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The Implementation of Monetary Policy in China: The Interbank Market and Bank Lending

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Abstract

We analyze the impact of monetary policy instruments on interbank lending rates and retail bank lending in China using an extended version of the model of Porter and Xu (2009). Unlike the central banks of advanced economies, the People's Bank of China uses changes in the required reserve ratios and open market operations to influence liquidity in money markets and adjusts the regulated deposit and lending rates and loan targets to intervene in the retail deposit and lending market. These interventions prevent the interbank lending rate from signalling monetary policy stance and transmitting the effect of policy to the growth of bank loans.

Keywords: Monetary Policy Implementation, Regulated Retail Interest Rates, Transmission Mechanism, Window Guidance, Bank Loans, China

JEL codes: E42, E52, E58

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1. Introduction

In normal times, when interest rates bound away from zero, central banks in advanced economies typically implement monetary policy by steering a short-term interbank rate. While the exact ways in which this is done differ among 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 the interbank rate is not a good measure of the stance of monetary policy.[1]

Indeed, empirical evidence suggests that the interest rate channel of monetary policy transmission is weak or non-existent in China. Geiger (2006) finds 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 the 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 but not M2 well, as there is no close relationship between reserve money and M2. This evidence suggests that the relationship between monetary policy instruments, short-term interest rates, loan growth and money growth in China differs from what we observe in advanced economies.

In considering the transmission mechanism of monetary policy in China, it is useful to distinguish the link between policy instruments and interbank rates as well as between interbank rates and the cost and availability of bank loans. Explanations put forward in the literature of the ineffectiveness of the monetary policy in China have 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, as 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 changes in required reserve ratios (RRR), the interest rates on reserves, open market operations (OMOs), the issuance of central bank bills, and changes in regulated deposit and retail lending rates plus window guidance. Window guidance is a measure that pressures banks to follow PBoC's guidelines on retail lending, a practice also used by the Bank of Japan in the early stages of Japan's economic development. The two regulated rates and window guidance are important for the implementation of monetary policy in China, in contrast to advanced economies. As the bank lending is the main official finance channel for corporations in China[3], this raises the question of what the coexistence of such regulations and market forces implies for PBoC's policy to influence interbank lending rates and total lending.

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1 He and Pauwels (2008), Shu and Ng (2010) construct indicators of the stance of monetary policy using PBoC statements or data on the policy instruments instead.

2 See Liu and Zhang (2007), Laurens and Maino (2007) and Podpiera (2006).

3 Zhang (2011), pp.11

To study this issue, 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 lending are determined when banks compete, when deposit and lending rates are regulated and when there is credit guidance. To implement the monetary policy, the PBoC intervenes in both the wholesale money market by OMOs, adjusting RRR, and in the retail deposit and lending market by changing the ceiling for deposit rates and the floor for retail lending rates and bank loan targets. Therefore, a reverse transmission of policy from the retail interest rates to the wholesale money market occurs.

The model suggests that the effect of policy instruments on the interbank money market and bank loans depends on how the regulated interest rates deviate from their equilibrium levels, defined as the rates we would observe in the absence of regulation. In the current case of China, the PBoC's intervention in the deposit and lending market impairs the transmission of OMOs and changes in RRR to bank credit growth through interbanks, therefore sometimes rendering window guidance of credit growth necessary for the PBoC's implementation of monetary policy. The effectiveness of window guidance depends on the perceived penalty cost for not obeying the guidance.

Three implications for Chinese monetary policy transmission follow this result.

First, interbank money market lending rates, such as Repo and SHIBOR, are insufficient and potentially misleading indicators of the central bank's monetary policy intentions. In particular, the deposit rate in China is believed to be binding. In this case, adjusting the ceiling for the deposit rate and the floor for the lending rate distort the effect of OMOs and changes in RRR on interbank rates. To characterize the stance of monetary policy, all policy instruments must be considered.

Second, the interbank rates do not play a role in transmitting the money market liquidity condition to retail bank lending when both the ceiling for deposit rate and the floor for retail lending rate are binding. As a consequence, a disconnet between interbank rates and the growth of bank loans exists.

Third, the uncertainty about the equilibrium deposit and lending rates in the absence of regulation complicates the conduct of monetary policy. As the equilibrium is unobservable, the central bank may not know if a change in the floor and ceiling of the retail interest rates would result in expansionary or contractionary effects on bank lending, which may make the window guidance and other administrative measures necessary to keep loan growth consistent with policy intention. Liberalizing the regulated rates eliminates this uncertainty and would facilitate the setting of policy.

The rest of the paper is organized as follows. Section 2 introduces the institutional background of monetary policy in China. Section 3 reviews the pattern and effectiveness of monetary policy

implementation in recent years. Section 4 presents the model and its policy implications. Section 5 concludes.

2. Institutional Background

In this section, we provide a review of the institutional arrangements that underpin the implementation of monetary policy in China. In particular, we highlight the regulation of interest rates for deposits, retail lending and window guidance, which are not used in monetary policy operation in advanced economies. We further discuss the development of the interbank market, which has recently become more important to the monetary policy in China.

2.1 The Objectives and Instruments of Monetary Policy

According to the Central Bank Law, the goal of monetary policy in China is to maintain the stability of the value of the currency and, thereby, promote economic growth. To achieve this final objective, a group of intermediate targets is set for M2 growth, domestic loan growth, exchange rate stability, and overall banking system stability, which implies maintaining the profitability of state-owned banks. The PBoC is under the leadership of the State Council; thus, the final authority on major monetary policy decisions lies with the State Council.

The PBoC uses a range of instruments to achieve these targets. These instruments can be classified into two categories. The first category serves to influence liquidity in the interbank money market and comprises changes in the RRR, changes in interest rates for required and excess reserves, and OMOs. The second category contains instruments that directly influence retail deposit and lending, such as changes in the regulated retail deposit and lending rates, and window guidance on loan growth. This second set of instruments is generally not used by central banks in advanced economies. The use of these instruments at both the wholesale and retail levels of banking liquidity indicates that the implementation of monetary policy in China is still in transition from direct quantity control to a more market-based framework. Furthermore, adjusting regulated deposit and lending rates implies a reverse transmission of monetary policy from the retail banking to the wholesale money market, as denoted in Figure 5. We introduce the second group of instruments in detail.

2.2 Window Guidance

The use of window guidance by the PBoC has a long history. At the early stage of China's economic reform, the PBoC used credit plans to control the lending of state-owned banks. Only after the first round of banking reform in 1995 were both the quarterly and annual targets of bank lending of state-owned banks abolished. Instead, the PBoC announced a new annual reference target in the form of growth for

total bank lending, a practice that has continued until the present. Furthermore, the PBoC now annually announces an M2 growth target. These two targets play key roles in the PBoC's quantity-based monetary policy.

To achieve the lending target, the PBoC uses moral suasion in the form of window guidance as a supplementary tool. By maintaining regular communication with commercial banks, the PBoC can monitor the lending growth and, if necessary, persuade banks to maintain loan growth at a target level. In most of the cases, the PBoC was concerned about fast loan growth that exceeded the target. In some rare cases, when loan growth was far below the taget, the PBoC would encourage banks to lend. This happened during the global financial crisis of 2008-2009, when the central bank encouraged more lending to mitigate the impact of the crisis. The window guidance can target over- or under-lending banks or specific overheating or under-developed sectors.

The effectiveness of window guidance depends on the bank's perception of the consequences of disregarding it. Together with the China Banking Regulatory Commission (CBRC), the PBoC has the authority to approve senior personnel appointments at commercial banks. This gives the PBoC influence over the lending behaviors of banks, especially state-owned banks. For those banks with excessive loan growth that disregard the PBoC's guidance, the PBoC can request that the banks make large time deposits with punishment rates into their accounts with the central bank or buy central bank bills.

Thus far, window guidance has been effective in slowing the loan growth of commercial banks in China. However, with financial liberalization, channels other than borrowing from commercial banks are available for firms to raise funds. These channels include the corporate bond market and the equity market. Therefore, the effectiveness of window guidance in achieving the final objective of controlling inflation has been eroded because firms do not have to borrow solely from commercial banks.

The role of window guidance in the interest rate tranmission process is included in the model in section 4 of this paper.

