



IMF Working Paper

What Drives China's Interbank Market?

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Asia and Pacific Department

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Authorized for distribution by Nigel Chalk

September 2009

Abstract

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The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

Interest rates in China comprise a mix of both market determined interest rates (interbank rates and bond yields), and regulated interest rates (lending and deposit rates), reflecting China's gradual process of interest rate liberalization. We argue, using a theoretical model and empirical analysis, that the regulation of key retail interest rates diminishes the ability of the market determined rates to act as independent price signals, or as benchmarks for use in asset pricing and monetary policy. Further interest rate liberalization should, therefore, strengthen the information conveyed by movements in interest rates, allowing for the better pricing of risk and capital.

JEL Classification Numbers: E43, E52, E58 and C22

Keywords: Interbank market; monetary policy; GARCH; China

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I. INTRODUCTION

Short-term interbank interest rates are key prices in all economies, typically playing two important roles: indicating the state of macroeconomic and liquidity conditions; and providing a building block for the pricing of financial assets. Consequently, large benefits are likely to follow—through the allocation of capital and risk in the economy—from ensuring that short-term funding rates provide independent market-based price signals. Recognizing this, China has been gradually liberalizing interest rates for more than a decade. While interbank interest rates and bond yields are now market determined, other key interest rates remain regulated. In particular, an administrative cap applies to deposit rates, and a floor applies to lending rates (section II describes activity in key interest rate markets).

In this paper, we ask whether short-term interbank rates can effectively reflect liquidity conditions and provide a basis for asset pricing in China. Our answer is that further reform is needed before they can fully play these roles. Although interbank rates are market determined, these rates are not independent of the binding regulation of other key interest rates. Regulating the deposit rate influences the supply of funds into the financial system and consequently affects liquidity and the interbank rate. Similarly, regulating the lending rate affects the volume of loans demanded and so should also alter the interbank rate. We develop, in Section III, a stylized model of China's banking sector that pins down the analytical relationship between regulated and market determined interest rates. If regulated rates influence interbank rates, then asset valuations made using interbank rates also largely reflect the position of the administered rates. Similarly, interbank rates would less effectively indicate fluctuations in monetary and financial conditions if this is the case.

The results of an estimated empirical model of China's 7-day repo rate (presented in Section IV) are consistent with this intuition. In particular, the parameter estimates suggest that the interbank rate increase with administered lending rates and falls with deposit rates, even after controlling for the systematic variations in liquidity throughout the week, during the month, or due to the timing of the Chinese New Year. After controlling for the impact of administered interest rates, changes to policy variables, by contrast, have a surprisingly small impact. Changes to administered retail interest rates also affect interbank rate volatility, as does announced changes to reserve requirements.

We conclude that further liberalization of deposit and lending rates should work to strengthen the role the interbank rate can play as an independent benchmark and in monetary policy formation. It will also serve to further advance China's financial market development. While interest rate volatility may increase after the liberalization, as has happened elsewhere, this volatility would be associated with the incorporation of macroeconomic and financial news into the pricing of risk and capital. Ultimately, this should be associated with a better allocation of scarce capital, and contribute to China's rebalancing.

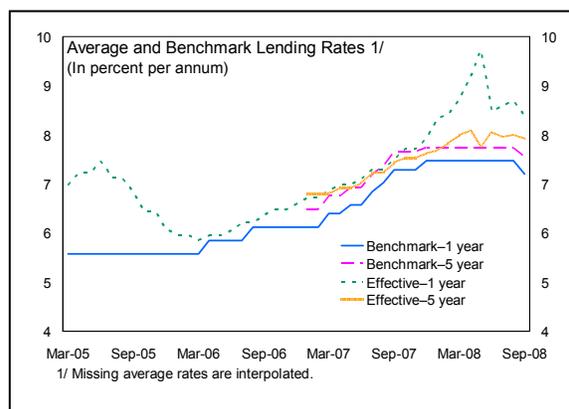
II. INSTITUTIONAL STRUCTURE OF INTEREST RATES

Interest rates in China reflect a mix of regulated and market determined outcomes. They are also affected by quantity controls and official “window guidance” placed on commercial banks. In this section, we review the institutional setup of the money market, as well as the main features of Chinese interest rates and monetary policy.

A. Interest Rate Regulation

Over the past two decades, interest rates have been steadily deregulated in China (People’s Bank of China (PBC), 2005). First, in the late-1990s, interbank repo lending rates and bond market yields were liberalized. Upper limits on interbank lending rates were abolished in June 1996, allowing these rates to be market determined. A year later, in June 1997, repos and the outright cash settlement of secondary transactions were introduced into the interbank lending market, with the interest rates also market determined. In 1998 and 1999, the rates on financial bonds by policy banks and Treasury bonds were allowed to be market determined, rather than linked to the administered rates set by the PBC. The interest rates on corporate fixed income financing were gradually liberalized beginning in 2005, with creation of the short-term bill financing (commercial paper) market. The referencing of market determined corporate bond yields off the SHIBOR rate began in 2007, while interest rates in medium-term corporate note market (which was created in 2008) are also market determined.

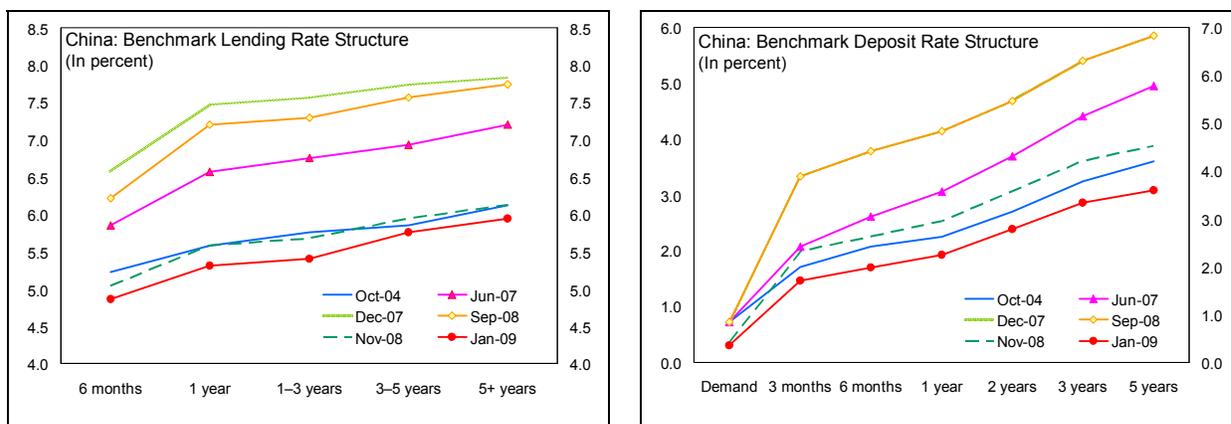
Following the deregulation of wholesale interest rates, restrictions on retail deposit and lending rates have also been gradually relaxed. From 1998, the upper bound on lending rates was gradually lifted, until it was finally removed in October 2004. At the same time, the floor on renminbi deposit rates was also removed. Consequently, there remains a ceiling on deposit rates, and a floor on lending rates (based on the PBC’s benchmark rates). Lending rates can typically be no lower than 90 percent of the benchmark lending rate (although mortgage rates have been allowed to fall to 70 percent of the benchmark since October 2008). The cap on deposit rates is generally considered binding, with deposit rates typically clustered at their benchmark and while generally positive, real deposit rates have at times been close to zero or negative for long periods.² Nonetheless, the deposit rate ceiling is not binding for large long-term depositors, such as insurers.³ The benchmark



² An exception occurred in the second quarter of 2009, when the extent of market liquidity led interest rates on medium- and long-term enterprise deposits to float below the benchmark.

³ Since October 1999, the rate for deposits over Y 30 million held for more than 5 years is negotiable.

rates are adjusted by the PBC on an irregular basis, typically in conjunction with movements in other monetary policy indicators, although the slope typically only changes at the short end. Average lending rates follow movements in the benchmark rates relatively closely.



B. Market Determined Interest Rates

While many interest rates have been liberalized, other restrictions have also influenced funding costs in these markets. The bond market is segmented, and there have been various types of restrictions on the issuance of securities. These issuance restrictions are also being gradually eased, and there are plans to address the segmentation issue this year. These additional steps should broaden the access of credit, and improve the pricing established in these markets.

Background: Creation of the Modern Interbank Market⁴

The PBC established the first unified national interbank lending market in January 1996. There had been unregulated interbank lending dating from around 1981, with the PBC first sanctioning lending between specialized state-owned banks in 1985. However, lending in this market often violated interest rate caps and occurred with unauthorized participants, leading the PBC to form a new market (the China Interbank Offered Rate (CHIBOR) market), increase monitoring (all trading between members was made electronic through the China Foreign Exchange Trading System), and set new rules for loan maturities, membership, and on the use of interbank funds raised. Banks were prohibited from participating in other funding markets, and were also explicitly forbidden from using the interbank market to fund fixed asset or other investments. Initially this new national market was primarily for settling temporary discrepancies in accounts and working capital loans, with the majority of lending for periods up to one week, but then was extended to other instruments and maturities.

