The Implementation of Monetary Policy in China

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Abstract: This paper analyzes the implementation of monetary policy in China, focusing on the linkage between policy instruments and interbank rate, as well as bank loans. We illustrate how the interbank rate and retail lending are determined in an environment where deposit and retail lending rates are regulated, using an extended version of the model of Porter and Xu (2009a). The effect of monetary policy on the interbank rate and bank loans depends on whether the regulated interest rates are above or below the respective unobserved equilibrium levels, defined as the rates in the absence of such regulation. Liberalizing the regulation of interest rate can eliminate the uncertainty and improve the policy effectiveness.

Keywords: Monetary policy, regulated interest rates, transmission mechanism, China

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1 Introduction

In ordinary times, when interest rates bounded away from zero, central banks in advanced economies typically implement monetary policy by steering short-term interbank rates. While the exact ways in which this is done differs between countries, the focus is squarely on the price of liquidity. Thus, given the policy interest rate, other variables contain no information about the stance of monetary policy. In the case of China, however, it is generally felt that interbank rates are not good measures of the stance of monetary policy.[1]

Indeed, empirical evidence suggests that the interest rate channel of monetary policy transmission is week or non-existent in China. Geiger (2006) shows that retail lending and money market rates do not have a tight and predictable relationship with loan and money growth, and Laurens and Maino (2007) find that GDP and price do not react to short-term interest rates, although they react significantly to M2 growth. Green and Chang (2006) show that the People's Bank of China (PBoC) controls reserve money well but not M2, since there is no close relationship between reserve money and M2. This evidence suggests that the relationship between the monetary policy instruments, short-term interest rates, loan growth and money growth differs from what we observe in advanced economies.

In thinking about the transmission mechanism of monetary policy in China, it is useful to distinguish between the link, first, between the policy instruments and interbank rates, and, second, that between interbank rates and the cost and availability of bank loans. Explanations put forward in the literature of the ineffectiveness of monetary policy in China has typically focused on how structural impediments in financial markets have weakened the second link.[2] In this paper, by contrast, we also study the first link since understanding it is a prerequisite for understanding the overall transmission of monetary policy to the real economy.

The PBoC conducts monetary policy using an array of instruments. These include required reserve ratios (RR hereafter), the rate of remuneration on reserves, open market oper-

[1] He and Pauwel (2006), Shu and Ng (2010) construct the indicator of the stance of monetary policy using PBoC statements or data on the policy instruments instead.

[2] See Liu and Zhang (2007), Larence and Maino (2007) and Podpiera (2006).

ations (that is, the issuance of central bank bills) and, crucially, regulated deposit and retail lending rates.[3] The two regulated rates are important for the implementation of monetary policy in China in contrast to in advanced economies. This raises the question of what the coexistence of such regulation and market forces implies for PBoC's policy to influence the macroeconomy.

To study this mechanism, we present a model of bank behavior in China, which is an extension of the model of Porter and Xu (2009a), which in turn is an extension of Freixas and Rochet (2008). The model illustrates how the interbank rate and the quantity and price of retail loans are determined in an environment where banks compete, given regulations concerning the interest rates they can pay on deposits and charge for loans. The model suggests that the presence of regulated rates have a large impact on the transmission mechanism of monetary policy. In particular, the effect of monetary policy on interbank rates and retail bank lending depends on how the regulated interest rates deviate from their equilibrium levels, defined as the rates we would observe in the absence of regulation. Two corollaries flow from this conclusion.

First, in this regulated framework, the interbank rate is not a sufficient, and potentially misleading, indicator of the central bank's policy intentions. To characterize the stance of monetary policy, all policy instruments, including the benchmark deposit rate, benchmark lending rate, RR, open market operations and the rate of remunerations on reserves, must be considered.

Second, to the extent that the central bank does not observe the equilibrium rates, it may not know if a change of its policy instruments is expansionary or contractionary. Liberalizing the regulated rates eliminates this uncertainty and improves the effectiveness of the monetary policy transmission.

The rest of the paper is organized as follows: Section 2 reviews the institutional background of the monetary policy in China. Section 3 provides an overview of the pattern and

[3] Window guidance, which pressures or impose rules on banks to follow PBC's instructions about retail lending, is also an important tool.

the effectiveness of monetary policy implementation. Section 4 presents the model and some policy implications. Section 5 concludes and provides suggestions for future research.

2 Institutional Background

In this section we provide a review of the institutional arrangements which underpin monetary policy in China. In particular, we emphasize the regulation of interest rates for deposits and retail lending, which is excluded in the monetary policy operation in advanced economies. We further discuss about the interbank market, since it plays a growing role in China and is the key market through which monetary policy is conducted.

2.1 The objectives of monetary policy and the multiple instruments

According to the law of People's Republic of China on the PBoC, the goals of monetary policy in China are to maintain the stability of the value of the currency and thereby promote economic growth. To achieve these final objectives, a group of intermediate targets has been set. They include the level of aggregate money, domestic loan growth, exchange rate stability, and a non-legally formulated target: maintaining profitability of state-owned banks. The PBoC is under the leadership of the state council, thus it is not independent of the government. The PBoC uses a range of monetary instruments to achieve these multiple objectives. These instruments can be classified into two categories. The first category of instruments influence the liquidity through wholesale money market, including required reserve ratio, open market operations, interest rates for required and excess reserves and so on. The second category of instruments aims at directly influencing the liquidity in the retail banking system, such as the regulated interest rates for bank deposits and retail lending, and administrative measures to control bank loans (window guidance). The second set of instruments is in contrast to those used by central banks in the advanced economies. In particular, the regulation of bank deposit and lending markets has played an important role for decades and is evolving towards a much more relaxed level.

2.2 Regulations of the Retail Lending and Deposit Markets

The PBoC had set the interest rates for deposits and lending in domestic and foreign currencies for decades in the era of central-planned economy. From the mid-1990s onwards, PBoC de-regulated the deposit and retail lending market to achieve efficient resource allocation, which is part of the transition of from planned economy to market based economy. The PBoC's plan had been to first liberalize interest rates on foreign currency, before turning to domestic currency rates, starting with lending rates rather than deposit rates, and starting with large, long-term deposit rather than small and short-term deposits.[4]

In October 2004, most of the interest rates were liberalized, except that the PBoC retained a regulated rate (the benchmark lending rate) as a ceiling for the deposit rate and another (the benchmark deposit rate) as a floor[5] for lending rates. These two restrictions are likely to be remained for a certain period. One of the concerns to keep them is that PBoC considers this regulation as an important tool to maintain financial stability in China. Removing the limits of lending and deposit rates might result in undesired market competition (Zhou (2005)). Another concern is to maintain an adequate profit margin and thus the profitability for commercial banks within the Chinese financial system.(Geiger 2006)

The regulation of retail interest rates has been served as a monetary policy instrument for the PBoC. At the time when the central bank set deposit and lending rates, changes in the regulated rates influenced the liquidity in the retail money market directly. At present, the same influences existed only when the regulated (ceiling for) deposit rate or the regulated (floor for) lending rates is binding. It is generally believed that the regulated deposit rates are binding, since the transaction rates have been clustered at the regulated level, which implies that the equilibrium deposit rates in the absence of such regulation have been higher than the regulated rates. However, it is less clear whether the regulated lending rates are binding. Table 1 shows that in 2004 and 2005, over half of the commercial loans were lent at

[4] For more details, please see Porter and Xu (2009).

[5] Lending rates are generally allowed to flow to a level not lower than 90% of the benchmark rate. Different floating ranges apply for other lending rates, such as mortgage rates.

Table 1: Percentage of Commercial Loans Priced at Different Rates

	Floating downward [90%to100% of benchmark]	at Regulated Level [100% benchmark]	Floating upward [above benchmark]
2004	22.02	26.83	51.16
2005	21.67	24.99	53.34
2006	24.71	27.01	48.28
2007	27.60	27.83	44.57
2008	22.89	31.22	45.90
2009	29.53	32.32	38.15
2010	29.76	30.61	39.63

Source: PBoC Monetary Policy Report (2004-2010) and authors' calculation.

rates higher than the regulated lending rates, while in the more recent period, the majority of loans were priced at or lower than the regulated rates.

2.3 The Interbank Market in China

The national interbank market was established in 1996, although there had been unregulated lending and borrowing between banks dating back to 1981. This unregulated lending and borrowing caused a lot of irregularities and generated excessive risking behavior. Therefore, in 1996, the PBoC centralized the lending and borrowing through China Foreign Exchange Trading System and created a national interbank market. This helped the PBoC to streamline the interbank lending and borrowing and to monitor banks' behavior.

The participants in the interbank market include not solely commercial banks but also insurance companies, security companies, fund management companies, credit cooperatives, large corporations and foreign banks. Initially, the market was for its participants to trade short-term liquidity among themselves, but later it became an important platform for PBoC to conduct open market operations.

Currently there are a few instruments trading in the interbank market, besides uncollateralized lending and borrowing. The most liquid market is the repo market. Its average daily turnover reached 314.6 billion renminbi, which is 3.4 times of the daily turnover of in-

terbank lending and borrowing. Besides repo and reverse repo, central bank bills and notes, treasury and corporate bonds, and medium and short-term commercial paper are also traded in the interbank market. It is worth noting that the four largest state-own banks are generally net lenders in the repo market and other commercial banks, foreign banks and other financial institutions are net borrowers.