2.3 Regulations of Retail Lending and Deposit Rates

In the era of the centrally planned economy, the PBoC established interest rates for deposits and lending in domestic and foreign currencies. From the mid-1990s onwards, the deposit and retail lending markets were deregulated as part of the transition into a market-based economy. The PBoC first liberalized foreign currency interest rates before turning to domestic currency rates. It liberalized lending rates before deposit rates and rates with large, long-term deposits before those with small, short-term deposits.[4]

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

By October 2004, most of the interest rates were liberalized, with the exception of retail deposit rates for which the PBoC retained a ceiling and retail lending rates for which it maintained a floor.[5] These two restrictions are likely to remain in the foreseeable future, as the PBoC considers them important for maintaining financial stability. In particular, removing the limits of lending and deposit rates might result in undesirable market competition (Zhou 2005). Another reason for keeping the restrictions is to maintain an adequate profit margin and, thus, the profitability for commercial banks in China (Geiger 2006).

Previously, during the era when central banks set deposit and lending rates, changes in the regulated rates directly influenced the retail lending market. This effect is still present but only when the regulated (ceiling for) deposit rates or the regulated (floor for) lending rates is binding. It is generally believed that regulated deposit rates are binding, as the actual deposit rates have been clustered at the regulated level, which implies that the equilibrium deposit rates in the absence of such a restriction could be higher than the regulated rates.

By contrast, it is less clear whether regulated lending rates are binding. As the PBoC allows actual lending rates to float downward to 90% of the regulated rates, we consider this lower bound as the floor for lending rates. Table 1 shows that 70 to 80 percent of the bank's commercial loans were lent at rates higher than the floor for lending rates. The proportion of loans lent around the floor rate has increased in recent years.

2.4 The Interbank Money Market in China

From 1981 until 1996, lending and borrowing among Chinese banks was unregulated. However, the market was characterized by irregularities and was generating excessive risk-taking by banks. Therefore, the PBoC centralized lending and borrowing through the China Foreign Exchange Trading System and created a national interbank market in 1996. This helped the PBoC monitor banks' behavior.

The interbank market[6] is composed of a money market, a bond market and a foreign exchange market. The money market is the focus of our paper. The participants in the interbank money market include commercial banks and other financial corporations. While the market was initially intended to allow participants to trade short-term liquidity among themselves, later it became an important platform for the PBoC to conduct open-market operations. The bond market is for direct financing but is restricted to a few financial institutions and big corporations. Eight currency pairs are traded in the foreign exchange market.

[5] Exceptions are rural credit cooperatives, for which the ceiling for lending rates remains.

[6] The interbank market is a misnomer. In China, it is not just a market between banks. Its participants include banks, large corporates, fund management companies, and securities companies.

Currently, there are several instruments trading in the interbank money market in addition to uncollateralized lending and borrowing. The repo market is the most liquid, with an average daily turnover of 350.4 billion renminbi in 2010, which is 3.1 times the daily turnover of interbank lending and borrowing[7]. It is worth noting that the four largest state-owned banks are generally net lenders in the repo market, and other commercial banks, foreign banks and other financial institutions are net borrowers in 2010.

Close to 90 percent of the transactions in the repo market are concentrated in agreements with maturities equal to or less than 7 days, and the 7-day repo rate is therefore the most representative short-term interbank rate. The central bank interest rate on excessive reserves serves as a floor for short-term interest rates, while the PBoC's discount rate can be considered a ceiling. The 7-day repo rate is sometimes very volatile. Large IPO activities and central bank monetary policy actions all affect the liquidity in the interbank market and therefore the short-term interest rates. Another two frequently quoted interbank rates are the Shanghai Interbank Offered Rate (SHIBOR) and the China Interbank Offered Rate (CHIBOR). In 2007, the PBoC established the SHIBOR system. The SHIBOR is not based on transaction rates in the interbank market but is a quote-based average similar to LIBOR. Currently, sixteen banks provide quotes, and the rates are fixed at 11:30 a.m. every business day. The CHIBOR is a weighted average of the daily transaction rates announced at the end of every business day. The PBoC has been pushing SHIBOR as the benchmark interest rate for pricing. In the meantime, the CHIBOR is less used for the purpose of pricing. On the other hand, the 7-day SHIBOR, CHIBOR and repo rates have followed each other closely. The wide use of the SHIBOR as the benchmark rate for pricing is yet to be achieved.

Open market operations and changes in reserve requirements directly affect the liquidity in the interbank market. Changes in the benchmark lending and deposit rates, as well as window guidance, indirectly affect the interbank liquidity through banks' reactions to those changes. In the next section, the impact of different monetary policy actions on interbank rates and retail bank lending is analyzed.

3. Implementing Monetary Policy in China

As the PBoC uses a variety of policy instruments to implement monetary policy, we start by briefly reviewing the changes in these instruments over time and the relationships between the instruments and the interbank rates. Figure 1 plots the RRR, net liquidity injection through OMOs, regulated deposit and lending rates, and remuneration rates on required and excess reserves together. Figures 2 through 4 plot the first four instruments against the interbank rates.

Several observations are warranted. First, changes in RRR, regulated deposit rate and lending rate, and OMO are the most frequently used policy tools. Other measures such as changes in the remuneration on

[7] Data source: China Financial Market Development Report (various issues), People's Bank of China, and authors' calculation.

reserves are used much less frequently. Second, the first three instruments experienced sharp increases or falls together. The net injection of liquidity through OMOs had sharp changes during the period when the other tools were on the path of increasing or decreasing. This indicates that when the PBoC tightens or loosens the monetary policy stance, it seeks to adjust banks' costs of funds both in interbank and deposit markets and to adjust the cost of capital for firms and individuals simultaneously. One example is the progressive tightening from 2005 onwards in response to overheating in the economy, in particular to very high investment spending and a rise in inflation in 2005 and 2007. Another example is the policy loosening in the fall of 2008, aiming to mitigate the effects on the Chinese economy of the rapidly worsening global economic and financial conditions. These figures are compatible with a "belts and suspenders" approach to the monetary policy in which many, if not all, policy levers are pulled simultaneously to achieve the desired change in monetary conditions. Again, this approach is in contrast to the approach in advanced economies where, typically, only a short-term policy rate is changed as a result of a change in the monetary policy stance. In the case of the U.S., the short-term policy rate is the federal funds rate, while in the Euro area, it is the refinancing rate. Third, changes in the regulated lending and deposit rates were the same in the past two years, showing the intention of the PBoC to maintain a stable interest rate gap for banks. Fourth, changes in the policy instruments do not have a clear relationship with the changes in the interbank rates. For example, in Figure 2, during mid-2006 and mid-2007, the repo and SHIBOR rates, on average, did not increase continuously following the continued rise in the RRR, although in some periods, they showed a positive relationship. Figure 3 shows that raising the regulated deposit and lending rates tends to be associated with lower interbank rates for several months in 2006, 2007, and 2010, which seems to be inconsistent with the policy intention.

Furthermore, it is not straightfoward to assess the effect of changes in the various monetary policy instruments on total bank lending. Table 2 provides an example of an episode of monetary policy changes in 2006. In this episode, the PBoC tightened monetary conditions by raising regulated rates for deposits and lending, raising the RRR, and withdrawing liquidity.[8] Surprisingly, however, the interbank rate fell and new loans increased on both occasions, suggesting that these measures were in fact expansionary. However, these ex-post data masked the individual effect of each policy instrument. The next section therefore studies the effects of changes in individual policy instruments in a model in which market forces and regulations coexist.

4. The Modelling Framework

4.1 The Theoretical Model

To study the effect of monetary policy instruments on aggregate bank loans, we present a simple model that integrates regulated deposit and lending rates with a competitive interbank market. The model is

[8] The defined tightening periods are consistent with the findings in Shu and Ng (2010).

based on that of Porter and Xu (2009), which is, in turn, an extended version of the model of Freixas and Rochet (2008). We assume that each bank chooses deposits, excess reserves, central bank bills, and loans to maximize profits, given the RRR, the reserve remuneration rate, and the regulated interest rates for deposit and lending. Thus, each bank's profit maximization problem is given as:

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

where L_i denotes the level of loans, E_i is the level of excess reserves, α D_i is the amount of required reserves (with α being the RRR and D_i the total deposits), B_i is the quantity of central bank bill holdings, which changes as a consequence of open-market operations,[9] and M_i is the net position in the interbank market. The relevant interest rates are denoted by r_L, r_E, r_R, r, r_D, and r_B.

