilibrium if state banks do borrow under R_{IB}^2, i.e.,

$$\frac{R_k - R_{IB}^2}{\eta + \delta_k} + \bar{x} - \frac{R_{IB}^2 - 1}{\gamma} \geq (1-\rho)\, d_s + m_s.$$

If this condition does not, then state banks lend on the interbank market, and the interbank rate is equal to R_{IB}^1.

Proof of Proposition 3

For non-state banks, by $b_i - l_i = k_i + x_i - (1-\rho)\, d_i - m_i$,

$$\frac{\partial \left(b_j - l_j\right)}{\partial R_{IB}} = \frac{\partial \left(k_j + x_j\right)}{\partial R_{IB}} = -\left(\frac{1}{\eta} + \frac{1}{\gamma}\right).$$

For state banks, if $b_s \geq 0 = l_s$,

$$\begin{aligned} b_s - l_s &= k_s + x_s - (1-\rho)\, d_s - m_s \\ &= \frac{R_k - R_{IB}}{\eta + \delta_k} + \bar{x} - \frac{R_{IB} - 1}{\gamma} - (1-\rho)\, d_s - m_s, \end{aligned}$$

so

$$\frac{\partial \left(b_s - l_s\right)}{\partial R_{IB}} = -\left(\frac{1}{\eta + \delta_k} + \frac{1}{\gamma}\right).$$

If $l_s > 0 = b_s$,

$$\begin{aligned} b_s - l_s &= \frac{R_k - R_{IB}}{\eta + \delta_k} + \frac{\delta_f}{\eta + \delta_k} l_s + \bar{x} - \frac{R_{IB} - 1}{\gamma} + \frac{\delta_f}{\gamma} l_s - (1-\rho)\, d_s - m_s \\ \Leftrightarrow \left(1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}\right) l_S &= \frac{R_{IB} - R_k}{\eta + \delta_k} + \frac{R_{IB} - 1}{\gamma} - \bar{x} + (1-\rho)\, d_S + m_S, \end{aligned}$$

so

$$\frac{\partial \left(b_s - l_s\right)}{\partial R_{IB}} = -\frac{1}{1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}} \left(\frac{1}{\eta + \delta_k} + \frac{1}{\gamma}\right).$$

In either case,

$$\left|\frac{\partial \left(b_j - l_j\right)}{\partial R_{IB}}\right| > \left|\frac{\partial \left(b_s - l_s\right)}{\partial R_{IB}}\right|.$$

Proof of Implication 1

For non-state PD banks,

$$\Delta\left(b_{nspd} - l_{nspd}\right) = -\left(\frac{1}{\eta} + \frac{1}{\gamma}\right)\Delta R_{IB} - \Delta e_{nspd}.$$

So, when they borrow on the interbank market,

$$\frac{\partial \Delta b_{nspd}}{\partial \Delta e_{nspd}} = -1;$$

when they lend on the interbank market,

$$\frac{\partial \Delta l_{nspd}}{\partial \Delta e_{nspd}} = 1.$$

For state banks,

$$\Delta\left(b_s - l_s\right) = -\left(\frac{1}{\eta + \delta_k} + \frac{1}{\gamma}\right)\Delta R_{IB} + \left(\frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}\right)\Delta l_s \cdot \mathbf{1}\left\{l_s > 0\right\} - \Delta e_s.$$

So, when they borrow on the interbank market, $\mathbf{1}\left\{l_s > 0\right\} = 0$, and

$$\frac{\partial \Delta b_s}{\partial \Delta e_s} = -1;$$

when they lend on the interbank market, $\mathbf{1}\left\{l_s > 0\right\} = 1$, and

$$\frac{\partial \Delta l_s}{\partial \Delta e_s} = \frac{1}{1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}} < 1.$$

Proof of Implication 2

Suppose that there is no other monetary policy shock, i.e., m_j stays unchanged. Consider two banks j_1 and j_2 that borrow on the market, and assume $d_{j_1} < d_{j_2}$.

$$\frac{b_{j_1} - b_{j_2}}{d_{j_1} - d_{j_2}} = -\left(1 - \rho\right) + \frac{\left(k_{j_1} + x_{j_1}\right) - \left(k_{j_2} + x_{j_2}\right)}{d_{j_1} - d_{j_2}}.$$