The 7-day repo rate is the most representative short-term interbank rate. Close to 90 percent of the transactions in the repo market are concentrated in agreements with maturities equal or less than 7 days. The central bank interest rate on excessive reserve serves as a floor for short-term interest rates, while the short-term rates of discount window from PBoC can be considered as a ceiling. The 7-day repo rate is sometimes very volatile. Large IPO activities, central bank monetary policy actions all affect the liquidity in the interbank market, therefore the short-term interest rates. The open market operations, changes in reserve requirement directly affect the liquidity in the interbank market. Changes in the benchmark lending and deposit rates affect the interbank liquidity in an indirect way, i.e. through banks' profit maximization decisions. In the next section, the impacts of different monetary policy actions on the interbank rates are also analyzed.

Another two frequently quoted interbank rates are the Shanghai Interbank Offer Rate (SHIBOR) and the China Interbank Offer Rate (CHIBOR). In 2007, the PBoC established the SHIBOR system. The SHIBOR is not based on transaction rates in the interbank market, but a quote based average similar to LIBOR. Currently sixteen banks provide quotes and the rates are fixed at 11:30 a.m. on every business day. On the other hand, the China Interbank Offer Rate (CHIBOR) is a weighted average of the daily transaction rates, announced at end of every business day. The PBoC has been pushing SHIBOR as benchmark interest rates for pricing. CHIBOR is less used for the purpose of pricing now. The 7-day SHIBOR, CHIBOR and repo have followed each other very closely over the past few years. The wide use of SHIBOR as benchmark rates for pricing is yet to be achieved.

3 Implementing Monetary Policy in China

Since the PBoC uses a large number of policy instruments in setting monetary policy, it is useful to start by briefly reviewing how these have evolved over time. Figure 3 contains data on the interest rate on central bank bills, which are used in open market operations to steer interest rates more broadly, and interbank rates as captured by the 7-day repo rate. We also plot the required reserve ratio, rates paid on required and on excess reserves, and the regulated rates on deposits and loans.

Several observations are warranted. First, the yield on central bank bills and the repo rate are closely correlated, indicating the important role played by open market operations (OMO) in the PBoC's conduct of policy. OMO is the most often used instrument when PBoC conduct its monetary policy. Second, when the central bank bill yield experienced sharp increase or fall, the required reserve ratio (RR), regulated deposit rate and lending rate also changed in the same way. This tends to indicate that when PBoC tightens or loosens the monetary policy, it seeks to adjust banks's costs of funds both in interbank and deposit markets, as well as to adjust the cost of capital for firms and individual investors simultaneously. Examples are the progressive tightening from 2004 onwards in response to robust economic growth, in particular to very strong investment spending, and a rise in inflation in 2004 and 2007 onwards, in both cases largely due to rapidly increasing food prices. Another episode is the policy loosening in the fall of 2008, aiming to mitigate the effects on the mainland economy of the rapid worsening of global economic and financial conditions to limit their effects on the Mainland economy. Third, changes in the regulated lending rate and benchmark deposit rate were the same in the past two years, showing the intention of PBoC to maintain a constant profit margin for banks. Overall, the figure is compatible with a "belts and suspenders" approach to monetary policy in which many, if not all, policy levers are used simultaneously to achieve the desired change in monetary conditions. Again, this contrasts with the approach in advanced economies in which typically only the interbank interest rate is used to change policy.

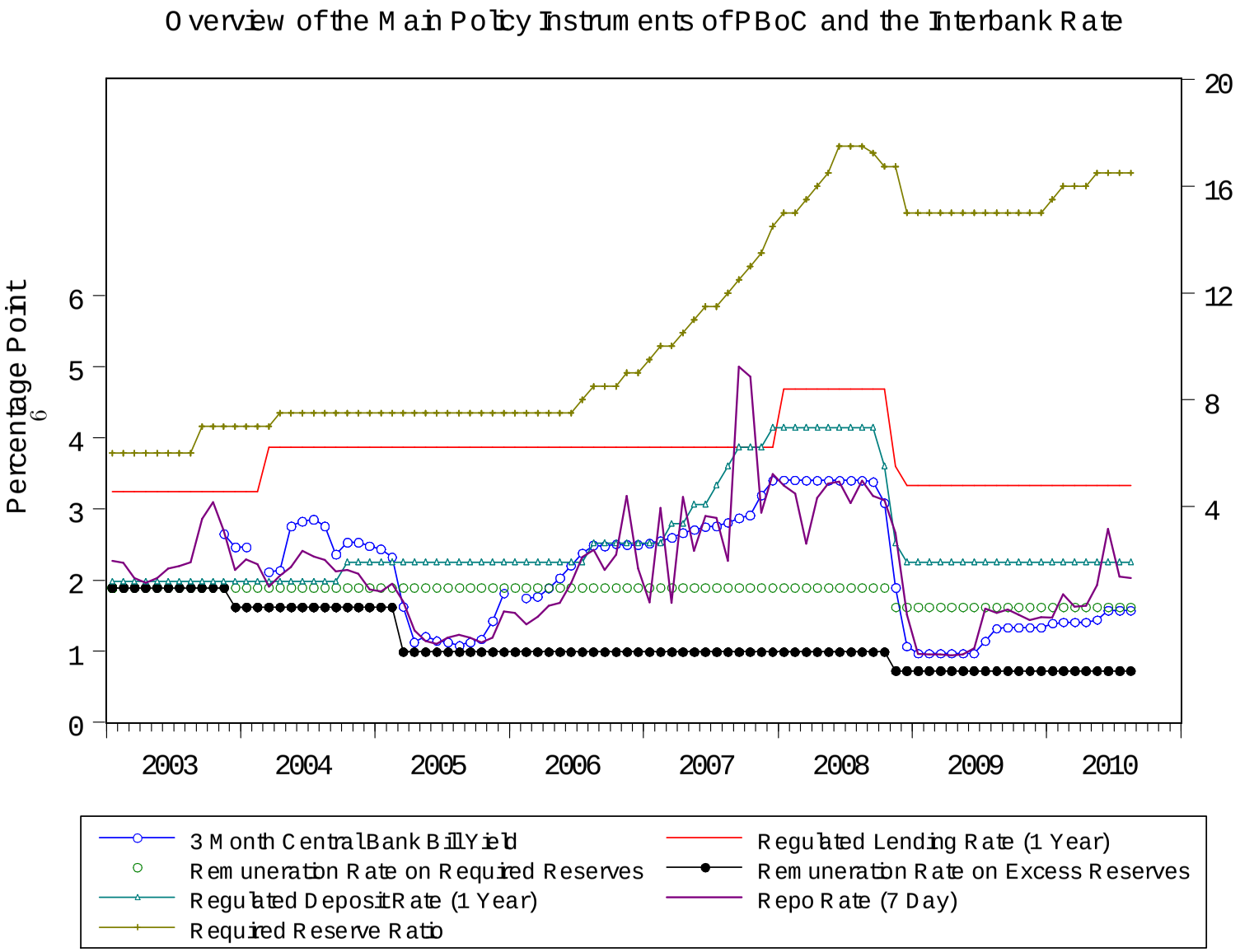

Overview of the Main Policy Instruments of PBoC and the Interbank Rate
Percentage Point
0
1
2
3
4
5
6
4
8
12
16
20
2003
2004
2005
2006
2007
2008
2009
2010
3 Month Central Bank Bill Yield
Remuneration Rate on Required Reserves
Regulated Deposit Rate (1 Year)
Required Reserve Ratio
Regulated Lending Rate (1 Year)
Remuneration Rate on Excess Reserves
Repo Rate (7 Day)

Table 2: Episode 1

Period	Policy Actions		Interbank Rate Change bps	New Increased Loan Growth%
Sept. 15	Increase of RR by 0.5%	Withdrawal of liquidity by 73billion	-19	16
Sept. 19	Increase of the regulated deposit and lending rate by 27 bps			
Sept. 30				
October	Withdrawal of liquidity by 97.25 billion		22	-2.56
Source: CEIC and author's calculation				

Table 3: Episode 2

Period	Policy Actions		Interbank Rate Change bps	New Increased Loan Growth%
May 5th	Increase of RR by 0.5%	Injection of liquidity by 212 billion	-27	5.4
May 19th	Increase of the regulated deposit and lending rate by 27 bps			
June 5th	Increase of RR by 0.5%			
Source: CEIC and author's calculation				

One not always understood the consequence of this approach in that how controlling liquidity in the retail level-by regulating the deposit and retail lending rates-together with the the controls in wholesale level influences the monetary policy transmission through the interest rate channel. Does this regulation help the central bank to achieve its target more effectively or the other way round? Does the change of an instrument which would clearly have expansionary or contractionary effect in a liberalized market might have perverse effects in a quasi-liberalized market system such as that in China?

Two of the episodes of monetary policy implementation in 2006 shown in Table 2 and 3 provide possible answers to these questions.

In both episodes, the PBoC appears to have taken policy actions to tighten monetary conditions.[6] In particular, they raised the regulated rates for both deposits and lending simultaneously, raised RR, and withdrew liquidity. However, surprisingly, the resulting in-

[6] This is consistent with what the monetary policy indicators imply in Shu and Ng (2010).

terbank rate fell and new loans increased on most occasions, suggesting that these measures were expansionary. These ex-post data mask the individual effect of each policy instrument as well as the transmission mechanism of the monetary policy. To answer the above questions, it is therefore important to study the effects of changes in individual policy instruments in a model in which market forces and regulations coexist.