⁴ Xu (2006) and Thurston (2006) provide surveys of the main development and institutional features of these markets.

China's bond markets were segmented shortly after the creation of the interbank market. Bond markets had been established on the Shanghai and Shenzhen stock exchanges in 1990 and 1991, respectively. These new exchanges were instrumental in the development of bond markets for primary issues, secondary trading, and repurchase operations. However, following the equity and real estate bubbles in the early 1990s, the PBC created an interbank government bond market in 1997 to permit trading of bonds by commercial banks (and other eligible participants) since the banks could no longer participate in trading on the exchanges.

Repo Market

Of the two types of interbank lending—uncollateralized lines of credit and collateralized repos—repos are by far the most important. This type of lending is typically very short term (overnight to 7 days), although transactions with maturity up to one year are possible.⁵ There are clear structural liquidity imbalances, with the large state commercial banks being the major supplier of liquidity in the repo market, and other financial institutions (principally insurers, securities firms, and fund managers), foreign banks and, to some extent, other commercial banks net recipients. Interestingly, state commercial banks and other commercial banks reverse their roles in the smaller unsecured lending market, with the latter the principal suppliers of liquidity.⁶

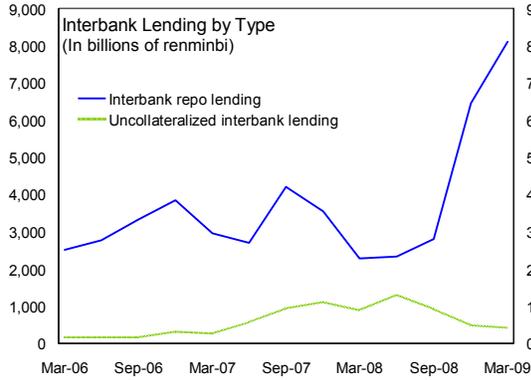
Repo activity is much more active in the interbank market than in the exchange markets. With banks only able to participate in the interbank market, the majority of repo trading followed them given the liquidity imbalances in the system. The repo activity on the exchange is, therefore, now only a very small share of total repo transactions. As the interbank bond market has developed, and the extent of instruments expanded, so have the diversity of instruments used for repo transactions. In particular, while financial bonds have consistently played the major role in repo transactions, there has been increasing use of PBC paper as the rise in sterilization operations in 2006 and 2007 expanded the availability of this paper, as well as a recent increase in the use of commercial paper.

⁵ From May 2004, there have been two types of repo transactions, with outright repo added to the existing collateralized repo. Under collateralized repo the underlying bond is placed with a custodian without the underlying ownership transferred, while in the outright repo the ownership of the bond is transferred.

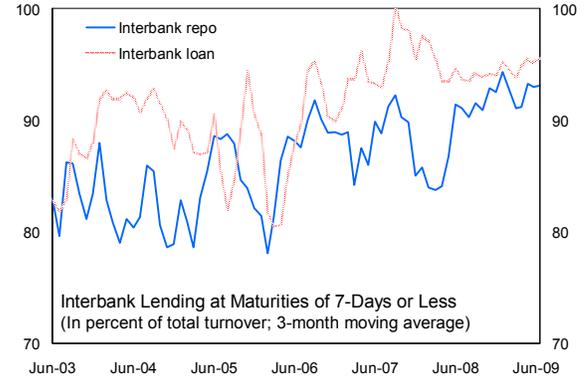
⁶ The major suppliers of liquidity in the loan market are state commercial banks, joint-stock banks, policy banks and the Postal Savings Bank, while the borrowers are finance companies, city commercial banks, foreign institutions and security companies. In the repo market, suppliers of liquidity are state commercial banks, joint-stock banks, policy banks, and the borrowers are city commercial banks, RCC and security companies.

Figure 1. Interbank Market Activity

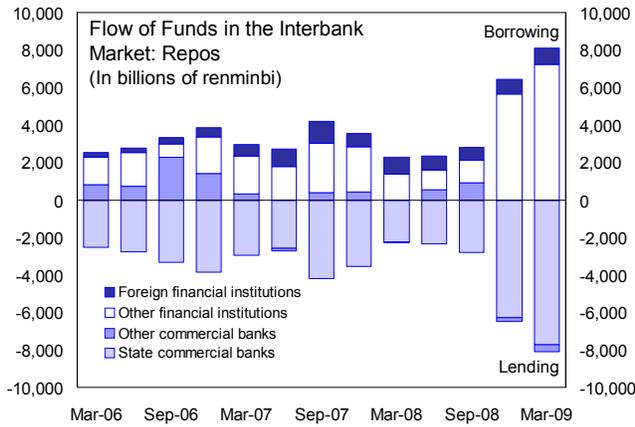
Most interbank credit is extended through collateralized repos, ...



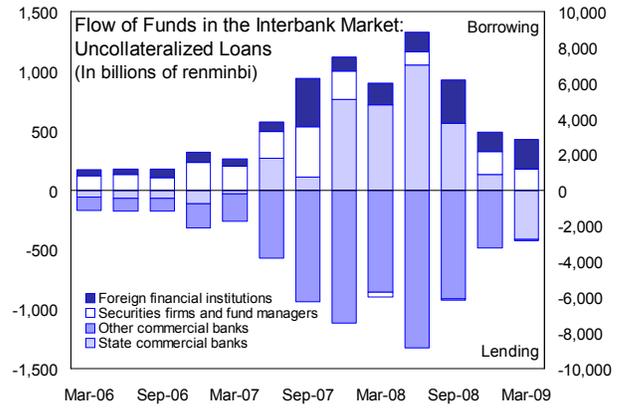
... with activity concentrated at short maturities.



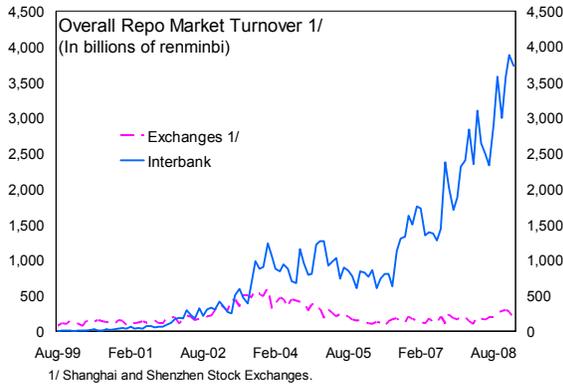
State commercial banks are the major suppliers of funds in the repo market, with other commercial banks only sometimes lending.



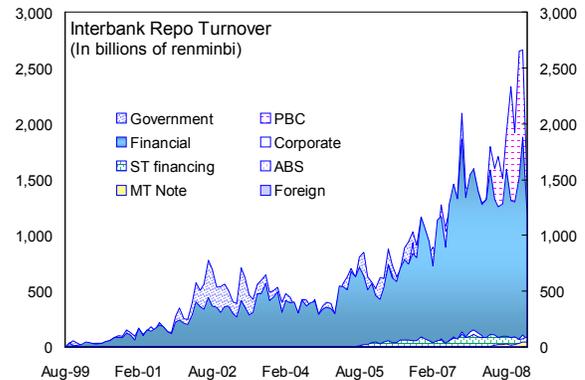
However, other commercial banks are the principal source of funds in the interbank loan market.



Repo activity shifted from the exchanges to the interbank market after its creation.



The expansion of instruments in the interbank market has led to the use of new instruments for repos.

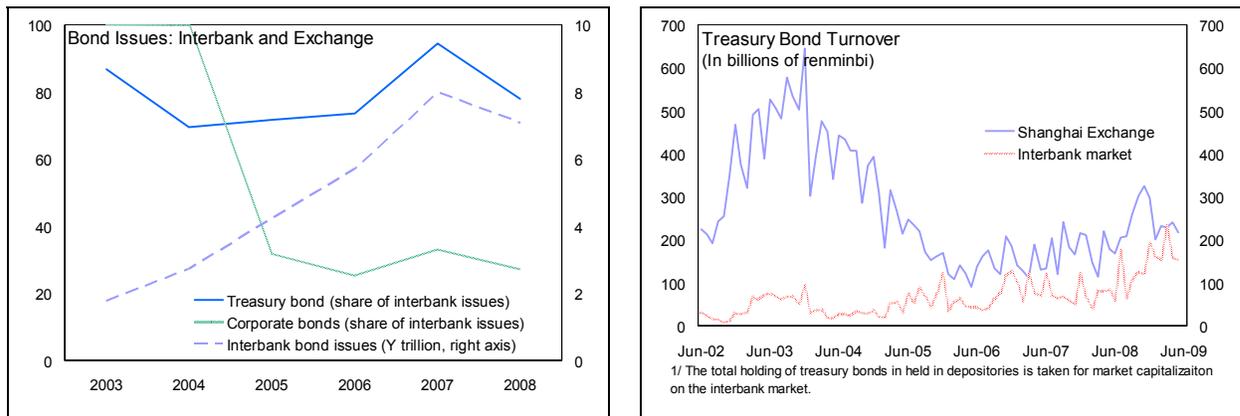


Source: CEIC Data Co., Ltd.; the People's Bank of China; and staff estimates.