Then

$$\Delta \frac{b_{j_1} - b_{j_2}}{d_{j_1} - d_{j_2}} \Big/ \Delta\rho = 1 + \Delta \frac{\left(k_{j_1} + x_{j_1}\right) - \left(k_{j_2} + x_{j_2}\right)}{d_{j_1} - d_{j_2}} \Big/ \Delta\rho$$

$$= 1 + \frac{1}{d_{j_1} - d_{j_2}} \left[\frac{\Delta\left(k_{j_1} + x_{j_1}\right)}{\Delta R_{IB}} - \frac{\Delta\left(k_{j_2} + x_{j_2}\right)}{\Delta R_{IB}} \right] \frac{\Delta R_{IB}}{\Delta\rho}.$$

If bank j_1 is affected by the GE effect to a lesser extent than bank j_2,

$$\frac{\Delta\left(k_{j_1} + x_{j_1}\right)}{\Delta R_{IB}} - \frac{\Delta\left(k_{j_2} + x_{j_2}\right)}{\Delta R_{IB}} > 0.$$

In that case,

$$\Delta \frac{b_{j_1} - b_{j_2}}{d_{j_1} - d_{j_2}} \Big/ \Delta\rho > 1,$$

since $\Delta R_{IB}/\Delta\rho > 0$.

Proof of Implication 3

For non-state banks, their investment and excess reserves depend on only the interbank rate. Given the interbank rate, their interbank lending move with their balance sheets by exactly the same amount. That means,

$$\frac{\Delta x_i^1}{\Delta L_i^1} = \frac{\Delta x_i^2}{\Delta L_i^2} = 0.$$

State banks in Scenario 2 follow the same allocation strategy, so

$$\frac{\Delta x_s^2}{\Delta L_s^2} = 0.$$

For state banks in Scenario 1,

$$\Delta L_s^1 = \Delta k_s^1 + \Delta x_s^1 + \Delta l_s^1$$
$$= \frac{\delta_f}{\eta + \delta_k} \Delta l_s^1 + \frac{\delta_f}{\gamma} \Delta l_s^1 + \Delta l_s^1,$$

so

$$\frac{\Delta l_s}{\Delta L_s^1} > 0.$$

This implies

$$\frac{\Delta x_s^1}{\Delta L_s^1} = \frac{\delta_f}{\gamma} \frac{\Delta l_s}{\Delta L_s^1} > 0.$$

Proof of Implication 4

We show that

$$R^1_{IB} - \delta_f l^1_s < R^2_{IB}.$$

Suppose the opposite. Then

$$R^1_{IB} > R^1_{IB} - \delta_f l^1_s \geq R^2_{IB},$$

so $x^1_s \leq x^2_s$, $k^1_s \leq k^2_s$, $x^1_i < x^2_i$, and $k^1_i < k^2_i$. This implies that the sum of the total investment and total excess reserves in Scenario 1 is smaller than that in Scenario 2. Since this sum is equal to the total available funds, this implication contradicts that the total available funds are the same in the two scenarios. With $R^1_{IB} - \delta_f l^1_s < R^2_{IB}$, we immediately obtain $x^1_s > x^2_s$ and $k^1_s > k^2_s$. Following a similar logic, we can also show that

$$R^1_{IB} > R^2_{IB},$$

which implies $x^1_i < x^2_i$ and $k^1_i < k^2_i$.

Proof of Implication 5

In Scenario 1, the total investment

$$\begin{aligned} TI^1 &= N_s k_s + \sum_{i=1}^{N_{ns}} k_i \\ &= N_s \frac{R_k - R^1_{IB}}{\eta + \delta_k} + \frac{\delta_f}{\eta + \delta_k} \frac{(1-\rho) D_s + M_s + N_s \frac{R^1_{IB} - R_k}{\eta + \delta_k} + N_s \frac{R^1_{IB} - 1}{\gamma} - N_s \bar{x}}{1 + \frac{\delta_f}{\eta + \delta_k} + \frac{\delta_f}{\gamma}} + N_{ns} \frac{R_k - R^1_{IB}}{\eta}. \end{aligned}$$