4 The Theoretical Model

4.1 Model Framework

To study the effect of the monetary policy instruments on aggregate bank loans, we present a stylized model that integrates regulation of banks' deposit and lending rates with a competitive interbank market. The model is based on that of Porter and Xu (2009a), which is in turn an extended version of the model of Freixas and Rochet (2008). We assume that each bank chooses the amount of the deposits, excess reserves, central bank bills, and loans in order to maximize profits, given the RR, the reserve remuneration ratio, central bank bill yield and the regulated interest rates for deposit and lending. Thus, each bank's profit maximization problem is given as:

$$\begin{aligned} \pi_i \quad = \quad & \max_{L_i,E_i,D_i,B_i} \{ r_L L_i + r_E E_i + r_R \alpha D_i + r_B B_i + r M_i - r_D D_i \\ & - c\left(D_i, L_i\right) - \frac{\beta}{2}\left(E_i - E^T\right)^2 - \frac{\kappa}{2}\left(L_i - L_i^T\right)^2 \} \end{aligned} \tag{1}$$

where L_i denotes the level of loans, E_i is the level of excess reserves, αD_i is the amount of required reserves (with α being the RR and D_i the deposit level), B_i is the quantity of central bank bill holdings and changes as a consequence of open market operations,[7] and M_i, is the net position in interbank market. The relevant interest rates are denoted r_L, r_E, r_R, r_D, and

[7] Corporate bonds and repo transaction is modelled as interbank lending.

r_B.

Equation 1 states that the profits of bank is the sum of revenues minus the costs. Revenues come from retail lending, $r_L L_i$; holdings of excess reserves[8], $r_E E_i$;[9] holdings of required reserves, $r_R \alpha D$;revenues on holdings of central bank bills, $r_B B_i$; and lending in the interbank market, rM_i.[10] The costs arise from interest payments on deposits, $r_D D_i$; the management of central bank bill holdings, deposits and loans, $c(\cdot)$;[11] and the cost of deviations of reserves from their target level E_i^T, $\frac{\beta}{2}\left(E_i - E_i^T\right)^2$.[12] The last term captures window guidance, that is, the fact that the PBoC on occasion sets a target loan level $L_i^T$for banks. In this section we disregard this cost by setting $\kappa = 0$.

The net position on the interbank market is given by M_i:

$$M_i = D_i - L_i - E_i - \alpha D_i - B_i \tag{2}$$

The management costs are given by:

$$C(D_i, L_i) = \frac{c_{Di} D_i^2 + c_{Li} L_i^2}{2} \tag{3}$$

with c_{Di}, $c_{Li} > 0$.

Following Bartolini et al. (2001) and Campbell (1987), we assume that banks are concerned about their access to liquidity. The cost is modelled as a quadratic function of the deviation of actual excess reserve holding from the target level. Using equation (2), the profit

[8] The main difference between our model and that of Porter and Xu (2009a) is that we make a distintion between required and excess reserves. Since the PBoC sometimes changes the spread between the interest rate it pays on these two types of reserves, this seems appropriate.

[9] The PBC pays interest for required and excess reserve.

[10] We assume there is only one interbank market and thus one interbank rate. Although there is segmentation of the Chinese interbank, it does not affect our result qualitatively.

[11] Costs include implicit source costs to attract depositors, i.e.labor, physical capital, material cost to produce service to depositors (Sealey and Lindley 1977, p. 1254); costs to attract lenders and costs to manage bond investment portfolio.

[12] Reserve plays a role as liquidity, banks typically set a target level of reserve to finance unexpected inflow or outflow from banks' reserve account (Campbell 1987 p. 61). "The target level is determined by banks' relationship with its non-bank customers, its role in teh payment system, and the need to secure positive balances to avoid end-of-day overdraft penalties" (Bartolini et al 2001 p. 1295).

maximization problem becomes:

$$\pi_i = \max_{L_i, E_i, D_i, B_i} \{ (r_L - r) L_i + (r_E - r) E_i + [r - r_D + \alpha (r_R - r)] D_i \tag{4}$$

$$+ (r_B - r) B_i - \frac{c_{Di} D_i^2 + c_{Li} L_i^2}{2} - \frac{\beta}{2} \left[E_i - E_i^T \right]^2 \} \tag{5}$$

Rearranging the first-order conditions with respect to L_i, we obtain:

$$r_L = r + c_{Li} L_i. \tag{6}$$

Equation (6) indicates that the optimal amount of loans is given by the point where the marginal benefit of loans equals the marginal cost of loans. The marginal benefit is the interest rate in retail lending and the marginal cost depends on two components: the interbank rate and the cost of managing the loans.

Similarly, the first-order condition for excess reserves can be rearranged to yield:

$$r_E = r + \beta \left[E_i - E_i^T \right] \tag{7}$$

Thus, the optimal level of excess reserves is selected such that remuneration equals the cost of holding them. These costs are given by the sum of the interbank rate and cost of deviation from target reserve level.

Turning to deposits, we obtain:

$$\alpha r_R + (1 - \alpha) r = r_D + c_{Di} D_i \tag{8}$$

The bank should thus attract deposits to the point where their marginal benefit and marginal cost are equal. The benefit of holding reserves is the sum of the interest earned on required reserves, αr_R, and the interbank lending return from the part of deposits that do not serve as required reserves, $(1 - \alpha) r$. The cost composes of the interest rate on deposits, r_D, and

management costs.

Finally, the optimal quantity of central bank bills to hold is given by the level that equates the central bank bill yield with opportunity cost of holding central bank bills, r:

$$r_B = r \tag{9}$$

Holding central bank bills is therefore a perfect substitute for lending the same amount of funds in interbank market.

Furthermore, the supply for loans can be written as a function of the spread between the lending rate and the interbank rate:

$$L_i = \frac{r_L - r}{c_{Li}} \tag{10}$$

and optimal excess reserve as:

$$E_i = \frac{1}{\beta}\left(r_E - r\right) + E_i^T \tag{11}$$

The deposit demand function is:

$$D_i = \frac{1}{c_{Di}}\left(r - r_D + \alpha\left(r_R - r\right)\right) \tag{12}$$

Assuming there are N banks in the interbank market, the market clearing condition is:

$$\sum_{i=1}^{N} M_i = 0 \tag{13}$$

The supply of central bank bills is exogenous and set through OMOs. r_B and r are jointly determined by the interbank market clearing condition (equation 13). In practice, the PBoC announces the reference rate for the central bank bills in order to influence the interbank rate.

So far we have assumed that banks maximize profits by choosing the amount of deposits,

loans, excess reserves and central bank bill holdings, given interest rates and their cost functions. The net position M_i of each firm can be positive, zero, or negative, while the sum of M_i equals zero, as shown in equation (13). Equations (10)-(13) have three unknowns we need to determine: the interbank market rate, r, the deposit rate, r_D, and the retail lending rate, r_L. In the next section, we study the model solution and the impact of changes in policy instruments on interbank rate and lending.

4.2 The Impact on Interbank Rate and Loans

We first discuss the solution for the standard case in which the interest rates for lending and deposits are market determined.

Case 1: r_L and r_D are market determined.

In the standard case, the retail lending rate, r_L, and deposit rate, r_D, are endogenously determined in the loan and deposit markets. To capture the demand side of the loan market, we simply assume that aggregate loan demand is negatively related to the lending rate and positively related to real GDP and the price level:

$$L^d = L^d\left(\overset{-}{r_L}, \overset{+}{Y}, \overset{+}{P}\right) \tag{14}$$

Loan supply is the sum of banks' loan supply so that the equilibrium lending rate, r_L^*, is implicitly determined by:

$$L^d\left(\overset{-}{r_L}, \overset{+}{Y}, \overset{+}{P}\right) = L^s = \sum_{i=1}^{N} L_i = \sum_{i=1}^{N} \frac{r_L - r}{c_{Li}} \tag{15}$$

which we can solve for r_L^*:

$$r_L^* = h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}\right) \tag{16}$$

Thus, r_L^* positively related to the interbank rate, r, real GDP, Y, the price level, P, and loan

management costs, as captured by c_{Li}. Furthermore, we assume that the supply of deposits is a function of the deposit rate, real GDP and the price level:

$$D^s = D^s\left(\overset{+}{r_D}, \overset{+}{Y}, \overset{+}{P}\right). \tag{17}$$

In equilibrium we have that:

$$D^s\left(\overset{+}{r_D}, \overset{+}{Y}, \overset{+}{P}\right) = D^d = \sum_{i=1}^{N} D_i = \sum_{i=1}^{N} \frac{1}{c_{Di}}\left(r - r_D + \alpha\left(r_R - r\right)\right) \tag{18}$$

By solving equation (18), the equilibrium deposit rate, r_D^*, is obtained:

$$r_D^* = f\left(\overset{+}{r}, \overset{+}{r_R}, \overset{+}{\alpha}, \overset{-}{Y}, \overset{-}{P}\right). \tag{19}$$

Thus r_D^* is positively related to the interbank rate, r; the remuneration rate on required reserves, r_R; the required reserve ratio, α; the price level, P; and negatively related to real GDP, Y. Substituting r_L and r_D in (10) and (12) with r_L^* and r_D^* respectively, and substituting M_i with D_i, L_i, E_i, and B, the sum of aggregate net position, i.e. equation (13) can be expressed as:

$$\begin{aligned} F(\cdot) &= \sum_{i=1}^{N} M_i = \sum_{i=1}^{N}\left[(1-\alpha) D_i - L_i - E_i\right] - B \\ &= \sum_{i=1}^{N}(1-\alpha) D_i - \sum_{i=1}^{N} L_i - \sum_{i=1}^{N} E_i - B \end{aligned} \tag{20}$$