Bond Markets

The interbank bond market is a wholesale bond market designed for banks and institutional investors, while individual investors are able to participate in the exchange markets. Trade in the interbank bond market is based on a quote driven OTC system, while the exchange markets are order driven. The segmentation of the bond market led to a divergence in the type of bond transactions in each market. The majority of government bonds, including all central bank and almost all financial bonds, have been issued in the interbank market. Over time, (larger) corporates have gradually increased their listing in the exchange bond markets reflecting the more active secondary trading in the exchange market given that banks typically hold bonds to maturity.⁷ The segmentation has also split the liquidity within the treasury market, meaning "... there is pricing uncertainty across the yield curve and price variation across the diverse markets ..." (ICMA, 2005, p. 13). In fact, despite the majority of treasury bonds being listed on the interbank market, overall turnover of these bonds (including for repos) is higher on the Shanghai exchange than in the interbank market.

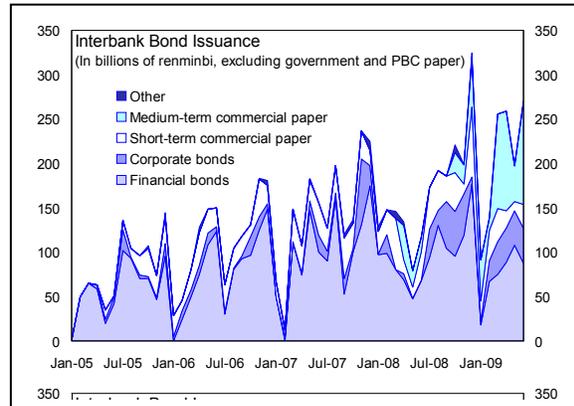
Until relatively recently, corporate bond issuance has been tightly regulated. Regulatory authority has also been scattered across several agencies (Arora, 2008).⁸ Prior to August 2007, there was a merit-based system for issuance and an annual cap on the volume of bond issues, as well as a requirement that all bonds be guaranteed by banks. These features resulted in most corporate bonds being issued by SOEs. The 2007 pilot (and other synchronized reforms) addressed many of these restrictions, by moving issuance procedures toward a disclosure based system, and removing the requirement for bank guarantees.



⁷ Participation in the interbank bond market is restricted to commercial banks, credit cooperatives, trust companies, leasing and insurance companies, fund management and securities companies, and foreign financial institutions permitted by the PBC. It is also the market that the PBC is active in.

⁸ The National Development and Reform Commission was responsible for primary issues, the China Securities Regulatory Commission was responsible for the trading of listed securities, while the PBC is responsible for regulating the interbank market.

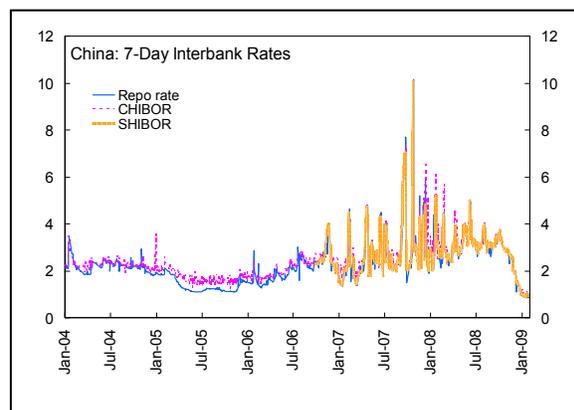
For smaller enterprises, there is also an interbank commercial paper market, which provides for more flexible financing. Until 2005, this market operated largely as a “bankers acceptance market,” with a commercial bank required to accept the paper, which they typically rediscounted and resold to qualified investors. Following reform in 2005, issuers that have a credit rating and submit audited accounts are able to issue commercial paper. In April 2008, this market was extended to include medium-term notes (up to five years), although this market was temporarily suspended between July and September 2008. Without the borrowing caps and stringent approval process required for bond issues, the market has developed quickly—in the first six months of 2009, short-term commercial papers and medium-term notes accounted for almost half of the issuance of nongovernment and non-PBC paper in the interbank market.



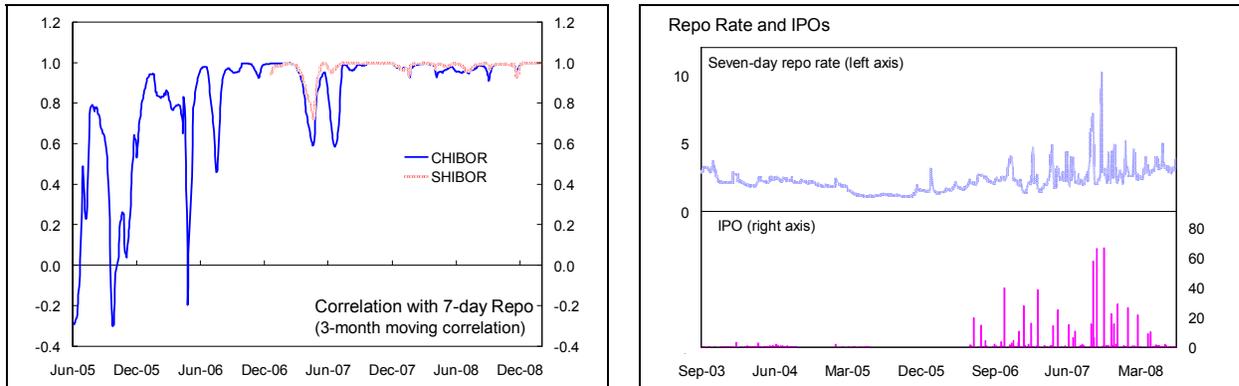
Interbank Offered Rates and Other Interest Rates

In January 2007 the PBC established the Shanghai Interbank Offer Rate (SHIBOR) System with the aim of building a benchmark yield curve. The SHIBOR rate is not determined in a funding market, but is set in a similar way to LIBOR, with the rate calculated as an arithmetic average of renminbi offered rates by participating banks (currently 16), and is a fixing at 11:30 a.m. on each business day. Relative to the CHIBOR market that had existed since 1996, the maturity of rates was extended to one year (since volumes exchanged in the CHIBOR market were small and erratic beyond 90 days). The objective was to remove the impact of trading volumes on benchmark interest rates.

The three key short-term interbank interest rates (CHIBOR, SHIBOR and the repo rate) have followed each other very closely over the past few years, with volatility having increased substantially since late-2005. The rise in volatility reflects both the growing depth of these markets (with increasing turnover), and also is coincident with the development of other parts of the financial market, especially the foreign exchange market and the equity markets (as seen by IPO activity). While the extent of volatility is likely to be driven by several other



institutional and policy factors, it is also probably affected by the institutional arrangements governing reserve requirements (see Box 1). Given the greater liquidity in the repo market (with the turnover in the repo market far exceeding that in the uncollateralized CHIBOR market), and the tight relationship between the SHIBOR and CHIBOR rates with the repo, it seems little additional information is added by the SHIBOR rates for maturities and period when trading is active in either the interbank repo or loan market.⁹ The SHIBOR system does, however, provide a benchmark interest rate quote when interbank trading is limited.



C. Interest Rates and Monetary Policy

The PBC's monetary policy relies on a variety of both direct and indirect instruments. While the use of open market operations has grown rapidly over time, the PBC also frequently uses reserve requirements to influence the volume of funds banks have available to lend. Moreover, it maintains annual (and typically binding) bank-by-bank caps on credit growth, and uses official "window guidance" to influence the direction of bank lending. Finally, as noted above, the PBC regulates retail interest rates, which it typically moves in conjunction with other monetary policy instruments.

Despite this array of instruments, Chinese monetary policy relies heavily on quantity based instruments (through annual credit caps) and administrative measures (reserve requirements and window guidance). Indeed Koivu, and others (2008) argue that observed Chinese monetary growth is consistent with a McCallum (monetary growth) rule.¹⁰ Laurens and Maino (2007), however, find that while the PBC is able to meet its base money target, it is less effective at achieving its broad money targets or influencing economic growth.

⁹ Given the limited liquidity in the repo market at longer maturities (especially at 12 months), the relationship between SHIBOR and repo rates is less uniform, but the correlation is relatively high during periods of heavier transaction volumes in the repo market.

¹⁰ Under such a rule, money growth is equal to target (nominal) GDP growth less velocity growth and half the previous deviation of nominal GDP from its target.

Box 1. Interest Rate Volatility and China's Reserve Requirements

The structure of reserve requirements in China is likely to increase interest rate volatility.