Equation 1 states that bank profits are the sum of revenue minus costs. Revenue comes from retail lending, $r_L L_i$; holdings of excess reserves,[10] $r_E E_i$; 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, $r M_i$. 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, $\frac{\beta}{2}\left(E_i - E_i^T\right)^2$, with β >0.[12] The last term captures window guidance, that is, the target loan level L^T set occasionally by the PBoC. Banks who lend more or less than the policy target level have to pay a penalty, which is the product of the quantity $\frac{1}{2}\left(L_i - L^T\right)^2$ and the unit cost κ [13].

[9] We do not explicitly model other standing facilities such as central bank lending through the discount window, as they are fine tuning measures intended to maintain the interbank rate at the target level, and their effect on interbank rates is similar to that of open market operations.

[10] We deviate from Porter and Xu (2009a) in that we distinguish between required and excess reserves, as the PBoC sets different interest rates for these two types of reserves, and in that we also consider window guidance.

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

[12] Reserves play a role as liquidity. Banks typically set a target level of reserves to finance unexpected inflow or outflow from banks' reserve accounts (Campbell (1987), p. 61).

[13] The penalty for deviating from the target loan level is difficult to measure, as it is usually implicit. However, PBoC, from time to time, sells a certain amount of central bank bills to banks whose loan levels are higher than the policy target level (PBoC Monetary Policy Annual Report 2009). In this case, κ can be represented by $r_L - r_B$.

The net position on the interbank market is given by M_i such that

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

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 modeled as a quadratic function of the deviation of the actual excess reserves holding from the target level. Using equations (2) and (3), the profit maximization problem (1) becomes:

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

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

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

$$r_L = r + c_{Li} L_i + \kappa(L_i - L^T). \tag{6}$$

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 consists of three components: the interbank rate, the cost of managing the loans, and the cost of deviating from the policy-guided level of loans.

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

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

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

Turning to deposits, we obtain:

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

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

From equation (6), the supply for loans can be written as:

$$L_i = \frac{r_L - r + \kappa L^T}{c_{Li} + \kappa}. \tag{10}$$

A bank's loan supply increases along with the spread between the retail lending rate and the interbank lending rate. Furthermore, a bank will increase its supply for loans if the PBoC raises the target level of loans.

From equation (7), the optimal amount of excess reserves is expressed as:

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

From equation (8), the deposit demand function is:

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

Banks demand more deposits if the net gain of lending out the deposits in the interbank market, $r - r_D$, increases; they demand fewer deposits when the opportunity cost of the required reserves, $\alpha\left(r - r_R\right)$, rises.

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 or r is determined by the interbank market clearing condition (equation 13).

Thus far, we have assumed that banks maximize profits by choosing deposits, loans, excess reserves and central bank bill holdings given interest rates and their cost functions. The net position M_i of each bank can be positive, zero, or negative, while the sum of M_i equals zero, as shown in equation (13). Plugging equations (10) through (12) into equation (13), we have three unknowns to be determined: 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 the Interbank Rate and Bank Loans

We first discuss the solution for the standard case in which the interest rates for lending and deposits are market determined and there is no window guidance.

Case 1: r_L and r_D are market determined, and $\kappa = 0$.

In the standard case, the retail lending rate, r_L, and deposit rate, r_D, are endogenously determined. 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 the 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 the loan supply of the individual bank:

$$L^s = \sum_{i=1}^{N} \frac{r_L - r}{c_{Li}}, \tag{15}$$

so that the equilibrium lending rate, r_L^*, is implicitly determined by:

$$L^d\left(\overset{-}{r_L}, \overset{+}{Y}, \overset{+}{P}\right) = \sum_{i=1}^{N} \frac{r_L - r}{c_{Li}}. \tag{16}$$

Thus, we can solve for r_L^*:

$$r_L^* = h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}\right), \tag{17}$$

where h is assumed to be continuously differentiable. Thus, r_L^* is positively related to the interbank rate, r; the real GDP, Y; the price level, P; and the loan management costs, as captured by c_{Li}. Furthermore, we assume that the supply of deposits is a function of the deposit rate, the real GDP, and the price level:

$$D^s = D^s\left(\overset{+}{r_D}, \overset{+}{Y}, \overset{-}{P}\right). \tag{18}$$

In equilibrium, we have:

$$D^s\left(\overset{+}{r_D}, \overset{+}{Y}, \overset{-}{P}\right) = D^d = \sum_{i=1}^{N} D_i = \sum_{i=1}^{N} \frac{1}{c_{Di}}\left(r - r_D - \alpha\left(r - r_R\right)\right) \tag{19}$$

By solving equation (19), the equilibrium deposit rate, r_D^*, is obtained:

$$r_D^* = f\left(\overset{+}{r}, \overset{-}{Y}, \overset{+}{P}, \overset{+}{r_R}, \overset{\pm}{\alpha}\right), \tag{20}$$

where f is assumed to be continuously differentiable. Thus, r_D^* is positively related to the interbank rate, r, and negatively related to the price level, P, and the real GDP, Y. Additionally, r_D^* is positively related to the remuneration rate on required reserves, r_R, if the opportunity cost of required reserves, $r - r_R$, is non-zero. Furthermore, if $r - r_R > 0$, r_D^* falls with the required reserve ratio, α, then the opposite is true when $r - r_R < 0$. If $r - r_R = 0$, the equilibrium deposit rate is independent of α.[14] 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 the aggregate net position, that is, equation (13), can be expressed as:

$$\begin{aligned} F(\cdot) = \sum_{i=1}^{N} M_i &= \sum_{i=1}^{N}\left[(1-\alpha)D_i - L_i - E_i\right] - B \\ &= (1-\alpha)D^* - L^* - \sum_{i=1}^{N} E_i - B \end{aligned} \tag{21}$$

where

$$D^* = D^s\left(f\left(\overset{+}{r}, \overset{-}{Y}, \overset{+}{P}, \overset{+}{r_R}, \overset{\pm}{\alpha}\right), \overset{+}{Y}, \overset{-}{P}\right) = \sum_{i=1}^{N} \frac{1}{c_{Di}}\left(r - f\left(\overset{+}{r}, \overset{-}{Y}, \overset{+}{P}, \overset{+}{r_R}, \overset{\pm}{\alpha}\right) - \alpha(r - r_R)\right) \tag{22}$$

and

$$L^* = L^d\left(h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}\right), \overset{+}{Y}, \overset{+}{P}\right) = \sum_{i=1}^{N} \frac{h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}\right) - r}{c_{Li}} \tag{23}$$

The aggregate net position $F(\cdot)$ depends on four factors: the fraction of aggregate deposits that is not held as required reserves, $(1-\alpha)D^*$; aggregate loans, L^*; 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:

$$r^* = g(\alpha, r_R, r_E, B, Y, P). \tag{24}$$

[14] The U.S. Federal Reserve and the ECB typically set interest rates for required reserves to be close to the interbank rates in general. However, the sign of $r_R - r$ changed over time in China.

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

Proposition 1. When the deposit rate, r_D, and lending rate, r_L, are market determined, and there is no window guidance policy, the impact of increasing the rate of remuneration on excess reserves and sales of central bank bills on interbank rates, that is, $\frac{\partial r}{\partial r_E}$ and $\frac{\partial r}{\partial B}$, are positive, and their impact on loans, that is, $\frac{\partial L}{\partial r_E}$ and $\frac{\partial L}{\partial B}$, are both negative. The same impact of increasing RRR, $\frac{\partial r}{\partial \alpha}$ and $\frac{\partial L}{\partial \alpha}$, depends on $r - r_R$.

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

Sales of bills by the central bank have the same effect on the interbank rate and loans as increasing the remuneration on excess reserve does by making the aggregate net position negative. The impact of a change in RRR depends on two factors. First, higher RRR reduces the funds available in the interbank market. Moreover, a higher RRR also raises the demand for deposits if there is a net interest gain on required reserves, that is, if $r_R - r$ is positive. It reduces the deposit demand if there is a net interest loss on required reserves, that is, if $r - r_R > 0$. It has no effect on deposit demand if $r_R - r = 0$. Thus, if $r - r_R \geq 0$, raising RRR reduces the liquidity in the interbank market and hence raises the interbank rate and reduces the lending, while the effect is ambiguous otherwise. These effects on the interbank rate and loans are summarized in Tables 4 and 5, respectively.