The aggregate net position $F(\cdot)$ depends on four factors: the fraction of aggregate deposits that is not held as required reserves, $\sum_{i=1}^{N}(1-\alpha) D_i$; aggregate loans, $\sum_{i=1}^{N} L_i$; aggregate excess reserves, $\sum_{i=1}^{N} E_i$; and the aggregate amount of central bank bills, B, which is determined by the central bank's open market operations and is exogenous. The equilibrium interbank rate,

r^*, clears the interbank market, and is given by:

$$r^* = g\left(\alpha, r_R, r_E, B, Y, P\right). \tag{21}$$

The solution of r^* equations (14) or (15), implies that:

$$L = L^d = L^s = \sum_{i=1}^{N} \frac{h\left(\overset{+}{r^*}, \overset{+}{Y}, \overset{+}{P}\right) - r^*}{c_{Li}} \tag{22}$$

The partial effects of adjusting monetary policy instruments on this equilibrium loan level is given by Proposition 1:

Proposition 1 *When the deposit rate, r_D, and lending rate, r_L, are market determined, the impact of increasing the rate of remuneration on excess reserves and sales of central bank bill on loans, i.e. $\frac{\partial L}{\partial r_E}$ and $\frac{\partial L}{\partial B}$, are both negative. The impact of increasing remuneration rate on required reserve on loans, $\frac{\partial L}{\partial r_R}$, is positive, and the impact of increasing RR on loans, $\frac{\partial L}{\partial \alpha}$, is ambiguous.*

The proof of Proposition 1 is in Appendix B. The intuition is as follows: increasing the remuneration on excess reserve leads banks to hold more excess reserves, which results in a negative aggregate position in the interbank market, $F(\cdot) < 0$, given the original equilibrium interbank rate. Hence the equilibrium rate must rise to clear the interbank market. In turn, that results in a higher lending rate and a lower loan level.

Sales of bills by the central bank has the same effect on loans by making the aggregate net position negative. By contrast, a higher remuneration rate on required reserves lead banks to attract more deposits. The resulting rise in aggregate deposits causes the aggregate net position in the interbank market to become positive, thus resulting in a lower interbank rate and hence more lending.

	Case 1	**Case 2.1**	**Case 2.2**	**Case 2.3**
	No	$r_L^B < r_L^*$	$\mathbf{r}_L^B \geq \mathbf{r}_L^*$	
Instrument	**Intervention**	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B \geq \mathbf{r}_D^*$
$\mathbf{r}_L^B$	/	0	$-$	$-$
$\mathbf{r}_D^B$	/	$-$	$-$	0
$\boldsymbol{\alpha}$	$\mp$	$+$	$+$	$\mp$
$\mathbf{r}_R$	$-$	0	0	$-$
$\mathbf{r}_E$	$+$	$+$	$+$	$+$
B	$+$	$+$	$+$	$+$

Table 4: Impact of Changes in Policy Instruments on Interbank Rate

	case 1	**case 2.1**	**case 2.2**	**case 2.3**
	No	$r_L^B < r_L^*$	$\mathbf{r}_L^B \geq \mathbf{r}_L^*$	
Instrument	**Intervention**	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B \geq \mathbf{r}_D^*$	$\mathbf{r}_D^B < \mathbf{r}_D^*$
$\mathbf{r}_L^B$	/	0	$-$	$-$
$\mathbf{r}_D^B$	/	$+$	0	0
$\boldsymbol{\alpha}$	$\pm$	$-$	0	0
$\mathbf{r}_R$	$+$	0	0	0
$\mathbf{r}_E$	$-$	$-$	0	0
B	$-$	$-$	0	0

Table 5: Impact of Changes in Policy Instruments on Loans

The impact of a change in RR depends on two factors. First, higher RR reduces the funds banks have available to lend, purchase central bank bills, and to hold excess reserves. Moreover, a higher RR also increases the demand for deposits by banks. The overall impact on the aggregate net position in the interbank market and on loans is ambiguous. Table 4 and 5 summarize the policy effects on interbank rate and loans respectively.

So far, we have discussed a model in which banks maximize profits, under the assumption that the interest rates on deposits and retail lending are market determined. The case considered above is relevant for central banks that conduct monetary policy principally by influencing interest rates in interbank markets. While this is the standard procedure in advanced economies, the PBoC continues to rely on regulation of the interest rates that banks pay on deposits and charge for loans.

We therefore consider how the introduction of regulated interest rates modifies the conclusions from the above analysis assuming market determined deposit and lending rates in the next step. This complicates the analysis considerably because such regulation could apply to either or both deposit and lending rates. Moreover, the regulation can force the actual rate below or above the equilibrium level. To limit the number of cases that we must consider, we therefore focus on the sub-cases that we believe best capture the present situation in China. The discussions on the sub-cases that capture the regulations before 2004 are provided in appendix B.

Case 2 The floor of r_L and the cap of r_D are set by the central bank

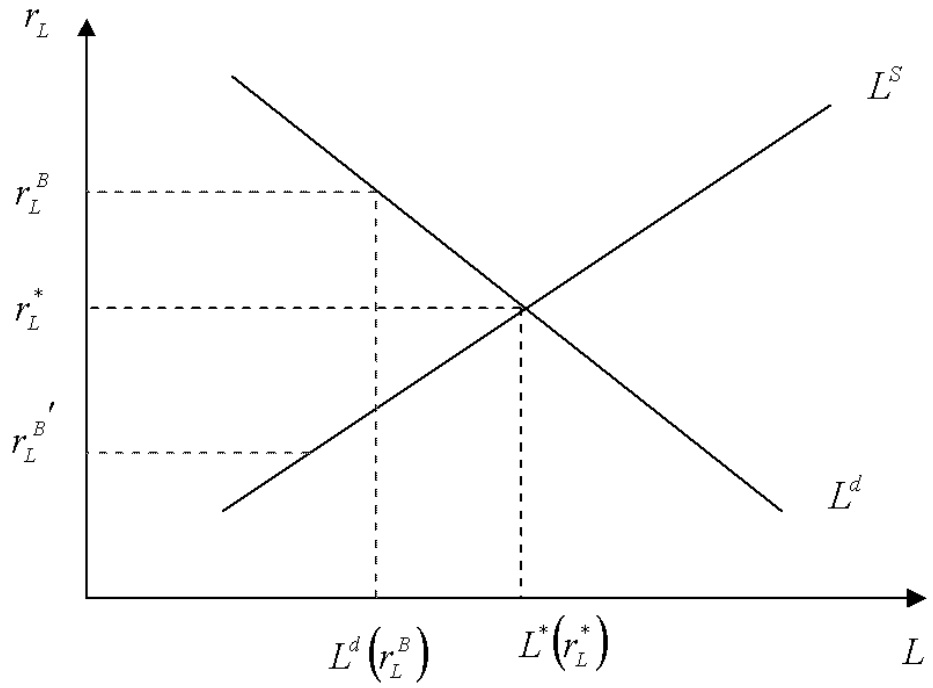
Figure 2 illustrates the determination of loan and deposit when the regulated rates provide a floor for the lending rate and a ceiling for the deposit rate.[13] The level of loans and the lending rate are equilibrium outcomes, when the regulated lending rate is below the equilibrium level. However, when the regulated lending rate is above the equilibrium rate, the loan level is determined by the loan demand, which is exogenous to the banks. The opposite holds true in the case of deposits. If the regulated deposit rate is above the equilibrium level, the amount of deposits is determined as if there was no such regulation. In contrast, if the regulated rate is below the equilibrium rate, deposits are determined by supply function.

Whether the regulated interest rates are above or below their equilibrium levels is crucial because it determines whether the quantity of deposits and loans will rise, fall or remain the same following a change in some instruments. Since it may be difficult for policy makers to determine the equilibrium rate, one consequence is that they may not know whether a change in the regulated interest rate will be expansionary or contractionary.