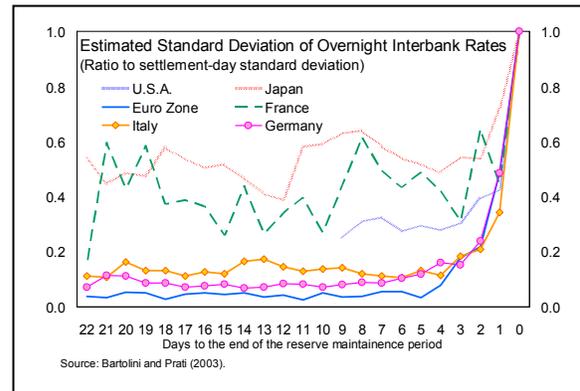
In China reserve requirements must be met strictly on a daily basis. In other words, the PBC has not adopted the practice of reserve averaging, as is common elsewhere. Under reserve averaging, commercial banks need only meet their reserve target on average over some time period (the reserve maintenance period). The length of these periods varies from country to country, with the U.S. averaging over a two week period, while Japan and the Euro zone average over a month. (Prati and others, 2001).

The PBC adopts a differentiated reserve ratio system—required reserves from renminbi deposits differ from those from foreign currency deposits.^{1/} To calculate the required value of reserves on any day (for both renminbi and foreign currency deposits), the level of deposits at the end of the previous Xun is used.^{2/} Each bank's daily reserve ratio is calculated as:

$$\text{Daily reserve ratio} = \frac{\text{Reserves at close of business}}{\text{Deposit level at the end of the preceding Xun}}$$

Banks may hold too few reserve before closing, but they are penalized for not holding sufficient reserves at closing.

If reserve requirements were only met over some maintenance period, then the volatility of short-term interbank rates would likely be lower. In most countries, interest rate volatility rises systematically through the reserve maintenance period, increasing as settlement day approaches (Hamilton, 1996; Prati and others, 2001). As settlement day approaches, banks become increasingly aware that they are either short of the required reserves (and need to borrow to avoid the penalty), or are likely to hold excess funds at end the maintenance period (which they wish to lend), and so transactions and interest rate volatility increase (Bartolini and Prati, 2003; see figure). By not averaging reserves over some maintenance period, this additional trading to either borrow sufficient funds or lend surplus funds is required every day, thereby resulting in higher average volatility. A longer reserve maintenance period would allow banks to hold fewer (costly) precautionary excess reserves, and would require less liquidity in the system for a given level of volatility. Central bank liquidity adjustments within the maintenance period in response to shocks to bank liquidity can further limit this volatility (Bartolini and Prati, 2003; Moschitz, 2004).



1/ The current system was introduced in 1998 for renminbi deposits, and in 2005 for foreign currency deposits.

2/ Each month is divided into three segments, known as Xuns. The first ten days is known as the “upper Xun,” the middle ten days (11th to 20th) are the “middle Xun,” and the remaining days (after the 21st) are the “lower Xun.”

This reflects movements in velocity and the money multiplier that have accompanied the uneven process of financial development in China. They also find that even though broad money growth is an important indicator of *high* inflation, the relationship breaks down when inflation is low (below 5 percent), suggesting that rather than purely the effectiveness of monetary policy, wage and price control regulations have helped the authorities achieve their inflation objectives.

Monetary policy instruments will have to evolve as China's financial markets develop, and quantity measure become less effective (Feyzioglu and others, 2009). Nonetheless, the prerequisites for a greater use of indirect instruments are not yet in place. Due to its relatively nascent financial market and the dominant position of banking in intermediation, quantity measures are likely to remain relatively effective in the near term. However, they have a distortionary impact on the efficient allocation of credit and act like a tax on financial intermediation. In particular, quantity restrictions have resulted in the limited credit available being directed principally toward large SOEs, given their favorable credit characteristics, rather than to small- and medium-sized enterprises. In the longer run, however, further economic and financial developments will erode the effectiveness of quantity based measures. With financial development, the share of intermediation conducted by banks should shrink (as that intermediated in capital markets expands), resulting in increasing instability in the velocity of circulation and the money multiplier (together with nominal shocks). Moreover, the more significant role price (interest rate) signals will play after liberalization will strengthen the effectiveness of indirect monetary policy instruments (Feyzioglu and others, 2009).

Despite a desire to move towards indirect monetary policy instruments, the interest rate channel is still weak (Laurens and Maino, 2007). For short-term interest rates to become an effective operational target (influencing inflation and economic activity), the PBC must be able to influence this rate through open market operations. This rate would then need to be transmitted to longer-term (interbank and corporate financing) rates along the yield curve and finally to retail rates. These channels may be disrupted by several distortions in the market, including the segmentation of the bond market (which prevents interest rates in the interbank market from transmitting to economy-wide financing costs), and the regulation of other (retail) interest rates. In the coming sections we consider whether short-term market determined interest rates are independent price signals, and therefore can be a policy tool for the PBC, and can be effective in transmitting the impact of policy given the existence of binding regulation on other (retail) interest rates.

III. A STYLIZED MODEL OF CHINA'S INTERBANK MARKET

While interbank (and bond market) interest rates have been largely unregulated—market determined—since the late-1990, are they independent of the regulation that affects other interest rates in China? We discuss this question with the aid of a stylized model of China's banking market in this section, and through empirical analysis in the next.

We develop a model, although highly stylized, that captures the key features of the market, including the regulated nature of retail interest rates, daily reserve requirements and, despite the absence of reserve averaging, a desire to hold excess reserves. Following Freixas and Rochet (2008), we consider a competitive model of commercial banks, where there are N independent price taking banks. The banks take as given the lending rate (r_L), the deposit rate (r_D), the bond yield (r_B), the reserve remuneration rate (r_R), and the interbank lending rate (r). As discussed above, the PBC sets the benchmark lending and deposit rate in China.

Taking into account the need to maintain some operational excess reserves, management costs, and needs to withstand deposit fluctuations, we assume that the typical bank has some liquidity preference and faces real costs when their own reserve target ($T(\alpha D)$), a function of required reserves, is not met (see for example Bartolini and others 2001). As a result, the bank's profit maximization problem is given below:

$$\pi = \max_{R,L} \{r_L L + r M + r_R R + r_B B - r_D D - c(D, L) - \frac{\beta}{2} (R - T(\alpha D))^2, s.t. R \geq \alpha D\}$$

where R is the level of reserves (required reserves, RR , and excess reserves, ER), L is the level of loans, M is the net position of the bank on the interbank market, D is the level of deposits, B is the security holdings by the bank (which are assumed to be supplied inelastically by the government), T is the target level of reserves holdings by the bank and β is the strength of liquidity concerns. The cost of managing deposits and loans is given by $c(D, L)$, which we assume to be strictly convex, twice continuously differentiable, and separable in its arguments.

Since market clearing requires $M = D - B - L - RR - ER$,

$$\pi = \max_{R,D,L,B} \{(r_L - r)L + (r - r_B)(D - B) + (r_R - r)R + (r_B - r_D)D - c(D, L) - \frac{\beta}{2} (R - T(\alpha D))^2, s.t. R \geq \alpha D\}$$

First order conditions with regard to R , D , B and L are:

$$\begin{aligned}\frac{\partial \pi}{\partial R} &= (r_R - r) - \beta(R - T(\alpha D)) + \lambda = 0 \\ \frac{\partial \pi}{\partial L} &= (r_L - r) - c_L(D, L) = 0 \\ \frac{\partial \pi}{\partial D} &= (r - r_D) + \alpha\beta(R - T(\alpha D))T'(\alpha D) - c_D(D, L) - \lambda\alpha = 0 \\ \frac{\partial \pi}{\partial B} &= (r - r_B) = 0\end{aligned}$$

The first order conditions have intuitive interpretations. The first determines the overall amount of reserves that a bank wishes to hold, suggesting the amount is determined by equating the opportunity cost of holding reserves ($(r_R - r) + \lambda$) (including the shadow cost of binding reserve requirement) with the marginal cost incurred by deviating from the reserve target, $\beta(R - T(\alpha D))$. Notice that if target reserves exceed the minimum requirement, reserves will typically fall short of the target given the cost of holding them (as typically $r_R < r$). The second condition implies that lending is profitable until the lending rate equals the cost of marginal funds (the interbank rate) and the marginal administrative costs of lending. The third condition determines deposit holdings by equating the marginal profits from additional deposits (in terms of interbank lending) $(r - r_D)$ with the marginal costs from managing the deposits, under a looser reserve requirement and higher targeted reserves $(c_D(D, L) + \lambda\alpha - \alpha\beta(R - T(\alpha D))T'(\alpha D))$. Finally, in this simple framework, a no arbitrage condition requires that all liquid funds (for bonds or in the interbank market) attract the same yield, given these rates are market determined.

The above first order conditions characterize a unique solution to each bank's profit maximization problem, assuming that target reserves $(T(\alpha D))$ are linear and sufficiently flat in required reserves, αD .¹¹ Solving these first order conditions results in functions for the demand for deposits, supply of loans, demand for (excess) reserves, and the demand for bonds that depend on the key interest rates and the reserve requirement (as well as parameters governing bank's costs and liquidity preferences).