So,

$$
\begin{aligned}
dTI^1 &= \left[-\left(\frac{N_s}{\eta+\delta_k}+\frac{N_{ns}}{\eta}\right)+\frac{\delta_f}{\eta+\delta_k}\frac{1}{1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}}\left(\frac{N_s}{\eta+\delta_k}+\frac{N_s}{\gamma}\right)\right]dR_{IB}^1+\frac{\delta_f}{\eta+\delta_k}\frac{1}{1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}}d\left[(1-\rho)D_s+M_s\right] \\
&= \frac{\left(\frac{N_s}{\eta+\delta_k}+\frac{N_{ns}}{\eta}\right)-\frac{\delta_f}{\eta+\delta_k}\frac{1}{1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}}\left(\frac{N_s}{\eta+\delta_k}+\frac{N_s}{\gamma}\right)}{\frac{N_s}{\eta+\delta_k}+\frac{N_s}{\gamma}+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\left(\frac{N_{ns}}{\eta}+\frac{N_{ns}}{\gamma}\right)}d\left\{(1-\rho)D_s+M_s+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\left[(1-\rho)D_{ns}+M_{ns}+W\right]\right\} \\
&\quad+\frac{\delta_f}{\eta+\delta_k}\frac{1}{1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}}d\left[(1-\rho)D_s+M_s\right] \\
&\propto \left[1+\frac{\frac{N_s}{\eta+\delta_k}+\frac{N_s}{\gamma}+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\left(\frac{N_{ns}}{\eta}+\frac{N_{ns}}{\gamma}\right)}{\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\left(\frac{N_s}{\eta+\delta_k}+\frac{N_{ns}}{\eta}\right)-\frac{\delta_f}{\eta+\delta_k}\left(\frac{N_s}{\eta+\delta_k}+\frac{N_s}{\gamma}\right)}\frac{\delta_f}{\eta+\delta_k}\right]\cdot d\left[(1-\rho)D_s+M_s\right] \\
&\quad+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\cdot d\left[(1-\rho)D_{ns}+M_{ns}+W\right] \\
&\propto \left[1+\frac{\delta_f}{\eta+\delta_k}+\frac{\frac{N_s}{\eta+\delta_k}+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\frac{N_{ns}}{\eta+\delta_k}}{\frac{N_s}{\eta+\delta_k}+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\frac{N_{ns}}{\eta}}\frac{\delta_f}{\gamma}\right]\cdot d\left[(1-\rho)D_s+M_s\right] \\
&\quad+\left(1+\frac{\delta_f}{\eta+\delta_k}+\frac{\delta_f}{\gamma}\right)\cdot d\left[(1-\rho)D_{ns}+M_{ns}+W\right].
\end{aligned}
$$

This implies that

$$
\frac{dTI^1}{d\left[(1-\rho)D_s+M_s\right]}<\frac{dTI^1}{d\left[(1-\rho)D_{ns}+M_{ns}\right]}.
$$

In Scenario 2, the total investment

$$
TI^2=N_s\frac{R_k-R_{IB}^2}{\eta+\delta_k}+N_{ns}\frac{R_k-R_{IB}^2}{\eta},
$$