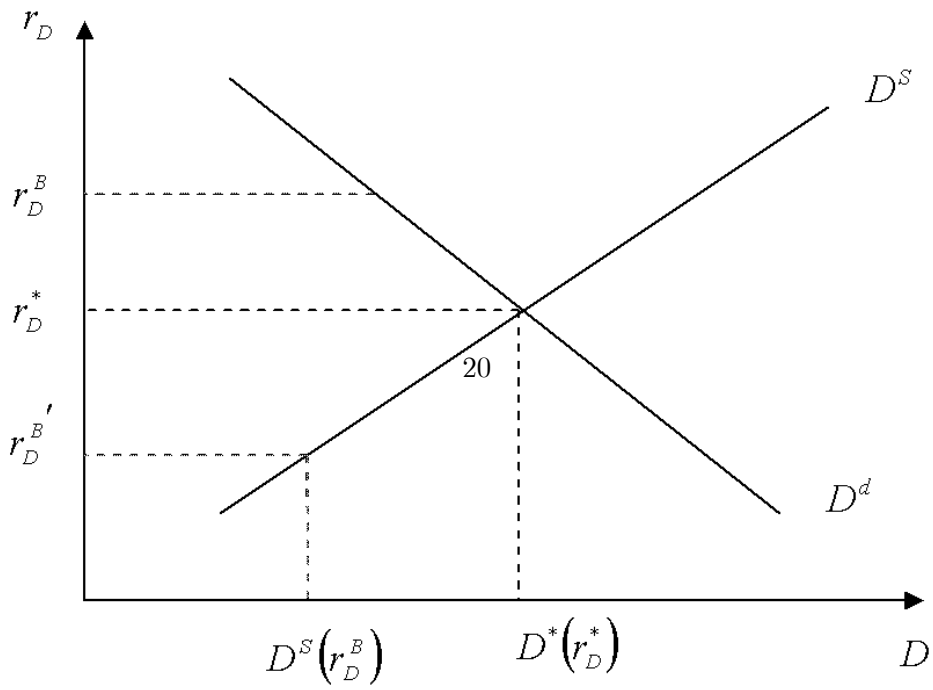
In order to explore the consequences of changing monetary policy instruments when the interest rates are regulated, below we discuss the sub-cases in which the regulated rates deviate from the equilibrium rates in different directions. Since the regulated rates only

[13] In practice, the lower bound of the lending rate is 90% of the regulated lending rate (also named benchmark lending rate). We do not model this detail since it does not change our result qualitatively.

Figure 1: Regulated Lending and Deposit Market



(a) Lending Market



affect the equilibrium when they are binding (that is, the lending rate is above equilibrium and the regulated deposit rate is below equilibrium), we solely discuss cases in which either or both regulated rates are binding.

Case 2.1 $r_L^B < r_L^*$ *and* $r_D^B < r_D^*$

Here we examine the effect of policy changes when both regulated rates are below their equilibrium levels. The fact that regulated lending rate is below the equilibrium level means the volume of bank loans are market determined and not affected by the regulation. In this case, we can solve for r_L^* using (16) and the loan level is then given by equation (22). In contrast, as the regulated deposit rate is below the equilibrium level, deposits are determined by supply factors. The aggregate net position in the interbank market is therefore given by:

$$F(\cdot) = (1-\alpha) D^s\left(r_D^B\right) - L^d\left(h\left(\overset{+}{r}, \overset{-}{\overset{+}{Y}}, \overset{+}{P}\right), \overset{+}{Y}, \overset{+}{P}\right) - \sum_{i=1}^{N}\left(\frac{1}{\beta}\left(r_E - r\right) + E_i^T\right) - B \tag{23}$$

The effect of policy instruments are presented in Proposition 2.

Proposition 2 *When r_L^B provides a floor for the retail lending rate and r_D^B a ceiling for deposit rate, and these two rates are both below their equilibrium rates respectively, increasing the benchmark deposit rate is expansionary. Increasing the RR, remuneration rate on excess reserve and sales of securities to banking system are contractionary. Changes in the regulated lending rate and on remuneration on required reserve do not influence the level of loans.*

The proof of Proposition 2 is in Appendix B. In this case, the increase of the benchmark deposit rate attracts more deposits from the public and thus attracts funds to the interbank market, which implies this is an expansionary policy. Higher RR, higher remuneration on excess reserves and sales of central bank bills reduce liquidity in the interbank market, thus are all contractionary. Raising the regulated lending rate does not change the level of loans

and actual lending rate, as long as the raised rate level is still lower than the equilibrium rate, since the regulated rate is not binding. A change in the remuneration on required reserves also does not have effect on interbank liquidity and loans. The reason is that this policy action only influences interbank liquidity through banks' demand for deposit, while in this case, the interbank liquidity is determined by the supply for deposit, not by this bank demand.

Case 2.2 $r_L^B \geq r_L^*$ *and* $r_D^B < r_D^*$

When the regulated lending rate exceeds the equilibrium level, it is binding and the level of loans is demand driven. As in Case 2.1, the deposit level is determined by supply function. The aggregate net position in the interbank market is given by:

$$F(\cdot) = (1-\alpha) D^s\left(r_D^B\right) - L^d\left(r_L^B\right) - \sum_{i=1}^{N}\left(\frac{1}{\beta}\left(r_E - r\right) + E_i^T\right) - B \tag{24}$$

The only instrument that matters for the determination of loans is the regulated lending rate, a rise in which leads to a lower demand for loans, and thus lower level of loans. Moreover, raising benchmark lending rate lowers interbank rates by leading the banks to demand less liquidity from the interbank.

This partial effect of raising regulated lending rate on loans is given by:

$$\frac{\partial L}{\partial r_L^B} = \frac{\partial}{\partial r_L^B} L^D\left(\overset{-}{r_L^B}, \overset{+}{Y}, \overset{+}{P}\right) < 0. \tag{25}$$

And the effect on interbank rate is:

$$\frac{\partial r}{\partial r_L^B} = -\frac{\partial F/\partial r_L^B}{\partial F/\partial r} = -\frac{-\partial L^d\left(r_L^B\right)/\partial r_L^B}{\partial F/\partial r} < 0 \tag{26}$$

However, changes in other instruments influence the interbank market rate in the same way as in Case 2.1. Thus, a rise in benchmark deposit (to a level that is lower than the

equilibrium rate) lowers the interbank rate , while raising RR, increasing remuneration on excess reserve and sales on central bank bills pushes up the interbank rate. There is no effect of a change in the remuneration on required reserves on the interbank rate.

In this case the central bank can directly control the loan level by changing the regulated lending rate, so that the interbank market plays no role for the transmission of monetary policy. Furthermore, there exist a disconnect between the interbank rate and bank loans. In particular, when the central bank raises RR, increase the remuneration on excess reserves, and conduct sales of central bank bills, the interbank rate increases but bank loans does not change.

Case 2.3 $r_L^B \geq r_L^*$ *and* $r_D^B \geq r_D^*$

When both regulated rates are above the equilibrium rates, bank loans are determined by demand while deposit is determined by the equilibrium rate. The aggregate net position thus is:

$$F(\cdot) = (1-\alpha) D^s \left(f \left(\overset{+}{r}, \overset{+}{r_R}, \overset{+}{\alpha}, \overset{-}{Y}, \overset{-}{P} \right) \right) - L^d \left(r_L^B \right) - \sum_{i=1}^{N} \left(\frac{1}{\beta} \left(r_E - r \right) + E_i^T \right) - B \qquad (27)$$

As in Case 2.2, raising benchmark lending rate lowers loans by reducing loan demand. Changes of other instrument do not have any effect on it. Raising benchmark lending rate lowers interbank rates by reducing the bank demand for funds from the interbank market. However, other instruments influence the interbank liquidity either directly, or through changing the equilibrium level of deposits and excess reserves. Their effects on the interbank rate are therefore the same as in Case 1. To be specific, higher remuneration on required reserves lowers the interbank rate, higher remuneration on excess reserves and sales of central bank bills increase the interbank rate, and the effect of raising required reserve on interbank rate is ambiguous.

The main implication from the theoretical model is thus that the effect of policy instruments on the interbank rate and bank loans differs from the standard case if the interest rates on deposit and lending are regulated. Furthermore, the effect depends on whether the regulated interest rate is above or below the equilibrium rate. The disconnect between the changes in interbank rate and loans can thus be explained by the presence of regulated rates in the policy framework.

Before proceeding, we emphasize that from the view point of the central bank, knowledge about wether the benchmark rates are above or below the equilibrium rates is crucial for knowing the effect of changes in policy instruments.

This section provides a theoretical model to show the transmission of monetary policy to bank loans in an monetary policy framework with regulations of deposit and retail lending market. In the next section, We apply the model to explain the puzzling episodes illustrated in Section 3.

4.3 Application of the model

To explain the different episodes mentioned in Section 3 with the model, we first need to identify in which regime or case the economy is. This is difficult since it requires us to know whether the regulated deposit and lending rates are above or below their underlying equilibrium levels. As already noted, the equilibrium deposit rates are in general believed to be above the benchmark rate, since there is little evidence that market deposit rates below the regulated rate. Thus we assume this is the case in our analysis. For the lending rate, it is less clear whether the regulated rate is binding. Table 6 shows the fraction of bank loans that are lent at rates above the regulated rate. In particular, for some periods, the largest four state-owned banks and joint-stock commercial banks had more than one third of their loans prices above the regulated rate, while the city commercial banks had more than two thirds. We therefore assume that either Case 2.1 or 2.2 best characterizes the economy.

Episode 1 shows the policy actions and the corresponding changes in interbank market

Table 6: Proportions of Lending Rates Higher than the Regulated Lending Rate

Period	Big Four	Joint-stock Commercial Banks	City Commercial Banks
2004Q3	35.70	33.20	66.30
2004Q4	44.33	36.00	60.23
2005Q1	39.80	34.60	66.80
2005Q2	39.96	32.37	57.79
2005Q3	41.08	35.62	68.10
2005Q4	41.09	35.07	51.94
2006Q1	39.92	35.07	57.01
2006Q2	39.41	34.7	58.32
2006Q3	35.70	31.02	62.82
2006Q4	38.52	29.03	56.93
2007Q1	36.01	28.43	54.67
2007Q2	36.48	27.41	49.82
2007Q3	36.88	26.19	44.12
2007Q4	35.54	29.35	46.30
2008Q1	36.47	35.57	NA

Source: CEIC and authors' calculation

and new loans between September 15th and October 31st, 2006. On September 15th, the PBoC raised RR by 0.5%, which the model suggests would push up the interbank rate. Four days later, PBoC increased the regulated rates for both deposit and lending simultaneously by 27 basis points. The model suggests that the combination of these two actions would reduce the interbank rate. At the same time, the withdrawal of 73 billion RMB of interbank liquidity was – according to the model – also expected to raise the interbank rate. The overall effect on the interbank rate thus depends on whether the increase in the regulated rates (which attracts deposits and tends to reduce interbank rates) was greater than the contractionary effects on interbank liquidity arising from the increase in the RR and the withdrawal of liquidity. The data shows that the interbank rate fell by 19 basis points, indicating the effect arising from the increase in the regulated rates, which attracts liquidity into the interbank markets, dominates. The resulting increase of new loans suggests that the economy is in Case 2.1.