¹¹ We assume the following sufficient conditions on the functional forms for a unique solution:

$T(\alpha D) = a_T(\alpha D)$, $c(D, L) = \frac{a_{cD}D^2 + a_{cL}L^2}{2}$, and $a_{cD} > \beta a_T^2$, where a_T , a_{cL} , and a_{cD} are constants.

We now turn to the competitive equilibrium in the interbank market. Indexing the banks by $n=1, \dots, N$, they each have a *loan supply function* $L^n(r_L, r)$ and a *deposit demand function* $D^n(r_D, r)$. Let $L^d(r_L)$ be the *demand function for loans* and $S(r_D)$ the *supply function for deposits* (savings). Typically, the loan and deposit markets would be closed (and relevant interest rates determined) by equating the demand and supply in these markets. However, given the extent of retail interest rate regulation in China, it is likely that the regulated deposit rate is below its equilibrium level (Feyzioglu, 2009). The lending rate, reflecting its regulated floor, is unlikely binding on marginal borrowers, even if it is on near-sovereign borrowers. If either the borrowing or lending market does not clear, then the quantity would be determined by the short side at the regulated interest rate. However, given that some (near-sovereign) loans occur at the lending rate floor, for simplicity in this simple analytical exercise, we assume that the loan market clears at r_L . The competitive equilibrium is then characterized by three conditions:

$$L^d(r_L) = \sum_{n=1}^N L^n(r_L, r) \quad (\text{Loans market}) \quad (1)$$

$$S(r_D) \leq \sum_{n=1}^N D^n(r_D, r) \quad (\text{Savings market}) \quad (2)$$

$$\sum_{n=1}^N L^n(r_L, r) = (1 - \alpha)S(r_D) - B - \sum_{n=1}^N ER^n(r_R, r, \alpha) \quad (\text{Interbank market}) \quad (3)$$

RESULT 1: *There exists an equilibrium market determined interbank rate, r^* , that solves (3), which is a unique function of the administratively set benchmark interest rates, as well as reserve requirement and government bond issues. The same hold for the market determined bond yields*

PROOF: For given $r_L, r_D, r_R, r, \alpha, B$, and cost and reserve target function parameters, there exists a unique interbank rate that solves either equation (3). Since the left hand side of (3) is downward sloping in the interbank rate ($\frac{\partial L^n(r_L, r)}{\partial r} < 0$), while the right hand side is an increasing function in the interbank rate ($\frac{\partial ER^n(r_L, r)}{\partial r} < 0$), the necessary condition is satisfied.¹² QED.

¹² Given the cost and $T(aD)$ functions assumed, both the left and right hand sides of (3) are linear in r .

Therefore, an overly sufficient condition for a unique solution would be $B > \left(1 + \alpha \frac{a_T - \beta}{\beta}\right) S(r_D) - \frac{Nr_R}{\beta}$.

The direct implication of Result 1 is that the market determined interbank and bond rates cannot be independent of the administratively determined interest rates. Some key properties of the resulting equilibrium interbank interest rate are summarized in Results 2 and 3:

RESULT 2: *Provided the lending rate does not exceed its equilibrium, the equilibrium interbank rate, r^* , that solves (3), is increasing in the lending rate, decreasing in the deposit rate, and increasing in central bank bond issuance. An increase in the required reserve ratio has an indeterminate impact on the interbank rate, although if banks have a sufficient liquidity preference ($\beta > 1$) an increase in the required reserve rate will increase the interbank rate. If the lending rate exceeds its equilibrium, then the interbank rate is decreasing in the lending rate.*

PROOF: The following comparative statics follow from (3), where

$$\Delta \equiv \sum_n \left[\frac{\partial L^n(r_L, r)}{\partial r} + \frac{\partial ER^n(r_R, r, \alpha)}{\partial r} \right] < 0:$$

$$\frac{dr}{dr_L} = - \frac{\sum_n \partial L^n(r_L, r) / \partial r_L}{\Delta} = - \frac{(+)}{(-)} > 0$$

$$\frac{dr}{dr_D} = \frac{(1-\alpha) \partial S(r_D) / \partial r_D}{\Delta} = \frac{(+)}{(-)} < 0$$

$$\frac{dr}{d\alpha} = - \frac{S(r_D) + \sum_n \partial ER^n(r_R, r, \alpha) / \partial \alpha}{\Delta} = - \frac{(1+T'(\alpha D) - 1/\beta) S(r_D)}{(-)} >> 0$$

$$\frac{dr}{dB} = - \frac{1}{\Delta} > 0$$

QED

The result that a rise in the deposit rate reduces the interbank rate follows from the fact that interest rate regulation holds the deposit rates below their equilibrium level. With rates below their equilibrium level, a rise in the deposit rate increases deposits in the system, resulting in additional liquidity in the banking system and lower overall interest rates. If, however, such regulation was not binding, then an exogenous rise in the deposit rate (due to developments in that market) would result in higher costs for the bank, thereby limiting their demand for deposits and resulting in higher interbank rates because of a reduction in the liquidity in the system. This is Result 3:

RESULT 3: *If the deposit (savings) market were allowed to clear $\left(S(r_D) = \sum_{n=1}^N D^n(r_D, r) \right)$, then an increase in the deposit rate would increase the interbank rate. All other comparative static results from Result 2 would continue to hold.*

PROOF: In this case, (3) would become

$$\sum_{n=1}^N L^n(r_L, r) = (1-\alpha) \sum_{n=1}^N D^n(r_D, r) - B - \sum_{n=1}^N ER^n(r_R, r, \alpha), \text{ and}$$

$$\Delta \equiv \sum_n \left[\frac{\partial L^n(r_L, r)}{\partial r} + \frac{\partial ER^n(r_R, r, \alpha)}{\partial r} - (1-\alpha) \frac{\partial D^n(r_D, r)}{\partial r} \right] < 0,$$

where $\frac{\partial D^n(r_D, r)}{\partial r} > 0$ from each bank's first order conditions. Then

$$\frac{dr}{dr_D} = \frac{(1-\alpha) \sum_n \frac{\partial D^n(r_D, r)}{\partial r_D}}{\Delta} = \frac{(-)}{(-)} > 0.$$

All other comparative static expressions remain as in the proof of Result 1. QED

Finally, before moving onto our empirical analysis, we note that other exogenous (short term) factors that affect liquidity (for example, IPO activity, exchange rate intervention, or capital inflow) should influence interbank rates in the same way as the exogenous changes in bond holding—increasing the interbank rate when liquidity falls and reducing the interbank rate when liquidity rises.

IV. EMPIRICAL ANALYSIS

In this section, we estimate a model of the interbank interest rate. We choose to model the 7-day repo rate given that it is one of the main market determined rates for short-term interbank funds, and has been used as a benchmark for pricing other financial assets. While the SHIBOR has since been established to act as a benchmark yield curve, the comovement of the two rates (as well as with the CHIBOR) suggest that it is not independent of the repo rates.

A. The Empirical Model

China's interbank rates, as those in the rest of the world, exhibit high volatility as well as volatility clustering. Consequently, we model the interbank rate using an exponential GARCH (EGARCH) model, which allows for rich specifications for both the time varying mean as well as the time varying volatility of the observed interest rate. Given the apparent "fat tails" exhibited by the Chinese interbank data, we will assume these innovations are

distributed with a Student's t-distribution. Such a model has been applied to many advanced country interbank markets (see for example Prati and others, 2001; Moschitz, 2004; and Perez Quiros and Rodriguez Mendizabal, 2006). These other studies have a different focus than we have. They examine the interbank markets in several developed (G-7) economies where the central bank targets a short-term interbank rate for monetary policy purposes. Their primary concern is to identify the liquidity effects within the market driven by the differences between reserve settlement and nonsettlement days, as well as the impact of parameters of the interest rate targeting regime on the interbank rate. They also model the interbank rate separately from other interest rates and markets. We, however, are principally concerned with the roles played by other policy variables—administered interest rates and other monetary policy instruments—in a less developed market.

Our basic empirical model of the interest rate is

$$r_t = \mu_t + \sqrt{h_t} v_t,$$

where v_t is a unit variance, serially uncorrelated, zero mean, iid error term, and μ_t and h_t are the time varying mean and variance, respectively, of the interest rate. The mean is assumed to show persistence in interest rates as well as in exogenous factors that should affect the interest rate, X_t^m ,

$$\mu_t = \sum_{i=1}^s \phi_i r_{t-i} + \beta_m' X_t^m,$$

where the ϕ_i autoregressive terms reflect the persistence of the interest rate and $\beta_m' X_t^m$ reflects the impact of other exogenous factors on the average interest rate. Consistent with the volatility clustering observed in the interbank data, the variance is specified as follows:

$$\ln(h_t) = \sum_{i=1}^p \gamma_i \ln(h_{t-i}) + \sum_{j=1}^q \alpha_j \left| \frac{v_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{k=1}^l \lambda_k \frac{v_{t-k}}{\sqrt{h_{t-k}}} + \beta_v' X_t^v,$$

where the α_j terms are the 'ARCH' effects (based on innovations in the absolute standardized residual), the γ_i terms are the 'GARCH' terms, and the λ_k terms show the asymmetric impact of positive or negative innovations to the standardized residuals. If the $\lambda_k=0$, then both positive and negative "news" (innovations) have symmetric impacts on interest rate volatility. $\beta_v' X_t^v$ measures the impact of other exogenous factors that drive volatility.