Thus far, we have discussed a model in which the interbank rate is determined in a competitive equilibrium under the assumptions that the interest rates on deposits and retail lending are fully liberalized and that the central bank does not have a loan target. This case is relevant for economies where central banks conduct monetary policy through interbank markets and where the interest rate transmission from wholesale to retail market is effective. While this is the case in advanced economies such as the U.S and the Euro area, the PBoC continues to rely on direct regulation. We therefore consider how the introduction of regulated lending and deposit interest rates and a loan target change the conclusions from the above analysis.

Case 2: The central bank sets a loan target, a floor of r_L and a ceiling of r_D.

The existence of a loan target and the regulation of interest rates for deposits and lending imply that the central bank can intervene in the liquidity on a retail level.

First, with the introduction of a loan target, the individual bank's loan supply function is augmented, as in equation (10), and the resulting equilibrium retail lending rate is also negatively related to the loan target, that is,

$$r_L^* = h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}, \overset{-}{L^T}\right). \tag{25}$$

Therefore, the equilibrium loan supply is

$$L^* = \sum_{i=1}^{N} \frac{h\left(\overset{+}{r^*}, \overset{+}{Y}, \overset{+}{P}, \overset{-}{L^T}\right) - r^* + \kappa L^T}{c_{Li} + \kappa} = L^d\left(h\left(\overset{+}{r^*}, \overset{+}{Y}, \overset{+}{P}, \overset{-}{L^T}\right), \overset{+}{Y}, \overset{+}{P}\right). \tag{26}$$

Proposition 2. Raising the target loan level will result in a credit expansion if the perceived penalty of not obeying the loan target is large enough. The proof is available in the Appendix.

Raising the target level for loans shifts the loan supply curve to the right, resulting in a lower lending rate and greater lending, given the interbank rate, r. On the other hand, a higher demand for liquidity by banks pushes up the interbank rate, which in turn tends to reduce the loan supply of banks. However, in deciding whether to increase lending, banks must consider the perceived penalty for deviating from the target loan level. If the perceived penalty is high enough, banks will choose to increase their loan supply.

The restrictions on deposit and retail lending rates complicate the analysis in case 1 above. The main issue is whether the restrictions are binding or not, which is unclear.

Beginning in October 2004 to the present, the PBoC only imposes a floor on the retail lending rate and a ceiling on the deposit rate. Figure 6 illustrates the equilibrium loan and deposit rates within this framework. The equilibrium level of loans and lending rates are the same as those without restriction when the floor of the lending rate is not binding. However, when it is binding, the actual loan level is determined by loan demand, which is exogenous to banks. Similarly, if the ceiling for the deposit rate is below the equilibrium level without regulation, the actual level of deposit is determined by deposit supply. Consequently, whether the ceiling or floor for interest rates is binding or not is crucial because that determines whether

the quantity of deposits and loans will rise, fall, or remain the same following a change in benchmark interest rates. As discussed in section 2, the ceiling for deposit rates in China is believed to be binding (i.e., the regulated deposit rate is below equilibrium), while it is unclear whether the floor for lending rates is binding. As the equilibrium deposit and lending rates without restrictions are unobservable, it is difficult for policy makers to know them, which leads to the risk that the consequences of a change in policy rates might be inconsistent with the policy intentions. In the following analysis, we focus on two sub-cases.

Case 2.1: The ceiling for the deposit rate is binding, and the floor for the lending rate is not binding. ($r_L^B < r_L^*$ *and* $r_D^B < r_D^*$).

In this case, both the benchmark lending and deposit rates are below their equilibrium levels, which implies that the lending market equilibrium is unregulated, and deposits are supply determined. We can solve for r_L^* using equation (25), and the loan level is then given by equation (26). The aggregate net position in the interbank market is therefore given by:

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

The effect of changes in policy instruments is presented in Proposition 3.

Proposition 3. When r_L^B provides a floor for the retail lending rate and r_D^B provides a ceiling for the deposit rate and these two rates are both below their equilibrium levels in the absence of regulation, increasing RRR or the remuneration rate on excess reserves or sales of central bank bills to the banking system raises the interbank rate and is contractionary. Increasing the benchmark deposit rate lowers the interbank rate and expands bank credit, providing it remains below the equilibrium level. Changes in the regulated lending rate do not have any effect on the interbank rate and the level of loans if the lending rate remains below the equilibrium level. Raising the target level of loans can have an expansionary effect if the perceived penalty of defying the target level is high enough.

The proof of Proposition 3 is in the Appendix. In this case, a higher RRR, a higher remuneration on excess reserves or sales of central bank bills reduces liquidity in the interbank market, which in turn pushes up the interbank rate and lowers lending. Therefore, these policies are all contractionary. Increasing the benchmark deposit rate attracts more deposits, assuming the elasticity of the deposit supply is positive. This will increase the liquidity of the interbank market, which will result in a lower interbank rate and higher lending. These policies are therefore expansionary. Raising the regulated lending rate does not change the level of loans and actual lending rate, as long as the increased level of

lending rate remains below the equilibrium rate. Raising the target level of loans will have the same effect as in the case without the regulation of interest rates.

Case 2.2: Both the ceiling for the deposit rate and the floor for the lending rate are binding ($r_L^B \geq r_L^*$ and $r_D^B < r_D^*$).

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

$$F(\cdot) = (1-\alpha)D^s\left(r_D^B\right) - L^d\left(r_L^B\right) - \sum_{i=1}^{N}\left(\frac{1}{\beta}\left(r_E - r\right) + E_i^T\right) - B \tag{28}$$

In this case, only the change in the benchmark lending rate will affect the total amount of loans. As the loan level is solely determined by the aggregate loan demand, other monetary policy instruments have no effect on the loan level. An increase in the benchmark lending rate will reduce the total loan level. Moreover, raising the benchmark lending rate lowers the interbank rate, as banks will have less need to borrow from the interbank market, given that the total loan demand is reduced.

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

$$\frac{\partial L}{\partial r_L^B} = \frac{\partial}{\partial r_L^B} L^D\left(\overset{-}{r_L^B}, \overset{+}{Y}, \overset{+}{P}\right) < 0. \tag{29}$$

The effect on the interbank rate is:

$$\frac{\partial r}{\partial r_L^B} = -\frac{\partial F/\partial r_L^B}{\partial F/\partial r} = -\frac{-\partial L^d\left(r_L^B\right)/\partial r_L^B}{\partial F/\partial r} < 0 \tag{30}$$

However, other monetary policy instruments also influence the interbank rate, as in Case 2.1. Thus, a rise in the benchmark deposit rate lowers the interbank rate, providing it remains below the equilibrium, while raising RRR or increasing remuneration on excess reserves or sales of central bank bills raises the interbank rate.

In this case, the central bank can directly influence the loan level by changing the benchmark lending rate. The interbank market plays no role in the transmission of monetary policy action. This means that the change in the interbank rate does not transmit to the retail lending rate and total level of lending.

Therefore, all other policy instruments, such as a change in RRR or in the remuneration on excess reserves, and sales of central bank bills that only affect the interbank rate will have no effect on the total lending. In this sense, there is a disconnect between policy intention and total lending.

A summary of the individual effects of each policy tool for these two cases is presented in Tables 3 and 4. The implication for Chinese monetary policy transmission can be summarized as follows.

First, raising the deposit rate ceiling distorts the contractionary effects of raising RRR and contractionary OMOs when the deposit rate ceiling is binding. The distortion can reduce, offset, or dominate the effects, depending on the amount of liquidity it attracts to the banking system. Therefore, the interbank rate and bank lending resulting from a combination of these three actions may go in an unexpected direction. This explains the uncertainities in the 2006 episode presented in Table 2.

Second, the transmission of liquidity conditions from the interbank market to the retail lending market is blocked when both the ceiling for the depsoit rate and the floor for the lending rate are binding. The only instrument that influences the bank lending is the floor for the lending rate.

Hence, the presence of interest rate regulation and the intervention on the interest rate at the retail level make it difficult for the interbank rate to signal monetary policy and transmit its effect further to the real economy.

One should bear in mind that our analysis is essentially a comparative static analysis. We also did not model the demand side of loans or the supply side of deposits. Our model is a one-period general equilibrium model that does not consider the intertemporal dynamics. In practice, monetary policy tightening or loosening usually occurs over several periods. It is carried out alternatively in a cyclical way. In this case, the monetary policy stance is usually not difficult to identify. With continuous tightening or loosening, the monetary policy can be effective in slowing down total commercial lending. However, given that there are other channels for firms to raise funds, such as bond or equity markets, the effectiveness of the monetary policy instruments, which only target the liquidity condition in the banking system, is more or less diluted.