so

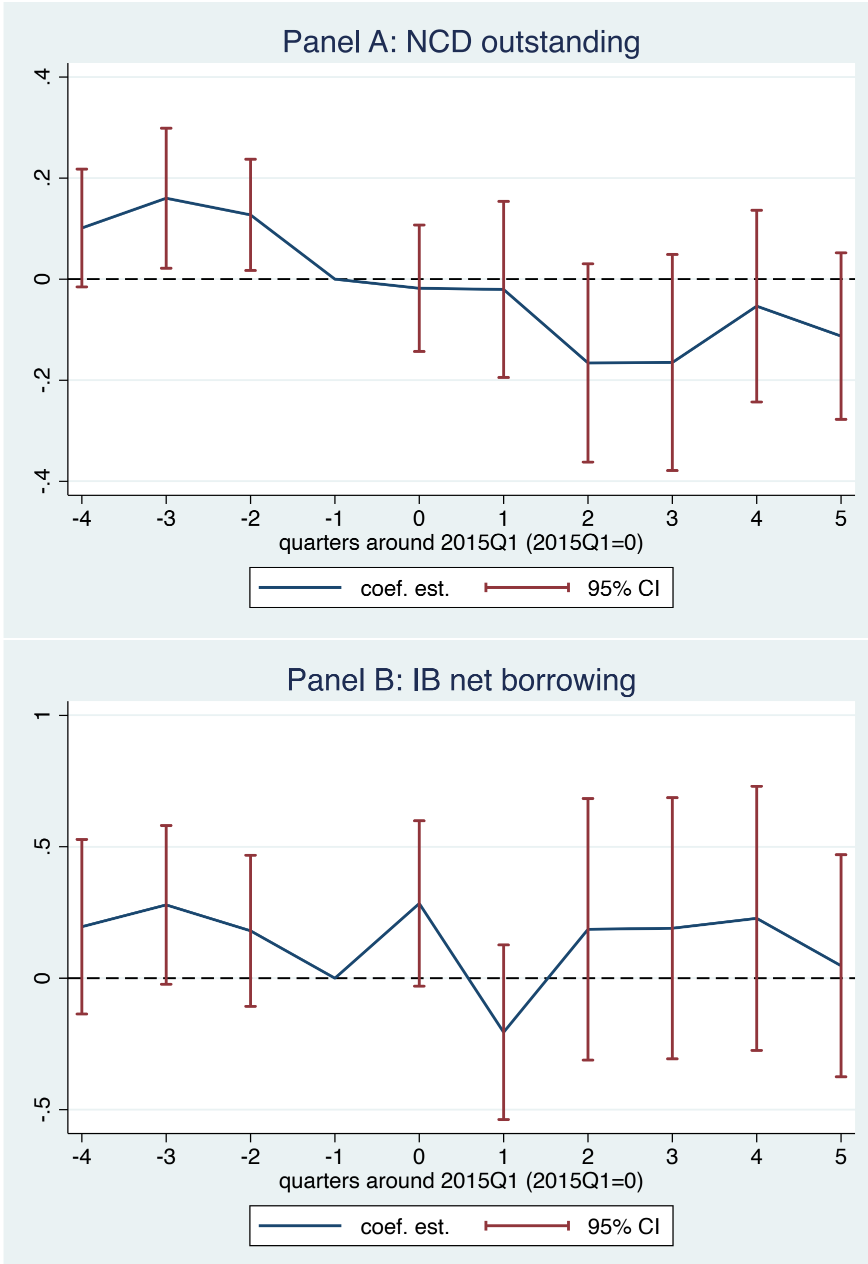
$$
dTI^2=\frac{N_s\frac{1}{\eta+\delta_k}+N_{ns}\frac{1}{\eta}}{N_s\left(\frac{1}{\eta+\delta_k}+\frac{1}{\gamma}\right)+N_{ns}\left(\frac{1}{\eta}+\frac{1}{\gamma}\right)}\cdot d\left[(1-\rho)D_s+M_s+(1-\rho)D_{ns}+M_{ns}+W\right].
$$

This implies that

$$
\frac{dTI^2}{d\left[(1-\rho)D_s+M_s\right]}=\frac{dTI^2}{d\left[(1-\rho)D_{ns}+M_{ns}\right]}.
$$

C Additional Results Regarding RRR Cuts

Figure 10: The first wave of RRR cuts



Panel A (B) plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$Y_{i,t} = \lambda_t + \sum_{\tau=-4}^{-2} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \sum_{\tau=0}^{5} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \beta_2 deposit_{i,t} + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}$$

with NCD outstanding (IB net borrowing) being the dependent variable for the wave of RRR cuts starting in 2015Q1. $Q_{\tau,t}$ is the quarter dummy variable that equals 1 if $t = \tau$. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. $X_{i,t}$ are fundamental controls. 2015Q1 is labeled as Quarter 0. Four quarters before the wave and six quarters in the wave are included in the regression. The quarter right before the wave, Quarter -1, is used as the benchmark.