Based on our stylized model of China's banking sector (developed in Section III), the interbank rate should reflect the benchmark deposit and lending rates, and the extent of

liquidity in the interbank system (driven by the stock of open market operations, and changes in reserve requirements). IPOs are also posited as an important contributor of short term fluctuations in the interest rate—as they lock up significant funds in the banking system for around a week ahead the IPO—and so these are included as exogenous explanatory variables. Finally, we allow for interbank liquidity to vary systematically through the year, as it does in other interbank markets (Prati and others, 2001; and Moschitz, 2004). In particular, we allow for liquidity effects resulting from the day of the week, the proximity to the end of the month, and the timing of Chinese New Year to possibly influence the average interest rate, as well as its volatility.

Interbank volatility is also likely to be driven by policies such as changes in the benchmark lending rates and changes in the liquidity, on the persistence of their impact. In the former case, a sudden increase in the incentive to lend is likely to cause a short-term rush for interbank funds (until, say, the level of deposits can increase) and temporarily increase volatility. In the latter, policy induced changes in liquidity (through OMOs and reserve requirement changes) are likely to drive changes in volatility in the short run, as are exogenous changes in liquidity that may occur through week, around the end of a month, or at Chinese New Year.

B. Data and Exogenous Variables

As mentioned above, we focus on the 7-day repurchase rate in our empirical analysis of the Chinese interbank market. We use the 1-year benchmark deposit and lending rates to capture the impact of interest rate regulation on the mean of the interbank rates. To capture the impact of monetary policy changes on the liquidity in the banking system, we use measures of open market operations and reserve requirements.¹³ To capture the impact of announced (and therefore anticipated) changes in reserve requirements, we construct a series for the change in the required reserve ratio on the date announced (usually around two weeks ahead of implementation). Data on IPOs cover the amount of funds raised (in billions of renminbi) on a particular day. With IPOs resulting in a significant amount of funds being locked up in the banking system (for around a week or so), we included leads of +5 and +10 days to capture the impact of this ‘lock-up.’ Finally, using dummy variables we also control for three types of systematic liquidity effects: within week, end of month, and for the timing of the Chinese New Year.

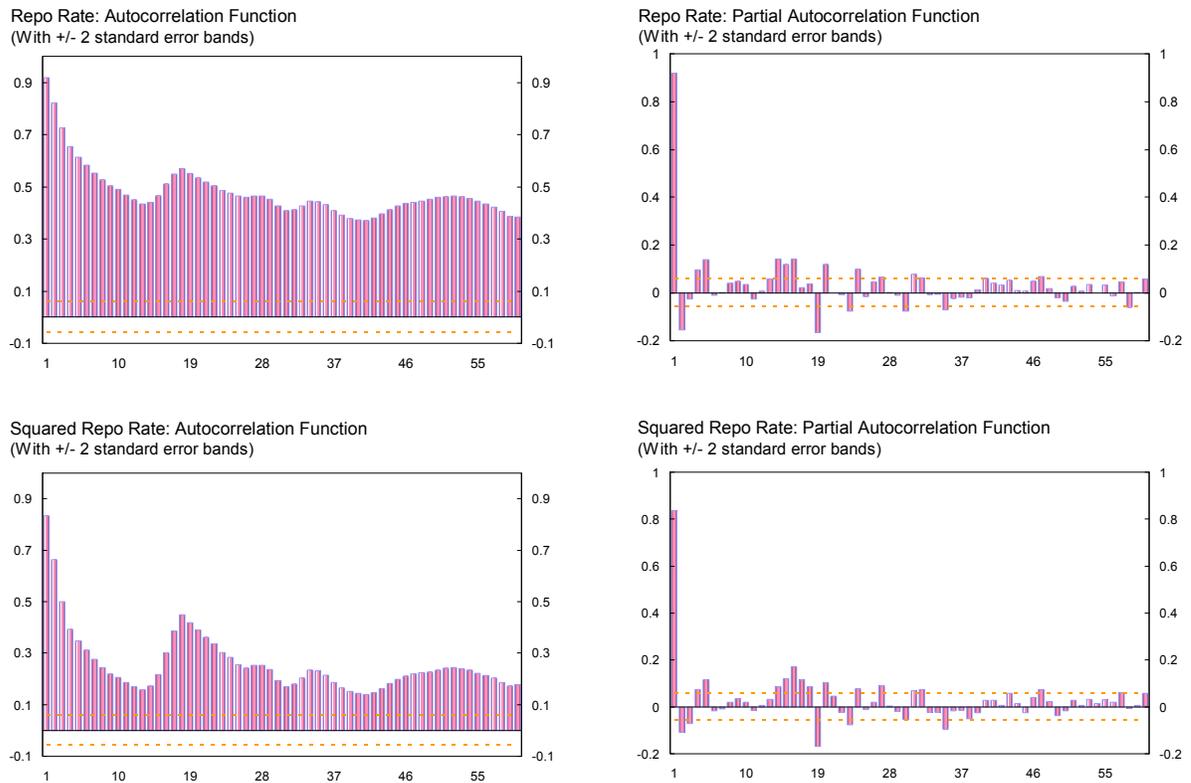
A similar set of variables is hypothesized to influence the variance of the interbank rate. The main difference is that in the variance equation we control the absolute change in benchmark interest rates, rather than with their level. The difference reflects the likelihood that *changes*

¹³ Specifically, the open market operations variable is defined as the net increase in liquidity from the expiration of central bank paper on that day (i.e., expiration less issuance). For reserve requirements, the measure reflects the liquidity injected from a fall in required reserves.

in administered rates are likely the drivers of (short-term) volatility, and any impact is more likely symmetric to both increases and reductions. The final equation specification is obtained using the general-to-specific approach.

Before moving on to discuss the empirical results, we consider the key empirical properties of the repo rate. The repo rate is clearly persistent, with its mean seemingly well characterized by autoregressive processes (slow decay in the autocorrelation function (ACF) and decay after more than 5–15 lags of the partial-ACF (PACF)). Despite the persistence, unit root tests is clearly rejected.¹⁴ There are also clear signs of volatility clustering, with similar indications of significant persistence in the squared rates.

Figure 2. Interbank Rate Persistence



¹⁴ The augmented Dickey-Fuller test is rejected with a p-value of 0.0669, and the Phillips-Perron test is rejected with a p-value of 0.0000.

C. Empirical Results

We now turn to the empirical results on the main drivers of the mean and variance of China's interbank rate. The relationship for the 7-day repo rate shown in Table 1 is estimated using daily data spanning October 2003 to August 2008. The resulting estimates confirm the extent of extreme movements in China's interbank rate—the estimated degrees of freedom for the error term is marginally above its feasible lower limit (of two) and far smaller than that estimated in models of other interbank markets (e.g., Prati and others (2001) present degree of freedom estimates between 2.23 and 3.95 for short-term G-7 and Euro zone interbank rates). With such a low estimate for the degree of freedom of the error terms, estimated innovation (news events) is far noisier than implied by a normal distribution.

Average Interest Rates

The main results are:

- *Persistence.* China's interbank rate, like that elsewhere, is extremely persistent. There is a more than proportionate response to a change in the repo rate on the previous day, which is then unwound in the days following. Although lags beyond 3 three days do not seem significant, jointly they are highly significantly negative (see Table 3).
- *Administered interest rates.* Changes to benchmark interest rates clearly have a significant impact on the interbank rate, and although they have opposite effects, each is clearly not monotonic.¹⁵ Increases in the benchmark lending rate lead to higher average interbank rates, as the higher lending rates transmit into pressure for interbank funds. The initial direct impact of a 100 basis points rise in the lending rate is to increase the interbank rate by 75 basis points, but after three days this direct impact is only 3 basis points. An increase in the deposit rate has the opposite effect, reducing the interbank rate, reflecting a likely supply response on the part of depositors, given the low regulated interest rate as suggested by our stylized model. The initial direct impact of a 100 basis points rise in the deposit rate is a 43 basis points fall in the interbank rate, although the interbank rate is less than 3 basis points lower (due the direct impact) after three days but this is still significant. Given the persistence of interbank rates, the *long-run* impact of a simultaneous 100 basis point increase in both deposit and lending rates is a 40 basis point rise in the interbank rate.
- *Monetary policy.* Conditional on the level of benchmark interest rates, changes to policy variables—open market operations and reserve requirements—do not have any significant impact on the interest rate. Not even the announcement of a change in the

¹⁵ At a daily frequency, the hypotheses that the benchmark deposit and lending rates do not Granger cause the 7-day repo rate can be rejected, with p-values of 9.25e-07 and 3.57e-07, respectively.

reserve requirement has a significant impact on the level of the interbank rate. This could reflect that these operations were aimed at pure sterilization—adjusting the amount of liquidity in the system with the aim of keeping the interest rate relatively constant.