In the next month, PBoC withdrew liquidity by 97 billion RMB without altering its other policy instruments. In contrast to the previous month, this time the interbank rate increased by 22 basis points and new loans fell by about 2.6%. The result is again consistent with the predictions of the model Thus, the model suggests that increasing the two regulated rates is probably the main reason leading to an opposite overall effect.

The second episode considers the policy actions from May 15th to June 5th, 2007. The sequence of adjustments in the instruments is the same as the first case, except that the PBoC increased the RR a second time after the adjustment of the regulated interest rates rates. Furthermore, it injected, rather than withdrew, a large amount of interbank liquidity. The impact on the interbank rate and new loans were similar to in the first episode. The explanation of the model is that although the second rise of the RR reduced liquidity in the interbank market, the large liquidity injection and the increase of the regulated deposit rate were more important. Hence the interbank rate dropped by more, and new loans grew faster, then in the earlier case.

5 Conclusion

In this paper we have studied the implementation of monetary policy and the interest-rate transmission mechanism in China. This is an interesting area of inquiry because the coexistence of regulation regarding what interest rates banks can charge for loans and offer on deposits with a market determined interbank rate make the transmission mechanism much more complicated than in a system in which all interest rates are fully flexible. Perhaps because of these complications and the resulting limited controllability of the degree to which monetary conditions are expansionary, the PBoC uses an array of policy instruments – including required reserve ratios, the rate of remuneration on reserves, open market operations – which further complicates the transmission mechanism.

To understand these issues better, we extend the model of bank behavior in China proposed by Porter and Xu (2009a). The model illustrates how the interbank rate and the

quantity and price of retail loans are determined in an environment where banks compete, given regulations concerning the interest rates they can pay on deposits and charge for loans. The analysis suggests to several conclusions.

First, the presence of regulated rates has a large impact on the interest rate transmission mechanism. In particular, the net effect of changes in the policy instruments depends on whether and how the regulated interest rates deviate from their equilibrium levels. For instance, an increase in deposit rates will attract more deposits – and therefore depress interbank rates and expand bank lending – if the deposit rate is below the equilibrium level, but may do the opposite if the deposit rate is above the equilibrium level, given macroeconomic conditions.

Second and as a consequence, the interbank rate does not fully reflect the stance of monetary policy. Indeed, it can even be a potentially misleading indicator of the central bank's policy intentions. For instance, an increase in the regulated lending rate above the equilibrium level will tend to depress interbank rates – suggesting a more expansionary policy – since banks may react to the resulting decline in bank lending rates by reducing their demand for funds in the interbank market.

Third, to characterize properly the central bank's policy stance, information from all policy instruments – including the remuneration on required and excess reserves, RR and open market operations – needs to be taken into account. Doing so is not an easy exercise, neither for outside analysts nor the PBoC's staff.

Fourth, since the PBoC does not observe the equilibrium rates, there is a risk that it may not know at all times whether a change of its policy instruments would be expansionary or contractionary. This raises the risk that policy changes do not always have their intended effects, which may lead to policy errors.

Fifth, liberalizing the regulated rates would eliminate much of this uncertainty and is therefore likely to improve the PBoC's ability to control the degree to which monetary policy is stimulatory. The system of regulated rates is also likely to lead banks and borrowers

to avoid the regulation by operating in grey markets. An additional benefit of lifting the regulations is that it would transfer this activity to the regulated sector.

While the focus of this paper has been to better understand the transmission mechanism by investigating theoretically how profit maximizing banks are likely to behave in the presence of regulation, a number of important empirical questions are readily apparent.[14]

One set of questions concerns the behavior of interbank rates. For instance, to what extent do they respond to the policy instruments reviewed above? Have the responses become stronger over time, as one would expect given the gradual liberalization of the Chinese financial system over time? How do answers to these questions depend on the maturity of the interbank rate considered? What is the role of macroeconomic conditions in determining their evolution over time?

A second set of questions pertains to the behavior of effective bank lending rates. How do they respond to the different policy instruments of the PBoC? Have these responses varied over time? What is the role of fluctuation in the demand for bank loans coming from movements in real GDP?

Finally, questions regarding the interconnectedness of Chinese interest rates with interest rates in the rest of the world arise. If the exchange rate is fixed or heavily managed, economic forces will tend to equalize interest rates across currencies. Of course, regulation to thwart these forces may be effective, at least for some time. Over time and as financial integration proceeds, one would expect international interest rate linkages to become stronger. Is this true for China?

While admittedly the available data set is limited, it would be fruitful to address these issues in a future paper. We hope to do so.

[14] It should be noted that the model traces out the responses of the banking system to monetary stimulus under the assumption that output and prices are exogenously given. While this is, of course, not a good characterization of the real world, the time spans that we consider below are short and it seems not unreasonable to assume that they are approximately constant.

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6 Appendix A

6.1 Proof of Proposition 1

Proof. : ■

The aggregate net position is given by:

$$\begin{aligned} F(\cdot) &= (1-\alpha) D^s - L^D - \sum_{i=1}^{N} E_i - B \qquad (28) \\ &= (1-\alpha) D^s \left(f\left(\overset{+}{r}, \overset{+}{r_R}, \overset{+}{\alpha} \overset{-}{Y}, \overset{+}{P} \right), \overset{+}{Y}, \overset{-}{P} \right) . - L^D \left(h\left(\overset{+}{r}, \overset{-}{Y}, \overset{+}{P} \right), \overset{+}{Y}, \overset{+}{P} \right) \\ &\quad - \sum_{i=1}^{N} \left(\frac{1}{\beta} (r_E - r) + E_i^T \right) - B \end{aligned}$$

The partial effect of a change in interbank market rate on the aggregate net position is:

$$\begin{aligned} \partial F(\cdot) / \partial r &= (1-\alpha) \frac{\partial}{\partial r} D^s - \frac{\partial L}{\partial r} - \frac{\partial}{\partial r} \sum_{i=1}^{N} E_i - \frac{\partial B}{\partial r} \qquad (29) \\ &= \underbrace{(1-\alpha) \frac{\partial}{\partial r} D^s \left(f\left(\overset{+}{r}, \overset{+}{r_R}, \overset{+}{\alpha} \overset{-}{Y}, \overset{+}{P} \right), \overset{+}{Y}, \overset{-}{P} \right)}_{>0} - \underbrace{\frac{\partial}{\partial r} L^D \left(h\left(\overset{+}{r}, \overset{-}{Y}, \overset{+}{P} \right), \overset{+}{Y}, \overset{+}{P} \right)}_{<0} + \underbrace{\frac{N}{\beta}}_{>0} \qquad (30) \end{aligned}$$

which implies

$$\partial F(\cdot) / \partial r > 0 \qquad (31)$$

The partial effects of raising remuneration on excess reserves on aggregate position is given by:

$$\partial F(\cdot) / \partial r_E = -\frac{\partial}{\partial r_E} \sum_{i=1}^{N} E_i = -\frac{N}{\beta} < 0, \qquad (32)$$

Using the implicit function theorem, we therefore obtain the partial effect of remuneration on excess reserves on interbank rate is given as the following:

$$\frac{\partial r}{\partial r_E} = -\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} > 0 \tag{33}$$

in turn, the impact on loans is:

$$\frac{\partial L}{\partial r_E} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_E} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} < 0 \tag{34}$$

Similarly, the partial effect of changes in remuneration on required reserves on the interbank rate and loans are:

$$\partial F(\cdot)/\partial r_R = (1-\alpha)\frac{\partial}{\partial r_R}D^s > 0, \tag{35}$$

$$\frac{\partial r}{\partial r_R} = -\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} < 0 \tag{36}$$

$$\frac{\partial L}{\partial r_R} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_R} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} > 0 \tag{37}$$

The same impact of RR is:

$$\partial F(\cdot)/\partial \alpha = \underbrace{-D^s}_{<0} + \underbrace{(1-\alpha)\frac{\partial}{\partial \alpha}D^s}_{>0} \gtrless 0 \tag{38}$$

$$\frac{\partial r}{\partial \alpha} = -\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} \lessgtr 0 \tag{39}$$

$$\frac{\partial L}{\partial \alpha} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial \alpha} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} \gtrless 0 \tag{40}$$

The impact of sales of central bank bills is thus:

$$\partial F(\cdot)/\partial B = -1 \tag{41}$$

$$\frac{\partial r}{\partial B} = -\frac{\partial F(\cdot)/\partial B}{\partial F(\cdot)/\partial r} > 0$$

$$\frac{\partial L}{\partial B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial B}{\partial F(\cdot)/\partial r} < 0 \tag{42}$$

Q.E.D

6.2 Proof of proposition 2

Proof.