Table 13: The first wave of RRR cuts

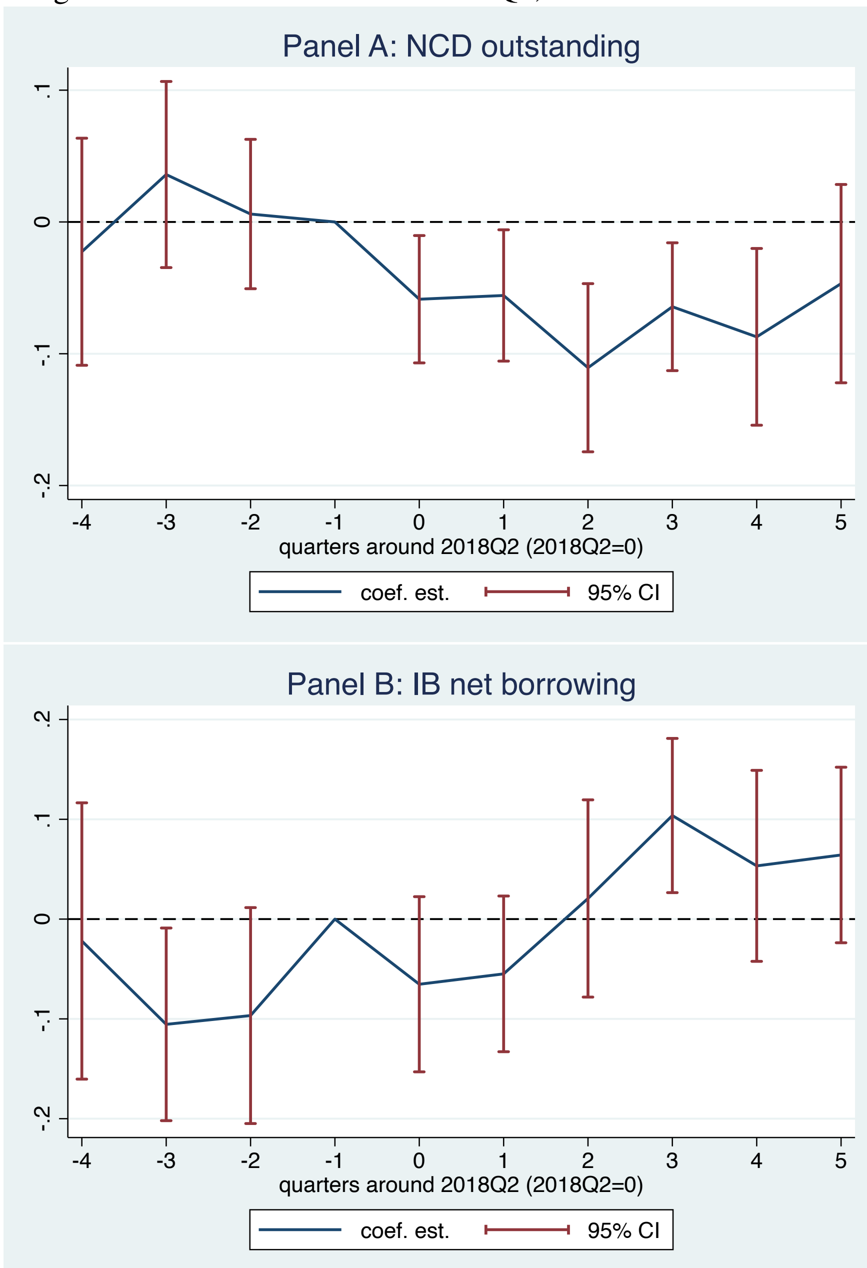
This table estimates the effect of the first wave of RRR cuts on the correlation between deposits and interbank borrowing by estimating the following model

$$Y_{i,t} = \lambda_t + \beta_1 RRR\_cut_t \times deposit_{i,t} + \beta_2 deposit_{i,t} + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here, the dependent variable $Y_{i,t}$ is either NCD outstanding or IB net borrowing. RRR_cut_t is a dummy variable that equals 1 for quarters in a wave of RRR cuts. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. Fundamental controls are the same as in model (7). Quarter fixed effects are included. Different time windows are used test the robustness of the result. For example, Column (1) is labeled as "3+1" as we include 3 quarters before and 1 quarter after the RRR cut. We include only banks with observations right before the wave to make samples balanced. Standard errors are all clustered by banks.

	$NCD\_outstanding_{i,t}$			$IB\_netborrow_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
	3+1	3+2	3+3	3+1	3+2	3+3
$RRR\_cut_t \times deposit_{i,t}$	-0.061	-0.102	-0.164**	0.227	-0.066	-0.028
	(0.060)	(0.068)	(0.075)	(0.169)	(0.145)	(0.165)
$deposit_{i,t}$	-0.037	-0.031	-0.030	-0.577***	-0.580***	-0.584***
	(0.024)	(0.027)	(0.029)	(0.113)	(0.114)	(0.111)
$cb\_borrow_{i,t}$	-0.121**	-0.131*	-0.168**	-0.303***	-0.360***	-0.325***
	(0.049)	(0.066)	(0.077)	(0.075)	(0.087)	(0.095)
NSB_i	0.936**	0.819**	0.927*	-1.021	-2.110	-2.456
	(0.387)	(0.373)	(0.467)	(1.844)	(1.595)	(1.689)
$\Delta r_t \times NSB_i$	1.123	-0.438	-0.540	2.730	-0.821	-0.790
	(0.720)	(0.287)	(0.328)	(2.416)	(1.200)	(1.239)
$ROA_{i,t-1}$	1.425	1.876	2.504*	-8.388*	-7.470	-8.525
	(1.025)	(1.126)	(1.247)	(4.365)	(4.877)	(5.068)
$LIQ_{i,t-1}$	-0.060	-0.082	-0.113*	-0.361***	-0.379***	-0.319**
	(0.039)	(0.056)	(0.063)	(0.109)	(0.136)	(0.145)
Quarter FE	Y	Y	Y	Y	Y	Y
Observations	99	122	144	99	122	144
R-squared	0.340	0.349	0.469	0.622	0.598	0.574