- *IPOs.* IPOs have apparently no significant impact on the mean interest rate. While this is surprising, given the volume of funds tied up during the IPO, the result could reflect offsetting policy actions (less sterilization during IPOs) or the guiding role played by policy (benchmark) interest rates.
- *Liquidity effects.* Of the three liquidity effects, the timing of the Chinese New year has the largest impact on average interest rates. Average repo rates are lower during the week before the New Year, and then jump significantly above average on the day before the New Year, with the New Year effect gradually declining over the subsequent week. There is also liquidity effects associated with the end of the month, with the average interest rate especially higher after the end of the month. Finally, there are significant within-week liquidity effects. In particular, the interest rate is significantly lower on Friday than on the other days of the week (see Tables 2 and 3).

Interest Rate Volatility

Volatility clustering is confirmed with significant GARCH effect. The variance is relatively persistent (with a half-life of over two weeks), and is driven by similar factors as the average interest rates. The first order ARCH effect is marginally significant, as is the asymmetric term. Consequently, “negative news” (innovations) have a smaller impact on interest rate volatility than news that increases the interest rate. Policy variables, IPOs and liquidity effects also drive volatility:

- *Administered interest rates.* Changes in benchmark interest rates affect volatility, although the impact is less than on the mean. Changes in the deposit rate tend to reduce volatility, while changes to the benchmark lending rate tend to increase volatility within the week around the change. Changes in the lending rate drive volatility as the incentive to raise funds for lending changes. The lower volatility resulting from changes to deposit rates is somewhat surprising, but may be an artifact of the structural liquidity surplus during the sample period. Nonetheless, changes in administered rates play a substantial role in moving volatility when they change.
- *Monetary policy.* Policy changes, at least those through reserve requirements, seem to have a larger impact on interest rate volatility than on the mean of the interbank rate. However, the impact of changing reserve requirements tends to anticipate the actual change in policy commencing, with a jump in volatility when the change is announced. The strength of this anticipatory effect probably reflects the daily nature of reserve requirements (see Box 1). An increase in net liquidity injections through

open market operations have seemingly little impact on volatility, as would be expected if open market operations act as a stabilizing force on interbank rates.

- *IPOs*. While IPO activity did not change the behavior of average interbank rates, they seem to affect their volatility, driving major movements when they occur. Volatility increases significantly ahead of the IPO (when funds are locked up), but there is little sign of above average volatility after that (including when surplus funds are released).
- *Liquidity effects*. As with the level, the liquidity effect of Chinese New Year is largest. Volatility is typically below average ahead of the New Year but jumps substantially the day before the holiday. Higher volatility persists through the trading week after the holiday, and then begins to fall in the second week. Volatility is typically highest on Fridays (Table 2), and significantly lower on Mondays than on other trading days (Table 3). There are also significant liquidity effects on interbank volatility though each month. Around the middle of the month, volatility is significantly higher than average. Volatility, however, declines as the end of the month approaches, and is then significantly below average during the first two weeks of the month (see Tables 2 and 3).

The resulting equitation has well behaved residuals, with no signs of volatility clustering in the standardized residuals. There are also no sign of persistence of either the standardized residuals or squared standardized residuals, suggests that there is no residual autocorrelation or ARCH effects (Table 4).

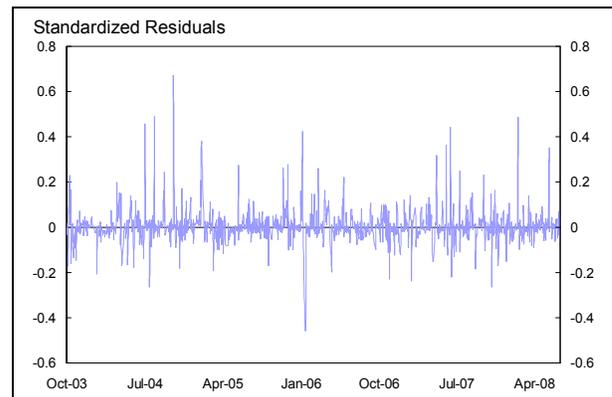
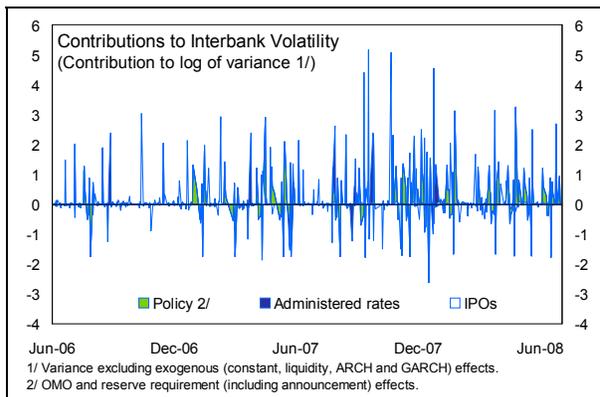
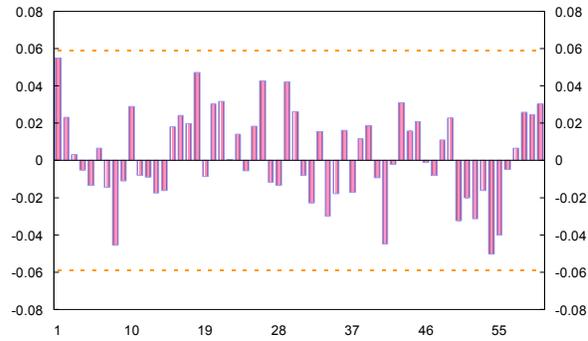
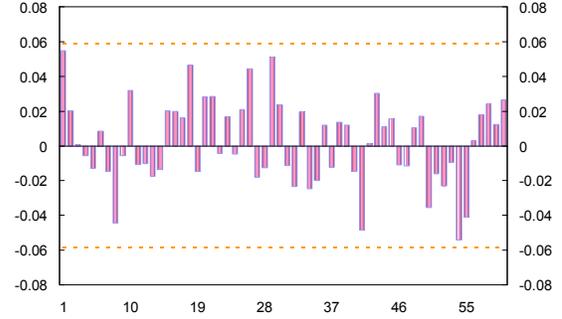
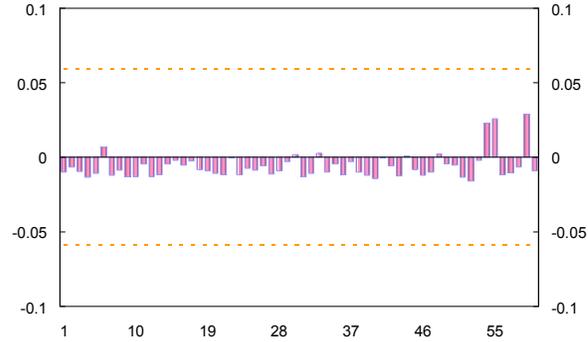
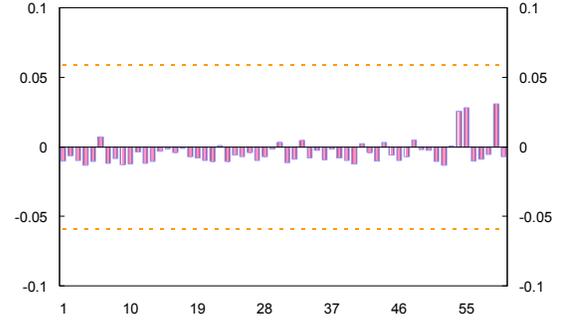


Figure 3. Properties of the Standardized Residuals

Standardized Residuals: Autocorrelation Function
(With ± 2 standard error bands)Standardized Residuals: Partial Autocorrelation Function
(With ± 2 standard error bands)Squared Standardized Residuals: Partial Autocorrelation Function
(With ± 2 standard error bands)Squared Standardized Residuals: Autocorrelation Function
(With ± 2 standard error bands)

V. CONCLUSIONS

This paper looks at the drivers of China's interbank rates, and finds that administered interest rates are key determinants of both the level and volatility of the market determined interbank rates. Despite the growing reliance on open market operations (using PBC paper), and direct instruments that should influence base interbank liquidity, the interbank rate is not particularly influenced by them. Consequently, short-term interbank lending rates are not able to act as an independent benchmark for asset pricing, or an independent indicator of macroeconomic or financial conditions. Further liberalizing interest rates, would allow the interbank rate (and other interest rates) to better provide essential price signals, better allocate capital, and strengthen the tools for macroeconomic management.