5. Conclusion

In this paper, we analyze the effects of changes in the monetary policy instruments in China. While central banks in advanced countries, at least before the financial crisis, implemented monetary policy by focusing solely on short-term interest rates in the interbank market, the PBoC's use of regulatory controls and moral suasion makes this an interesting question.

The paper uses an extended version of the model of Porter and Xu (2009a) to show the effects of different monetary policy instruments in China. We find that the transmission of the effect of monetary policy instruments through bank lending channels depends on whether the floor on the lending rate and the ceiling on the deposit rate is binding. Our analysis leads to the following implications.

First, the interbank money market rates, such as SHIBOR and the interbank repo rate, are incomplete and potentially misleading indicators of the PBoC's policy intention, although they are determined by policy instruments. The reason is that, among the instruments, the regulation on deposit and lending rates impairs the transmission of the effect of other instruments, such as OMOs and changes in RRR. To properly characterize the central bank's policy intention requires information from all policy instruments. To develop the interbank rate as a benchmark interest rate and as a signal of the monetary policy stance, it would be necessary to liberalize the retail lending and deposit rates.

Second, lacking the information about equilibrium retail interest rates in the absence of regulation leads to risks of policy errors. The combination of the effects of different policy instruments might not be consistent with the policy intention, which makes window guidance and other administrative measures necessary as policy tools.

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Table 1. Percentage of Commercial Loans Priced at Different Rates

	Floating downward [90% to 100% 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.

Table 2. Episode in 2006 August-October

	Period	**Policy Actions**		**7-day Repo Rate Change bps**	**New Loan Growth %**
August 15-September 30	August 15	Increase of RRR by 0.5%		-14.5	18
	August 19	Increase of the regulated deposit of liquidity and lending rate by 27 bps	Withraw liquidity through OMOs of 59.2 billion		
October 1-31		Withdraw liquidity through OMO of 97.25 billion		31	-90

Note: Liquidity withdrawn through OMOs is a sum of weekly net liquidity injection throughout the corresponding period. Liquidity injected during a period shorter than a working week is computed as a proportion of the weekly amount. The change in the 7-day repo rate is the difference between the rate on the last day and the first day of that period. The new loan growth from Aug.15-Sept.30 is the growth relative to the new loans in July 1-Aug.14, treated as the new loans in July plus half of the new loans in August. The same growth in October takes the new loans in Sept. as a base month. Source: CEIC, WIND and author's calculation.

Table 3. Impact of Changes in Policy Instruments on the Interbank Money Market Rate

Instrument	Case 1 No Regulation of Retail Interest Rates and Credit Growth	Case 2.1 $r_L^B < r_L^*$ $\mathbf{r}_D^B < \mathbf{r}_D^*$	Case 2.2 $\mathbf{r}_L^B \geq \mathbf{r}_L^*$ $\mathbf{r}_D^B < \mathbf{r}_D^*$
$\boldsymbol{\alpha}$	$+ \text{ if } r - r_R \geq 0$ *ambiguous otherwise*	+	+
$\mathbf{B}$	+	+	+
$\mathbf{r}_E$	+	+	+
$\mathbf{r}_L^B$	/	0	–
$\mathbf{r}_D^B$	/	–	–
L^T	/	+	0

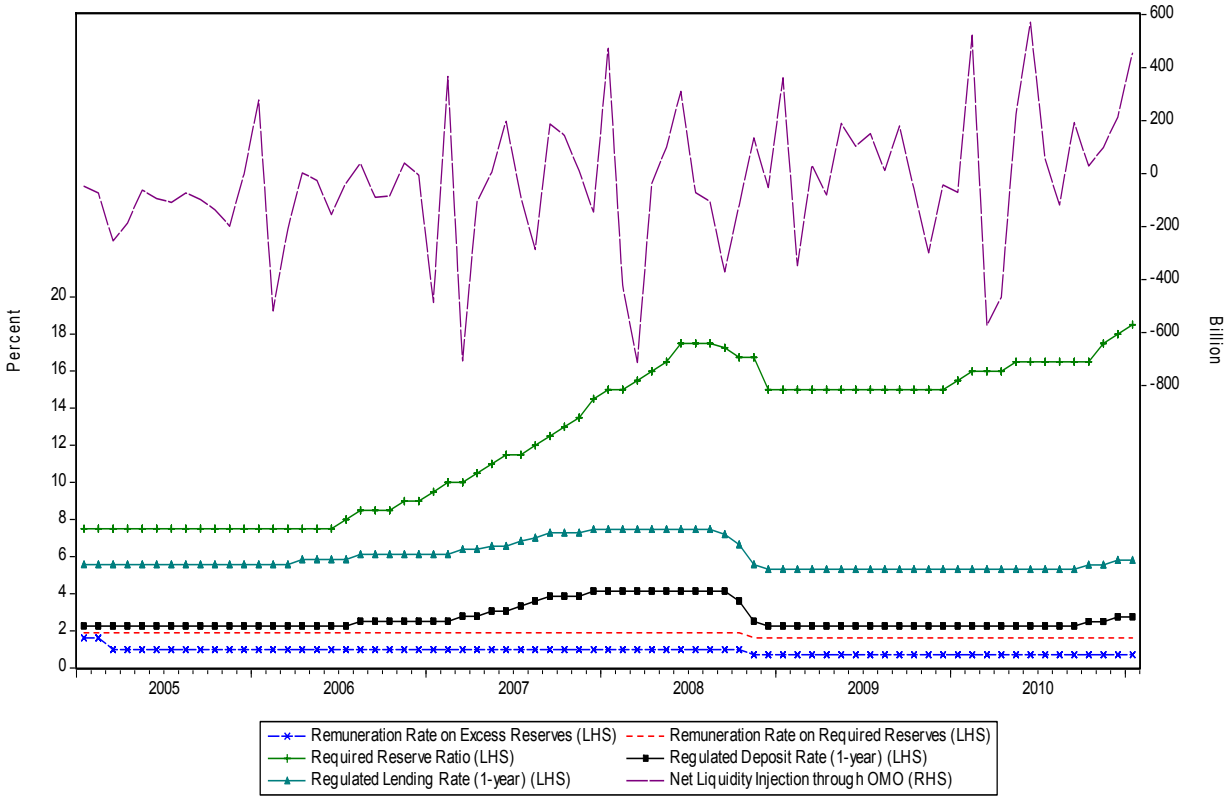
Note: The table shows the effect of raising each policy instrument on the interbank money market rate. '+' represents a positive effect, '-' represents a negative effect, and 0 denotes no effect. '/' denotes that raising the instrument in the corresponding row is not an option for the central bank in the case of the corresponding column. α is the required reserve ratio; B is the issuance of central bank bills through OMO; $\mathbf{r}_E$ is the renumeration on excess reserves; $\mathbf{r}_D^B$ is the regulated lending rate; $\mathbf{r}_D^B$ is the regulated deposit rate; L^T is the target level of loan growth set by the central bank. K is the

Table 4. Impact of Changes in Policy Instruments on the Loans

Instrument	Case 1 No Regulation of Retail Interest Rates and Credit Growth	Case 2.1 $r_L^B < r_L^*$ $\mathbf{r}_D^B < \mathbf{r}_D^*$	Case 2.2 $\mathbf{r}_L^B \geq \mathbf{r}_L^*$ $\mathbf{r}_D^B < \mathbf{r}_D^*$
$\boldsymbol{\alpha}$	$-$ *if* $r - r_R \geq 0$ *ambiguous otherwise*	$-$	0
$\mathbf{B}$	$-$	$-$	0
$\mathbf{r}_E$	$-$	$-$	0
$\mathbf{r}_L^B$	/	0	$-$
$\mathbf{r}_D^B$	/	$+$	0
L^T	/	$\pm$	0