Figure 11: The RRR cuts since 2018Q2, with decile fixed effects



Panel A (B) plots the estimates of $\beta_{1,\tau}$ and associated 95% confidence intervals from the regression

$$
\begin{aligned}
Y_{i,t} =& \lambda_t + \sum_{\tau=-4}^{-2} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \sum_{\tau=0}^{5} \beta_{1,\tau} Q_{\tau,t} \times deposit_{i,t} + \beta_2 deposit_{i,t} \\
&+ \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + decile_i + u_{i,t}
\end{aligned}
$$

with NCD outstanding (IB net borrowing) being the dependent variable for the wave of RRR cuts starting in 2018Q2. $Q_{\tau,t}$ is the quarter dummy variable that equals 1 if $t = \tau$. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. $X_{i,t}$ are fundamental controls. We divide banks into ten deciles based on their deposits in 2018Q1 and add deposit decile fixed effect $decile_i$. 2018Q2 is labeled as Quarter 0. Four quarters before the wave and six quarters in the wave are included in the regression. The quarter right before the wave, Quarter -1, is used as the benchmark.

Table 14: The second wave of RRR cuts, deposit decile fixed effects controlled

This table estimates the effect of the second wave of RRR cuts on the correlation between deposits and interbank borrowing by estimating the following model

$$Y_{i,t} = \lambda_t + \beta_1 RRR\_cut_t \times deposit_{i,t} + \beta_2 deposit_{i,t} + \beta_3 cb\_borrow_{i,t} + \gamma X_{i,t} + u_{i,t}.$$

Here, the dependent variable $Y_{i,t}$ is either NCD outstanding or IB net borrowing. RRR_cut_t is a dummy variable that equals 1 for quarters in a wave of RRR cuts. $deposit_{i,t}$ is bank i's deposits at time t. $cb\_borrow_{i,t}$ is included to control other monetary policy shocks. Fundamental controls are the same as in model (7). Quarter fixed effects and are included. In addition, we divide banks into ten deciles based on their deposits in 2018Q1, the quarter right before the second wave, and add decile fixed effects. Different time windows are used test the robustness of the result. For example, Column (1) is labeled as "3+1" as we include 3 quarters before and 1 quarter after the RRR cut. We include only banks with observations right before the wave to make samples balanced. Standard errors are all clustered by banks.

	$NCD\_outstanding_{i,t}$			$IB\_netborrow_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
	3+1	3+2	3+3	3+1	3+2	3+3
$RRR\_cut_t \times deposit_{i,t}$	-0.070***	-0.069***	-0.088***	-0.006	-0.004	0.020
	(0.022)	(0.022)	(0.025)	(0.040)	(0.035)	(0.037)
$deposit_{i,t}$	-0.116*	-0.146**	-0.164***	-0.443***	-0.468***	-0.470***
	(0.064)	(0.060)	(0.060)	(0.115)	(0.109)	(0.102)
$cb\_borrow_{i,t}$	-0.925***	-0.879***	-0.846***	-0.336	-0.384	-0.392
	(0.165)	(0.157)	(0.150)	(0.267)	(0.253)	(0.237)
NSB_i	3.366***	3.339***	3.507***	-3.961***	-4.064***	-4.035***
	(1.188)	(1.172)	(1.180)	(1.043)	(1.036)	(0.969)
$\Delta r_t \times NSB_i$	0.371	0.570*	0.650**	0.577	-0.077	-0.140
	(0.547)	(0.312)	(0.290)	(0.866)	(0.484)	(0.468)
$ROA_{i,t-1}$	-3.231**	-3.976***	-4.240***	-2.115	-2.131	-1.240
	(1.493)	(1.380)	(1.299)	(2.490)	(2.500)	(2.332)
$LIQ_{i,t-1}$	0.115	0.113	0.128	-0.560***	-0.563***	-0.559***
	(0.083)	(0.080)	(0.078)	(0.101)	(0.096)	(0.087)
Deposit Decile FE	Y	Y	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y	Y	Y
Observations	562	702	843	562	702	843
R-squared	0.541	0.544	0.549	0.505	0.510	0.510