In this case, the aggregate net position is given by:

$$\partial F(\cdot)/\partial r = \frac{\partial}{\partial r}(1-\alpha) D^s\left(r_D^B\right) - \frac{\partial}{\partial r} L^D\left(h\left(\overset{+}{r}, \overset{\overset{-}{+}}{Y}, \overset{+}{P}\right), \overset{+}{Y}, \overset{+}{P}\right) \tag{43}$$

$$-\frac{\partial}{\partial r}\sum_{i=1}^{N} E_i - \frac{\partial}{\partial r} B$$

$$= \underbrace{-\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}}_{>0} + \frac{N}{\beta} > 0 \tag{44}$$

■

The impact of a change in regulated lending rates on aggregate net position is given by:

$$\partial F(\cdot)/\partial r_L^B = 0 \tag{45}$$

Applying the implicit function theorem, this impact on interbank rate becomes:

$$\frac{\partial r}{\partial r_L^B} = -\frac{\partial F(\cdot)/\partial r_L^B}{\partial F(\cdot)/\partial r} = 0 \tag{46}$$

and the impact on loans is therefore:

$$\frac{\partial L}{\partial r_L^B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_L^B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_L^B}{\partial F(\cdot)/\partial r} = 0 \tag{47}$$

Similarly, the impact of a change in regulated deposit rate on net aggregate position, interbank rate, and loans are given by:

$$\partial F(\cdot)/\partial r_D^B = (1-\alpha)\frac{\partial}{\partial r_D^B}D^s\left(r_D^B\right) > 0 \tag{48}$$

$$\frac{\partial r}{\partial r_D^B} = -\frac{\partial F(\cdot)/\partial r_D^B}{\partial F(\cdot)/\partial r} < 0 \tag{49}$$

$$\frac{\partial L}{\partial r_D^B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_D^B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_D^B}{\partial F(\cdot)/\partial r} > 0 \tag{50}$$

The effects of raising remuneration on excess reserves is:

$$\partial F(\cdot)/\partial r_E = -\frac{\partial}{\partial r}\sum_{i=1}^{N}E_i = -\frac{N}{\beta} < 0 \tag{51}$$

$$\frac{\partial r}{\partial r_E} = -\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} > 0 \tag{52}$$

$$\frac{\partial L}{\partial r_E} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_E} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} < 0 \tag{53}$$

and the effects of raising remuneration on required reserves is:

$$\partial F(\cdot)/\partial r_R = 0 \tag{54}$$

$$\frac{\partial r}{\partial r_R} = -\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} = 0 \tag{55}$$

$$\frac{\partial L}{\partial r_R} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} = 0 \tag{56}$$

and the impact of a higher RR is given by:

$$\partial F(\cdot)/\partial \alpha = -D^s\left(r_D^B\right) < 0 \tag{57}$$

$$\frac{\partial r}{\partial \alpha} = -\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} > 0$$

$$\frac{\partial L}{\partial \alpha} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} < 0 \tag{58}$$

The impact of sales of central bank bill is:

$$\partial F(\cdot)/\partial B = -1 < 0 \tag{59}$$

$$\frac{\partial r}{\partial B} = -\frac{\partial F(\cdot)/\partial B}{\partial F(\cdot)/\partial r} > 0$$

$$\frac{\partial L}{\partial B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial B}{\partial F(\cdot)/\partial r} < 0$$

Q.E.D.

7 Appendix B

Between 1997 and 2004, the PBoC let the interbank rate to be market determined, however, they had stricter regulations on interest rates for deposit and lending by setting the deposit rate r_L and lending rate r_D directly. This sections illustrate the impact of monetary policy on interbank rate and bank loans during this period.

Case 3: r_L and r_D are Set by the Central Bank

Figure 3 shows the implication of these regulations on the deposit and lending market.

When the benchmark lending rate, r_L^B for retail lending is above the equilibrium lending rate, bank lending is determined by loan demand. By contrast, if the benchmark lending rate is below the equilibrium rate, lending depends on loan supply, which is determined by banks' maximization behavior. A similar argument applies to the regulated deposit rate.

To explore this, we need to consider these subclasses. We divide Case 3 into 3 subclasses.

Case 3.1: $r_L^B < r_L^*$ *and* $r_D^B < r_D^*$

When the benchmark lending rate and benchmark deposit rate are set below their equilibrium levels, the level of loans and deposits are determined by supply conditions as shown in Figure 3. The aggregate net position in the interbank market is now given by:

$$\begin{aligned} F(\cdot) &= (1-\alpha) D^s\left(r_D^B\right) - \sum_{i=1}^{N} L_i - \sum_{i=1}^{N} E_i - B \\ &= (1-\alpha) D^s\left(r_D^B\right) - \sum_{i=1}^{N} \frac{r_L^B - r}{c_{Li}} - \sum_{i=1}^{N} \left(\frac{1}{\beta}(r_E - r) + E_i^T\right) - B \end{aligned} \tag{60}$$

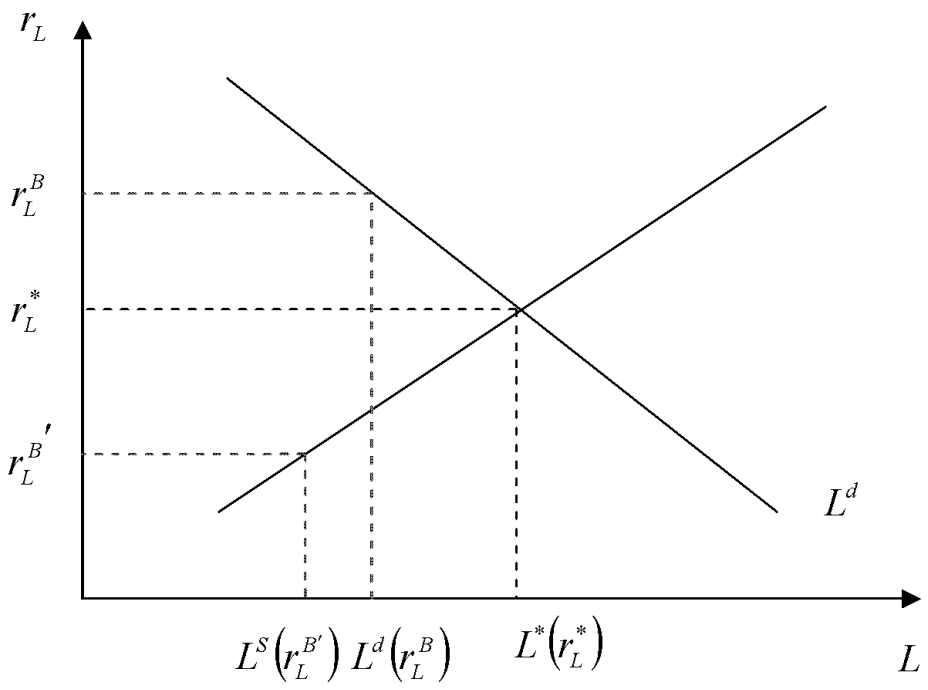
The equilibrium interbank rate r^* is obtained by solving $F(\cdot) = 0$. The level of aggregate loans is given by:

$$L = \sum_{i=1}^{N} \frac{r_L^B - r^*}{c_{Li}} \tag{61}$$

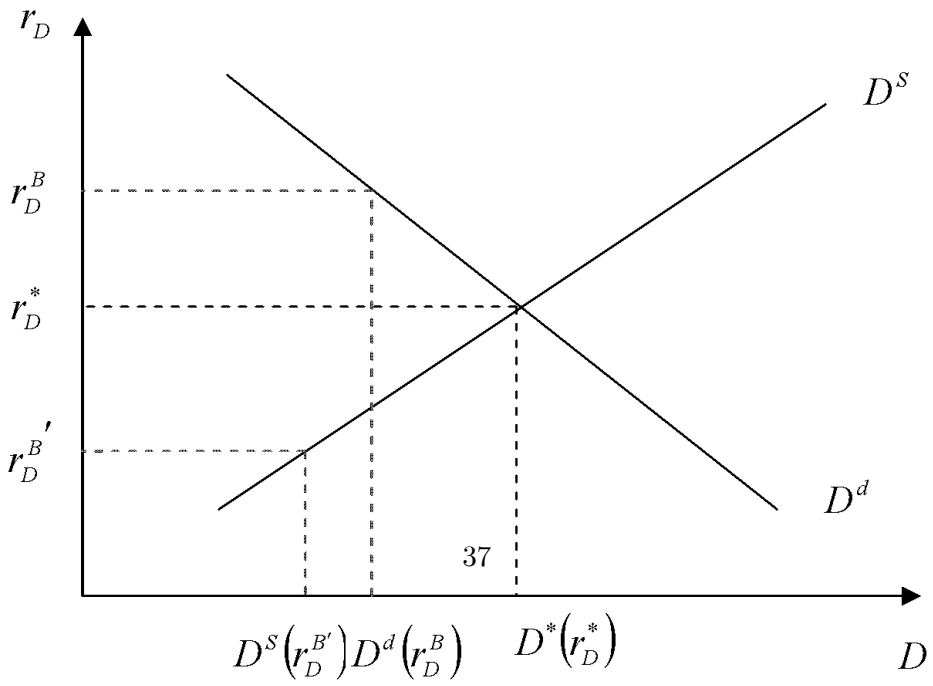
The following proposition summarizes the impact of monetary policy on bank loans:

Proposition 3 *When both the benchmark deposit and lending rates are below their equilibrium rates, the impact of increasing either of these two interest rates on loans is positive. The same impact of increasing RR, α, the remuneration rate on excess reserves, r_E, and issuance of central bank bills, B, on loan supply is negative. A change in the remuneration rate on required reserves on loans has no impact on lending.*

Proof of Proposition 3 is available upon request. The intuition is as follows:



(a) Lending Market



(b) Deposit Market

Increasing the benchmark lending rate raises banks' willingness to lend, and thus raises the loan supply. At the same time, the increasing supply raises demand for funds by banks in the interbank market. The aggregate net position for the given interbank rate turns negative, raising the interbank rate, and lowering the loan supply.