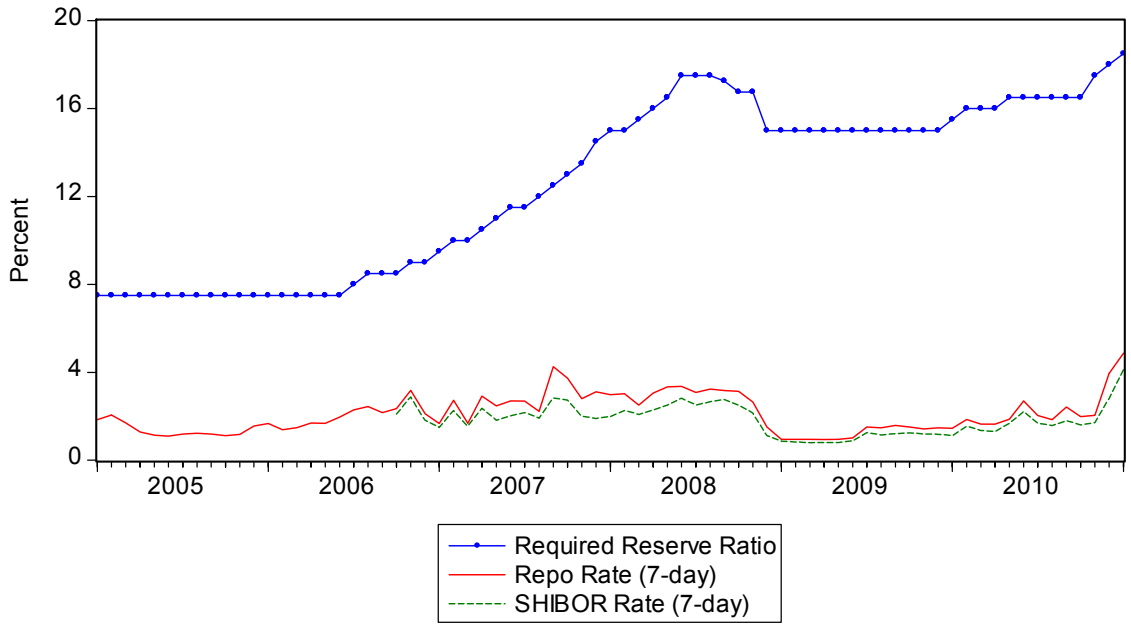
Note: The table shows the effect of raising each policy instrument on the interbank money market rate. '+' represents a positive effect, '-' represents a negative effect, and 0 denotes no effect. '/' denotes that raising the instrument in the corresponding row is not an option for the central bank in the case of the corresponding column. α is the required reserve ratio; B is the issuance of central bank bills through OMO; $\mathbf{r}_E$ is the renumeration on excess reserves; $\mathbf{r}_D^B$ is the regulated lending rate, $\mathbf{r}_D^B$ is the regulated deposit rate; L^T is the target level of loan growth set by the central bank.

Figure 1. Monetary Policy Instruments



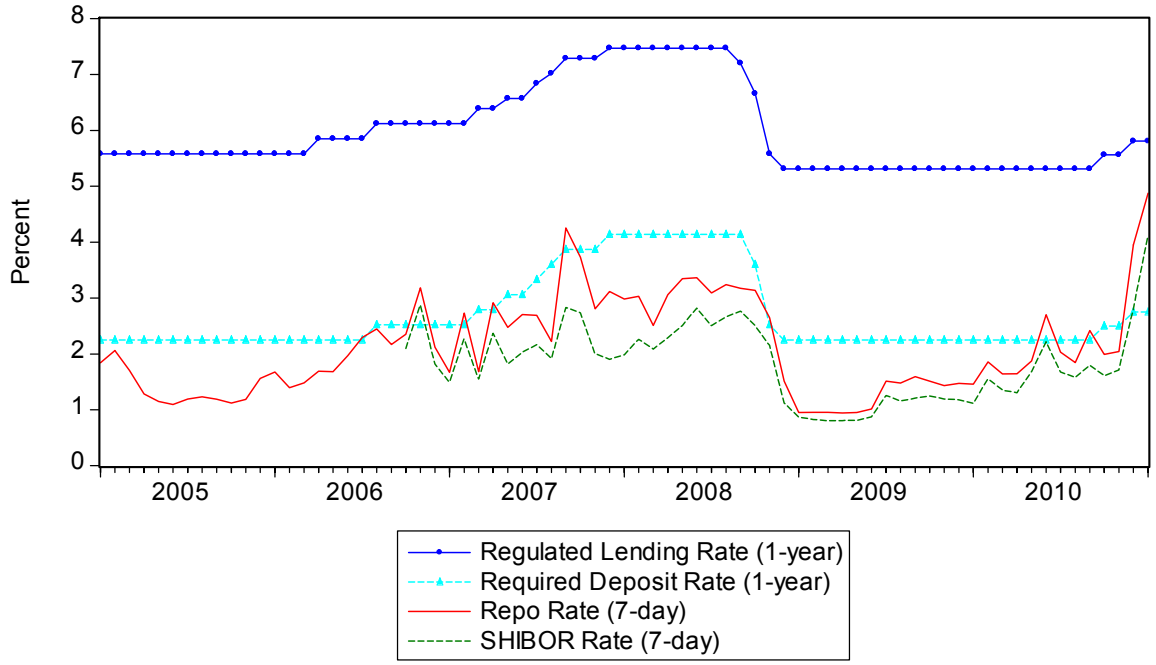
Data source: CEIC and authors' calculation.

Figure 2. RRR and Interbank Rates



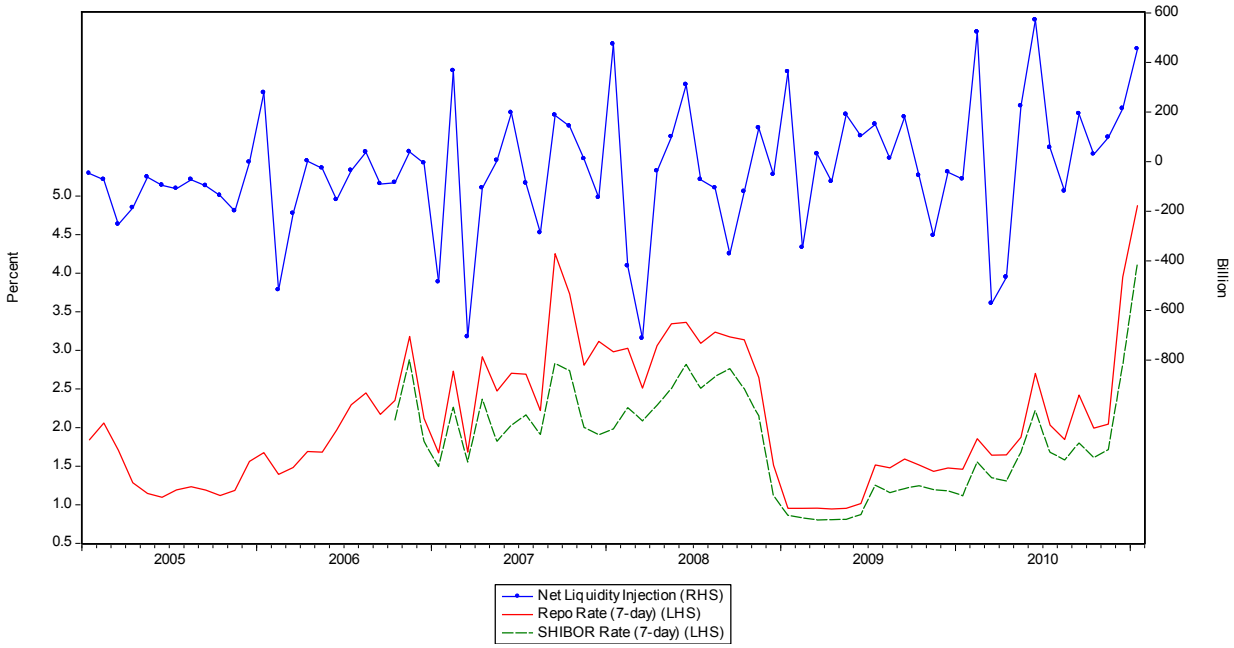
Data source: CEIC and authors' calculation

Figure 3. Regulated Deposit , Lending Rate and Interbank Rates



Data source: CEIC and authors' calculation.