Further interest rate liberalization may increase the volatility of interest rates after liberalization, depending on the post-liberalization conduct monetary policy. If the short-term interbank rate becomes a target for monetary policy, then volatility may decline. However, even if volatility does increase, as has been the experience elsewhere (Dermirguc-Kunt and Detragiache, 2003), this higher volatility will result from market determined rates being more responsive to fundamental changes in liquidity in Chinese markets and risk characteristics rather than changes in regulated interest rates. This is part of strengthening the price signals conveyed by interest rates.

Nonetheless, further liberalization will require strengthened supervision and monetary policy formation. By creating new channels for banks to attract deposits and compete, liberalization could lead to excessive lending and place pressure on credit quality and banks' profitability. However, if liberalization is accompanied by heightened supervision and strengthened monetary policy, then further liberalization is unlikely to create unnecessary instability (Feyzioglu and others, 2009).

Table 1. Estimated GARCH Parameters

Dependent variable: R_REPO (7-day repo rate)
Included observations: 1159 after adjustments

	Coefficient	Std. Error	z-Statistic	p value
C	-0.093	0.023	-3.941	0.000
R_REPO(-1)	1.178	0.013	88.351	0.000
R_REPO(-2)	-0.126	0.021	-5.883	0.000
R_REPO(-3)	-0.034	0.021	-1.655	0.098
R_REPO(-4)	0.001	0.017	0.035	0.972
R_REPO(-5)	-0.007	0.005	-1.605	0.109
R_REPO(-6)	-0.010	0.005	-1.876	0.061
R_REPO(-7)	0.001	0.010	0.144	0.885
R_REPO(-8)	-0.007	0.006	-1.154	0.249
R_REPO(-9)	-0.007	0.005	-1.420	0.156
R_REPO(-10)	0.006	0.004	1.578	0.115
IPO	0.0004	0.001	0.750	0.453
OMO	0.0000	0.000	0.961	0.337
RR	0.0002	0.000	1.287	0.198
Benchmark Deposit Rate	-0.4342	0.0962	-4.5161	0.0000
Benchmark Deposit Rate(-1)	1.1352	0.0675	16.8215	0.0000
Benchmark Deposit Rate(-2)	-0.7270	0.0671	-10.8303	0.0000
Benchmark Loan Rate	0.7580	0.0758	9.9962	0.0000
Benchmark Loan Rate(-1)	-1.7071	0.0316	-54.0050	0.0000
Benchmark Loan Rate(-2)	0.9771	0.0849	11.5073	0.0000
Liquidity Effects (see table 2)				
Variance equation				
C_var	-0.904	0.219	-4.125	0.000
ABS(RESID(-1)/@SQRT(GARCH(-1)))	1.741	1.021	1.706	0.088
RESID(-1)/@SQRT(GARCH(-1))	0.689	0.406	1.698	0.089
ln(GARCH(-1))	0.594	0.069	8.574	0.000
ln(GARCH(-2))	0.341	0.068	5.011	0.000
IPO(+10)	0.077	0.013	5.945	0.000
IPO(+5)	0.002	0.012	0.130	0.897
IPO	-0.023	0.015	-1.546	0.122
OMO	0.001	0.001	0.875	0.382
RR	-0.012	0.002	-4.762	0.000
RR Announcement	2.532	1.057	2.396	0.017
RR Announcement(-1)	1.195	1.262	0.947	0.344
RR Announcement(-2)	0.483	1.057	0.457	0.648
RR Announcement(-3)	-1.025	0.946	-1.084	0.278
RR Announcement(-4)	-0.760	1.018	-0.746	0.455
RR Announcement(-5)	-0.737	1.398	-0.527	0.598
RR Announcement(-6)	1.744	1.067	1.634	0.102
RR Announcement(-7)	-3.523	0.995	-3.542	0.000
RR Announcement(-8)	-0.142	1.245	-0.114	0.909
RR Announcement(-9)	1.505	1.217	1.237	0.216
RR Announcement(-10)	0.690	1.040	0.663	0.507
DR_Loan	2.653	13.032	0.204	0.839
DR_Loan(-1)	10.389	19.288	0.539	0.590
DR_Loan(-2)	-0.801	24.505	-0.033	0.974
DR_Loan(-3)	-10.744	19.904	-0.540	0.589
DR_Loan(-4)	-1.112	13.919	-0.080	0.936
DR_Loan(-5)	10.561	9.895	1.067	0.286
DR_Deposit	-2.841	11.475	-0.248	0.805
DR_Deposit(-1)	-10.598	18.242	-0.581	0.561
DR_Deposit(-2)	-4.002	23.322	-0.172	0.864
DR_Deposit(-3)	9.236	18.129	0.509	0.611
DR_Deposit(-4)	3.563	12.662	0.281	0.778
DR_Deposit(-5)	-1.724	8.927	-0.193	0.847
Liquidity effects (see table 2)				
T-DIST. DOF	2.063	0.076	27.106	0.000
R-squared	0.838			
Adjusted R-squared	0.831			
S.E. of regression	0.363			
Sum squared resid	146.684			
Log likelihood	1837.444			
Akaike info criterion	-2.953			
Schwarz criterion	-2.404			
Hannan-Quinn criter.	-2.746			
Durbin-Watson stat	2.064			
F-statistic	46.042			0.000

Table 2. Estimated Liquidity Effects

Lag	Mean Equation		Variance Equation	
	Coefficient	p value	Coefficient	p value
Day of week				
Tuesday	0.001	0.519	0.2609	0.3139
Wednesday	-0.001	0.585	0.1418	0.5643
Thursday	0.001	0.673	0.1625	0.5207
Friday	-0.003	0.000	0.9222	0.0002
End of month				
10	...	...	-0.6528	0.0437
9	...	...	-0.0099	0.9772
8	...	...	-0.1572	0.6583
7	...	...	-0.3250	0.3431
6	...	...	0.9622	0.0033
5	-0.001	0.716	-0.7378	0.0356
4	0.002	0.145	-0.9813	0.0072
3	0.002	0.235	-0.3902	0.2853
2	0.002	0.200	0.1822	0.6298
1	0.007	0.001	0.5095	0.1457
0	-0.003	0.098	-0.4491	0.1583
-1	0.003	0.263	-0.2059	0.5333
-2	0.000	0.732	-1.5288	0.0000
-3	0.004	0.000	-0.3738	0.2675
-4	0.000	0.955	-0.1592	0.6187
-5	0.002	0.462	0.5190	0.1221
-6	...	...	-0.0602	0.8707
-7	...	...	-0.6938	0.0523
-8	...	...	-0.3367	0.3194
-9	...	...	0.5055	0.1358
-10	...	...	0.8031	0.0137
Chinese New Year				
10	...	...	0.0448	0.9518
9	...	...	-0.3602	0.6212
8	...	...	-4.2390	0.0001
7	...	...	1.4940	0.2885
6	...	...	0.4168	0.7485
5	0.0034	0.1734	0.2292	0.8822
4	0.0035	0.2784	-0.1541	0.8837
3	0.0037	0.0923	-1.0734	0.3566
2	0.0616	0.0002	1.3564	0.1717
1	0.0881	0.1295	2.5730	0.0797
0	0.3477	0.0862	3.7339	0.0201
-1	-0.4453	0.0000	0.2069	0.8455
-2	0.0470	0.0713	-2.3784	0.0524
-3	0.0115	0.6551	-1.7505	0.3094
-4	-0.0057	0.8651	1.7994	0.1266
-5	-0.0155	0.0000	-6.2628	0.0000
-6	...	...	-0.6345	0.5709
-7	...	...	2.3923	0.0554
-8	...	...	-0.9125	0.5085
-9	...	...	0.5584	0.7571
-10	...	...	0.1714	0.9142

Table 3. Joint Significance Tests

	Total Impact	LR Statistic	p value
Mean equation			
Repo rate (-3 to -10)	-0.057	54.742	4.96E-09
Before end of month	0.009	74.158	1.39E-14
After end of month	0.012	84.282	1.06E-16
Before Chinese New Year	-0.408	75.406	7.65E-15
After Chinese New Year	0.160	57.092	4.84E-11
Variance equation			
Change in deposit rates (all lags)	-6.367	39.834	4.91E-07
Change in loan rates (all lags)	10.945	14.726	0.022
Anticipated reserve requirement change (all lags)	1.963	49.570	7.48E-07
Before end of month	-1.531	48.438	5.16E-07
After end of month	-1.600	66.848	1.79E-10
Before Chinese New Year	-6.810	80.138	4.72E-13
After Chinese New Year	0.287	62.592	1.17E-09
Weekdays (Tuesday, Wednesday, Thursday)	0.565	31.274	7.44E-07

Table 4. Standardized Residuals: ARCH Tests

Lag	F Test (p value)	LM Test (p value)
1	0.7350	0.7347
5	0.9879	0.9878
10	0.9995	0.9995
15	1.0000	1.0000
20	1.0000	1.0000
25	1.0000	1.0000
30	1.0000	1.0000
35	1.0000	1.0000
40	1.0000	1.0000
45	1.0000	1.0000
50	1.0000	1.0000
55	1.0000	1.0000
60	1.0000	1.0000

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