The second influence, which is driven by the movement of equilibrium interest rate, is smaller than the first. The overall net effect is therefore positive, implying that increasing benchmark lending rate raises bank lending when the regulated interest rates for deposit and retail lending are both below the equilibrium rates.

The impact of an increase in the regulated deposit rate on bank lending is given by:

$$\frac{\partial L}{\partial r_D^B} = \frac{\partial}{\partial r_D^B} \sum_{i=1}^{N} \left(\frac{r_L - r}{c_{Li}} \right) = -\frac{\partial r}{\partial r_D^B} \sum_{i=1}^{N} \frac{1}{c_{L_i}} > 0 \tag{62}$$

An increase in the regulated deposit rate attracts deposits, so that the aggregate net position turns positive. The equilibrium interbank rate falls, raising the level of loans. Increasing the regulated deposit rate is therefore expansionary.

Adjustments to the RR also influences the interbank market rate. Raising RR reduces the amount of deposits banks have to make profit, thus turning the aggregate net position negative. As a result, the equilibrium interbank rate rises and the loan falls.

An increase in the remuneration on excess reserve creates an incentive for the banks to hold more excess reserves, which tightens the interbank market liquidity. This results in a higher interbank rate and lower loan supply. A contractionary OMO also makes the aggregate net position negative, which raises interest rates and reduces loan supply. Hence, increasing the reserve required ratio and remuneration rate for excess reserve are both contractionary monetary policies.

Interestingly, changes in the remuneration rate for required reserve does not influence the aggregate net position. The reason being is deposit is determined by the supply condition, an additional demand by banks triggered by a higher remuneration on required reserves would not attracts more funds to the banking system. Adjustment of the remuneration rate for

required reserves is therefore has no impact on lending.

From the analysis of case 3.1, we conclude that if the regulated rates are below the equilibrium rates, increasing these two regulated rates are expansionary, raising RR and remuneration rate on excess reserve and withdrawing liequidity through OMO are contractiaonry policies, and adjustments of interest rates provided on required reserves has no impact on bank lending.

Case 3.2: $r_L^B < r_L^*$ *and* $r_D^B \geqslant r_D^*$

Here we consider the case in which the regulated deposit rate is below the equilibrium lending rate and the deposit rate is above the equilibrium rate. The fact that benchmark deposit rate is higher than the equilibrium deposit rate implies that the deposits are determined by demand. (see Figure 3). The aggregate interbank net position is given by:

$$\begin{aligned} F(\cdot) &= (1-\alpha)\sum_{i=1}^{N} D_i - L^s\left(r_L^B\right) - \sum_{i=1}^{N} E_i - B \\ &= (1-\alpha)\sum_{i=1}^{N} \frac{1}{c_{Di}}\left(r - r_D^B + \alpha\left(r_R - r\right)\right) - \sum_{i=1}^{N} \frac{r_L^B - r}{c_{Li}} - \sum_{i=1}^{N}\left(\frac{1}{\beta}\left(r_E - r\right) + E_i^T\right) \end{aligned} \tag{63}$$

The impact of adjusting each policy instrument on loans is presented in proposition 4.

Proposition 4 *If the benchmark lending rate is below the equilibrium lending rate and benchmark deposit rate is above or equal to the equilibrium deposit rate, increasing the benchmark lending rate and remuneration rate for required reserve have expansionary effects, by contrast, increasing the benchmark deposit rate, the remuneration rate for excess reserves and sales of central bank bills are contractionary policies. The impact of increasing the RR depends on the differential between the interest rate on required reserve and the interbank rate.*

The proof of Proposition 4 is available upon request. Since Equation (63) differs from Equation (60) in deposits only, the instruments entering the deposit demand function, i.e. r_D^B,

r_R and α, would have different effects on loans compared to Case 3.1. A higher benchmark deposit rate leads to a lower deposit demand, thus resulting in a negative aggregate net position, and a higher interbank rate and a lower level of loans. Increasing interest rate on required reserves leads to a higher demand for deposits and creates a positive net position in the interbank market, and therefore a lower interbank rate and higher loan demand. Raising the RR raises the demand for deposits if the net gain for required reserves $r_R - r$ is positive. It reduces the deposit demand if $r_R - r < 0$ and there is no effect on deposit demand if $r_R - r = 0$. In addition, as in Case 1 and keeping everything else constant, the higher RR leaves a lesser amount of deposits available as funds for the interbank market. Therefore, increasing the RR would lower the loan level if net gain of required reserves is negative or zero. The effect is ambiguous if net gain is positive.

In Case 3.1 and 3.2, when the central bank adjusts the benchmark lending rate, it influences the loan level and the liquidity available in the interbank market. What follows is a change to the interbank market interest rate, which in turn ultimately influences the loan level. The direction of transmission is "retail-wholesale-retail". This process contrasts the standard one-way transmission mechanism where the effects of policy are first shown in the interbank liquidity and influences the loan level and retail lending interest rate thereafter.

In the next section, we discuss the case in which the benchmark lending rate is higher than or equal to the equilibrium lending rate.

case 3.3: $r_L^B \geqslant r_L^*$

When $r_L^B < r_L^*$, lending is determined solely by the demand for loans. The partial effect of increasing benchmark lending rate is given by:

$$\frac{\partial L}{\partial r_L^B} = \frac{\partial}{\partial r_L^B} L^D \left(\overset{-}{r_L^B}, \overset{+}{Y}, \overset{+}{P} \right) < 0 \tag{64}$$

and the partial effect of other policy instruments on lending is zero (although they still influence the interbank lending rate as in case 3.1), i.e.:

	Case 1	**Case 3.1**	**Case 3.2**	**Case 3.3**	
	No	$r_L^B < r_L^*$	$r_L^B < r_L^*$	$\mathbf{r}_L^B \geq \mathbf{r}_L^*$	
Instrument	**Intervention**	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B \geq \mathbf{r}_D^*$	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B \geq \mathbf{r}_D^*$
$\mathbf{r}_L^B$	/	$+$	$-$	0	0
$\mathbf{r}_D^B$	/	$-$	$+$	$-$	$+$
$\boldsymbol{\alpha}$	$\mp$	$+$	$\mp$	$+$	$\mp$
$\mathbf{r}_R$	$-$	0	$-$	0	$-$
$\mathbf{r}_E$	$+$	$+$	$+$	$+$	$+$
B	$+$	$+$	$+$	$+$	$+$

Table 7: Impact of Changes in Policy Instruments on Interbank Rate

	case 1	**case 3.1**	**case 3.2**	**case 3.3**
	No	$r_L^B < r_L^*$	$r_L^B < r_L^*$	$\mathbf{r}_L^B \geq \mathbf{r}_L^*$
Instrument	**Intervention**	$\mathbf{r}_D^B < \mathbf{r}_D^*$	$\mathbf{r}_D^B \geq \mathbf{r}_D^*$	
$\mathbf{r}_L^B$	/	$+$	$+$	$-$
$\mathbf{r}_D^B$	/	$+$	$-$	0
$\boldsymbol{\alpha}$	$\pm$	$-$	$\pm$	0
$\mathbf{r}_R$	$+$	0	$+$	0
$\mathbf{r}_E$	$-$	$-$	$-$	0
B	$-$	$-$	$-$	0

Table 8: Impact of Changes in Policy Instruments on Loans

$$\frac{\partial L}{\partial r_D^B} = \frac{\partial L}{\partial r_E} = \frac{\partial L}{\partial r_R} = \frac{\partial L}{\partial \alpha} = \frac{\partial L}{\partial B} = 0 \tag{65}$$

Case 3.3 is summarized in table 7 and 8. Comparing the two corresponding columns in these two tables, we can find the disconnection between interbank rate and bank loans in the case of adjusting some instruments. Since raising the benchmark lending rate lowers bank loans but does not influence the interbank rate, raising other instruments influence interbank rate but not bank loans. Any policy actions solely change the benchmark rate or the rest of the instruments (or combination of the rest of instruments) will result in a disconnection of the movement between interbank rate and bank loans. Therefore, the existing empirical finding can be attributed to the feature of the policy framework.

In Section 7, we discuss the effect of different policy instruments on loans in the case in which the deposit and lending rates are set by policy. When the policy set (regulated) lending rate is below the equilibrium lending rate, which is unobserved by policy makers, increasing the remuneration rate on excess reserve and conducting contractionary OMOs lowers the level of bank loans. The effect of other policy instruments, though, depend on whether the regulated deposit rate is above or below the equilibrium deposit rate. When the benchmark lending rate is higher than the equilibrium lending rate, increasing the benchmark lending rate is a contractionary policy and adjusting other instruments has no effect on lending.