Figure 4. Net Liquidity Injection through OMO and Interbank Rates



Data source: WIND, CEIC and authors' calculation

Figure 5. The Framework of Monetary Policy Implementation in China

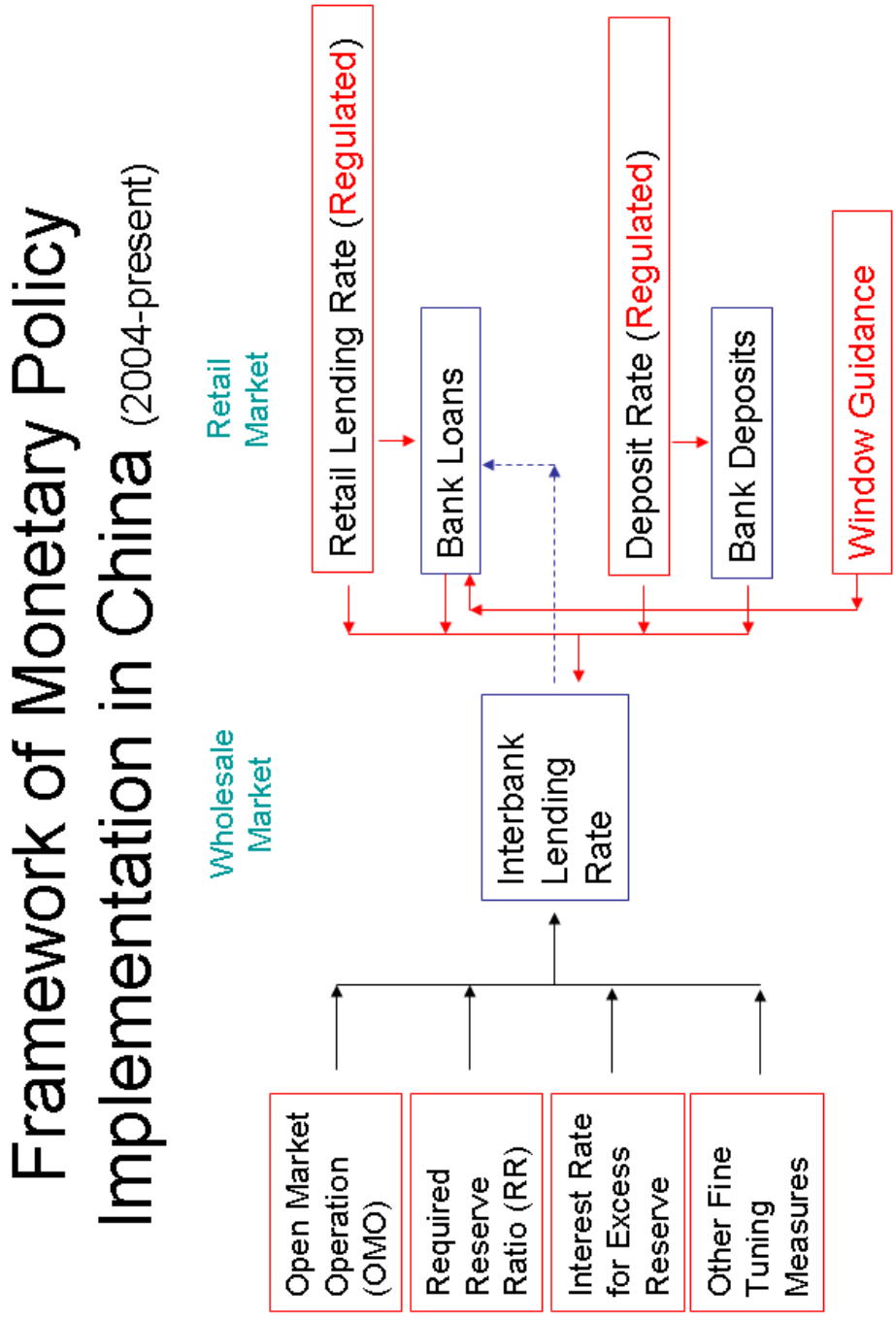
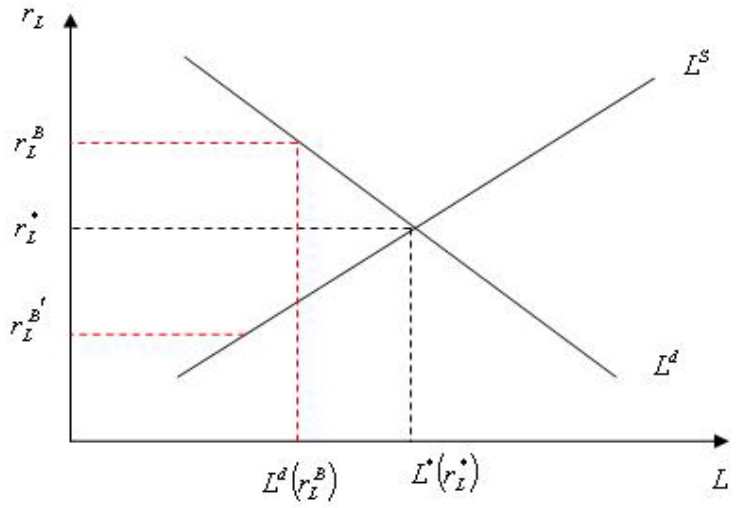
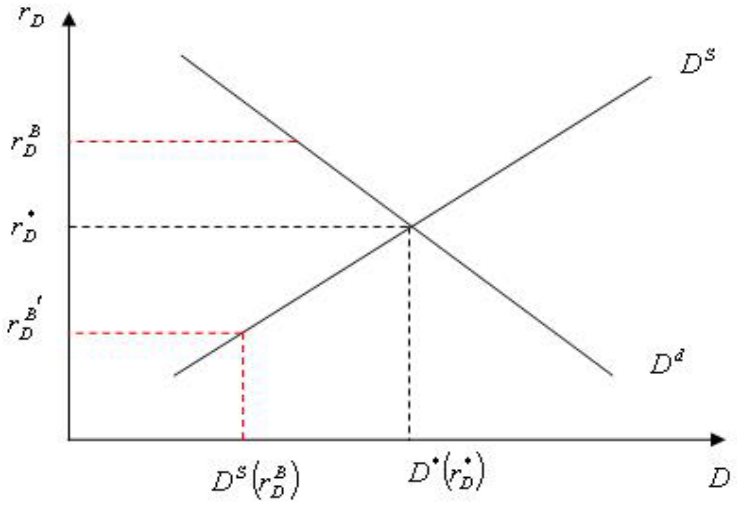


Figure 6. Interest Rates in Lending and Deposit Markets



(a) Lending Market



(b) Deposit Market

Appendix

Proof of Proposition 1

The aggregate net position is given by:

$$F(\cdot) = (1-\alpha)D^s - L^D - \sum_{i=1}^{N} E_i - B \tag{31}$$

$$= (1-\alpha)D^s\left(f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right),\overset{+}{Y},\overset{-}{P}\right) - L^D\left(h\left(\overset{-}{r},\overset{+}{Y},\overset{+}{P}\right),\overset{+}{Y},\overset{+}{P}\right)$$

$$- \sum_{i=1}^{N}\left(\frac{1}{\beta}(r_E - r) + E_i^T\right) - B$$

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

$$\partial F(\cdot)/\partial r = (1-\alpha)\frac{\partial}{\partial r}D^s - \frac{\partial L^D}{\partial r} - \frac{\partial}{\partial r}\sum_{i=1}^{N} E_i - \frac{\partial B}{\partial r} \tag{32}$$

$$= \underbrace{(1-\alpha)\frac{\partial}{\partial r}D^s\left(f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right),\overset{+}{Y},\overset{-}{P}\right)}_{>0} - \underbrace{\frac{\partial}{\partial r}L^D\left(h\left(\overset{-}{r},\overset{+}{Y},\overset{+}{P}\right),\overset{+}{Y},\overset{+}{P}\right)}_{<0} + \underbrace{\frac{N}{\beta}}_{>0} \tag{33}$$

which implies

$$\partial F(\cdot)/\partial r > 0 \tag{34}$$

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

$$\partial F(\cdot)/\partial r_E = -\frac{\partial}{\partial r_E}\sum_{i=1}^{N} E_i = -\frac{N}{\beta} < 0, \tag{35}$$

Since h and f are assumed to be continuously differentiable functions and assume there is a point satisfying $F(\cdot) = 0$ and $\partial F(\cdot)/\partial r$ is non zero, using the implicit function theorem, we therefore obtain the partial effect of remuneration on excess reserves on interbank rate is given as the following:

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

in turn, the impact on loans is:

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

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

$$\partial F(\cdot)/\partial r_R = (1-\alpha)\frac{\partial}{\partial r_R}D^s > 0, \tag{38}$$

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

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

The same impact of RRR is:

$$\partial F(\cdot)/\partial \alpha = \underbrace{-D^s}_{<0} + \underbrace{(1-\alpha)\frac{\partial}{\partial \alpha}D^s}_{>0} \gtrless 0 \tag{41}$$

$$\frac{\partial r}{\partial \alpha} = -\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} \lessgtr 0 \tag{42}$$

$$\frac{\partial L}{\partial \alpha} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial \alpha} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} \gtrless 0 \tag{43}$$

The impact of sales of central bank bills is thus:

$$\partial F(\cdot)/\partial B = -1 \tag{44}$$

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

$$\frac{\partial L}{\partial B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial B}{\partial F(\cdot)/\partial r} < 0 \tag{45}$$

Q.E.D

Proof of Proposition 2

The equilibrium levels of deposit and loan are given by:

$$D^* = D^s\left(f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right),\overset{+}{Y},\overset{+}{P}\right) = \sum_{i=1}^{N}\frac{1}{c_{Di}}\left(r - f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right) - \alpha\left(r - r_R\right)\right) \tag{46}$$

$$L^* = \sum_{i=1}^{N}\frac{h\left(\overset{+}{r},\overset{+}{Y},\overset{+}{P},\overset{-}{L^T}\right) - r + \kappa L^T}{c_{Li} + \kappa}.$$

and the aggregate net position is given by:

$$\begin{aligned} F(\cdot) &= (1-\alpha)D^s - L^D - \sum_{i=1}^{N} E_i - B \\ &= (1-\alpha)D^s\left(f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right),\overset{+}{Y},\overset{+}{P}\right). - L^D\left(h\left(\overset{+}{r},\overset{+}{Y},\overset{+}{P},\overset{-}{L^T}\right),\overset{+}{Y},\overset{+}{P}\right) \\ &\quad - \sum_{i=1}^{N}\left(\frac{1}{\beta}\left(r_E - r\right) + E_i^T\right) - B \end{aligned} \tag{47}$$

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

$$\partial F(\cdot)/\partial r = (1-\alpha)\frac{\partial}{\partial r}D^s - \frac{\partial L^D}{\partial r} - \frac{\partial}{\partial r}\sum_{i=1}^{N} E_i - \frac{\partial B}{\partial r} \tag{48}$$

$$= \underbrace{(1-\alpha)\frac{\partial}{\partial r}D^s\left(f\left(\overset{+}{r},\overset{-}{Y},\overset{+}{P},\overset{+}{r_R},\overset{\pm}{\alpha}\right),\overset{+}{Y},\overset{+}{P}\right)}_{>0} - \underbrace{\frac{\partial}{\partial r}L^D\left(h\left(\overset{+}{r},\overset{+}{Y},\overset{+}{P},\overset{-}{L^T}\right),\overset{+}{Y},\overset{+}{P}\right)}_{<0} + \underbrace{\frac{N}{\beta}}_{>0} > 0 \tag{49}$$

which implies

$$\partial F(\cdot)/\partial r > 0 \tag{50}$$

$$\partial F(\cdot)/\partial L^T = -\left(\frac{\partial L^D\left(h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}, \overset{-}{L^T} \right), \overset{+}{Y}, \overset{+}{P} \right)}{\partial h} \frac{\partial h}{\partial L^T} \right) < 0 \tag{51}$$

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

$$\frac{\partial L}{\partial L^T} = \underbrace{\frac{\partial L^D\left(\overset{-}{h(\cdot)}, \overset{+}{Y}, \overset{+}{P} \right)}{\partial h} \frac{\partial h}{\partial r} \frac{\partial r}{\partial L^T}}_{<0} + \underbrace{\frac{\partial L^D\left(\overset{-}{h(\cdot)}, \overset{+}{Y}, \overset{+}{P} \right)}{\partial h} \frac{\partial h}{\partial L^T}}_{>0} \lessgtr 0 \tag{53}$$

If the perceived penalty of defying the loan target κ, is high enough, such that:

$$\left| \frac{\partial h}{\partial L^T} \right| > \left| \frac{\partial h}{\partial r} \frac{\partial r}{\partial L^T} \right| \tag{54}$$

$$\frac{\partial L}{\partial L^T} > 0 \tag{55}$$

Q.E.D.

Proof of Proposition 3

In this case,

$$\partial F(\cdot)/\partial r = \frac{\partial}{\partial r}(1-\alpha) D^s\left(r_D^B \right) - \frac{\partial}{\partial r} L^D\left(h\left(\overset{+}{r}, \overset{+}{Y}, \overset{+}{P}, \overset{-}{L^T} \right), \overset{+}{Y}, \overset{+}{P} \right) \tag{56}$$

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

$$= \underbrace{-\frac{\partial L^D}{\partial h} \frac{\partial h}{\partial r}}_{>0} + \frac{N}{\beta} > 0 \tag{57}$$

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

$$\partial F(\cdot)/\partial r_L^B = 0 \tag{58}$$

Since h is assumed to be continuously differentiable functions and assume there is a point satisfying $F(\cdot) = 0$ and $\partial F(\cdot)/\partial r$ is non zero, applying the implicit function theorem, this impact on interbank rate becomes:

$$\frac{\partial r}{\partial r_L^B} = -\frac{\partial F(\cdot)/\partial r_L^B}{\partial F(\cdot)/\partial r} = 0 \tag{59}$$

and the impact on loans is therefore:

$$\frac{\partial L}{\partial r_L^B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_L^B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_L^B}{\partial F(\cdot)/\partial r} = 0 \tag{60}$$

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

$$\partial F(\cdot)/\partial r_D^B = (1-\alpha)\frac{\partial}{\partial r_D^B} D^s\left(r_D^B\right) > 0 \tag{61}$$

$$\frac{\partial r}{\partial r_D^B} = -\frac{\partial F(\cdot)/\partial r_D^B}{\partial F(\cdot)/\partial r} < 0 \tag{62}$$

$$\frac{\partial L}{\partial r_D^B} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_D^B} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_D^B}{\partial F(\cdot)/\partial r} > 0 \tag{63}$$

The effect of raising remuneration on excess reserves is:

$$\partial F(\cdot)/\partial r_E = -\frac{\partial}{\partial r_E}\sum_{i=1}^{N} E_i = -\frac{N}{\beta} < 0 \tag{64}$$

$$\frac{\partial r}{\partial r_E} = -\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} > 0 \tag{65}$$

$$\frac{\partial L}{\partial r_E} = \frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial r}{\partial r_E} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_E}{\partial F(\cdot)/\partial r} < 0 \tag{66}$$

and the effect of raising remuneration on required reserves is:

$$\partial F(\cdot)/\partial r_R = 0 \tag{67}$$

$$\frac{\partial r}{\partial r_R} = -\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} = 0 \tag{68}$$

$$\frac{\partial L}{\partial r_R} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial r_R}{\partial F(\cdot)/\partial r} = 0 \tag{69}$$

and the impact of a higher RRR is given by:

$$\partial F(\cdot)/\partial \alpha = -D^s\left(r_D^B\right) < 0 \tag{70}$$

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

$$\frac{\partial L}{\partial \alpha} = -\frac{\partial L^D}{\partial h}\frac{\partial h}{\partial r}\frac{\partial F(\cdot)/\partial \alpha}{\partial F(\cdot)/\partial r} < 0 \tag{71}$$

The impact of sales of central bank bills is:

$$\partial F(\cdot)/\partial B = -1 < 0 \tag{72}$$

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

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

The impact of raising the loan target level is:

$$\partial F(\cdot)/\partial L^T = -\left(\frac{\partial L^D\left(h\left(\overset{+}{r},\overset{+}{Y},\overset{+}{P},\overset{-}{L^T}\right),\overset{+}{Y},\overset{+}{P}\right)}{\partial h}\frac{\partial h}{\partial L^T}\right) < 0 \tag{73}$$

$$\frac{\partial r}{\partial L^T} = -\frac{\partial F(\cdot)/\partial L^T}{\partial F(\cdot)/\partial r} > 0 \tag{74}$$

$$\frac{\partial L}{\partial L^T} = \underbrace{\frac{\partial L^D\left(\bar{h}(\cdot), \overset{+}{Y}, \overset{+}{P}\right)}{\partial h} \frac{\partial h}{\partial r} \frac{\partial r}{\partial L^T}}_{<0} + \underbrace{\frac{\partial L^D\left(\bar{h}(\cdot), \overset{+}{Y}, \overset{+}{P}\right)}{\partial h} \frac{\partial h}{\partial L^T}}_{>0} \lessgtr 0 \tag{75}$$

Q.E.D.