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# Chinese Monetary Policy and the Dollar Peg

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Discussion Paper

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# Chinese Monetary Policy and the Dollar Peg<sup>\*</sup>

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## Abstract

This paper investigates to what extent Chinese monetary policy is constrained by the dollar peg. To this end, we use a cointegration framework to examine whether Chinese interest rates are driven by the Fed's policy. In a second step, we estimate a monetary model for China, in which we include also other monetary policy tools besides the central bank interest rate, namely reserve requirement ratios and open market operations. Our results suggest China has been relatively successful in isolating its monetary policy from the US policy and that the interest rate tool has not been effectively made use of. We therefore conclude that by employing capital controls and relying on other instruments than the interest rate China has been able to exert relatively autonomous monetary policy.

*Keywords: Chinese monetary policy; monetary independence; cointegration.*

*JEL Classification: C32, E52, F33.*

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# 1. Introduction

China's reinstatement of its dollar-peg in July 2008 in the wake of the global financial crisis has stirred a heated discussion about China's alleged currency manipulation and beggar-thy-neighbour policy. Proponents of a reform of China's currency regime have argued that the dollar peg not only has negative effects on China's trading partners, but also detrimental effects on the Chinese economy since it impedes an independent monetary policy by the People's Bank of China (PBC), China's central bank (e.g. Roberts and Tyers, 2003; Eichengreen, 2004; Prasad et al., 2005; Goldstein and Lardy, 2006, 2009).

The theoretical implications of a fixed exchange rate peg on the conduct of monetary policy are clear. The "impossible trinity" stipulates that a country is unable to maintain an open capital account, a fixed exchange rate and an independent monetary policy simultaneously. Policymakers are thus obliged to choose between two of the three goals. Since Chinese policymakers have opted for a fixed exchange rate against the dollar and a fairly closed capital account, this policy choice should theoretically provide room for an independent conduct of monetary policy. However, the validity of the impossible trinity hypothesis has been contested. On the one hand, the isolation property of floating exchange rates has been questioned and the empirical evidence has been mixed (e.g. Rose, 1996; Calvo and Reinhart, 2002; Frankel et al., 2004; Shambaugh, 2004; Obstfeld et al., 2005). On the other hand, in practice it is difficult to maintain effective capital controls over time, especially for economies that are open to trade. The empirical evidence suggests that capital controls can be circumvented and that they are not very effective in achieving a higher degree of monetary policy independence (Edwards, 1999).

Surprisingly, there has been relatively little empirical research on the impact of the Chinese dollar peg on the conduct of and constraints on Chinese monetary policy so far. Ma and McCauley (2007) examine price and flow evidence to determine the effectiveness of China's capital controls. Looking at onshore and offshore renminbi yield differentials, as well as gaps in the dollar/renminbi interest rate differentials, they find that China's capital controls remain substantially binding. Although the Chinese capital controls have not been watertight, Ma and McCauley conclude that they have allowed the Chinese authorities to retain some degree of short-term monetary autonomy, despite the fixed exchange rate.

Cheung et al. (2007) focus on the link between US and Chinese interest rates. Using multiple-equation cointegration analysis they investigate the interaction between US and Chinese money market rates. According to their findings, China does not meet the assumptions of a perfect interest rate pass through since the effect of US interest rates on Chinese rates that they find is rather weak. Like Ma and McCauley, Cheung et al conclude that China has had alternative means in place to de-link its interest rates from the US rates.

Glick and Hutchison (2009) scrutinise to what extent China's current account surpluses, foreign direct investment (FDI) inflows and occasionally large non-FDI capital inflows compromise China's monetary policy goal of limiting inflation in the presence of a fixed or tightly managed exchange rate regime. They estimate a vector error correction model that links foreign exchange reserve accumulation to developments in China's reserve money, broad money, real GDP and price level to explore the inflationary implications of different policy scenarios. Under a scenario of limited exchange rate flexibility, rapid foreign exchange reserve accumulation and limited effectiveness of sterilisation operations, their model predicts a rapid increase in inflation. They see a temporary yet

limited effect of increasing reserve requirements in dampening inflationary pressures. Glick and Hutchison conclude that as long as China continues to place a higher priority on exchange rate stability than on using monetary policy as a tool for macroeconomic management, China's scope for an autonomous monetary policy is constrained.

Prasad (2008) concurs that, when constrained by a tightly managed exchange rate, monetary policy can at best play a very limited role for China in responding to economic shocks, be they internal or external. However, he points out that although the huge accumulation of foreign exchange reserves – a consequence of Chinese foreign exchange market intervention to counter the appreciation of the yuan – added to the liquidity of the banking system and further complicated the control of credit growth, the PBC was able to sterilise the capital inflows rather well. Unlike in most other emerging market economies, where sterilisation policies usually run into limits quickly, the PBC encounters a great demand for its bills even at relatively low interest rates, a result of both high savings rates in the private and corporate sectors as well as limited diversification alternatives in the closed Chinese capital market. Still, Prasad insists that the PBC's inability to use interest rates as a primary tool of monetary policy implies that monetary growth has to be controlled by blunter and non-market-oriented instruments such as targets or ceilings for credit growth as well as “non-prudential administrative measures”.

In this paper we attempt to shed more light on China's monetary and exchange rate policy by conducting a number of empirical analyses. The difficulty of carrying out empirical analysis on China, and Chinese monetary policy in particular, is common knowledge: Data availability is limited, the quality of the data that is available is often questionable, and the economy is undergoing dramatic and rapid structural change. Also, research is complicated by the fact that the PBC uses a host of non-conventional measures in its conduct of monetary policy.<sup>1</sup> When the recent global financial crisis is taken into consideration one might be tempted to abandon all hope of learning anything from Chinese economic data. However, we believe this is not the best course of action. Economic data is only interesting and informative when it contains variation because only then can we begin to discover the constancies that remain beneath the variation and start to test whether economic theories of steady states and relationships between variables exist in the data. Naturally, structural change by definition may make any such steady-state relationships difficult to detect because they may change dramatically. However, co-breaking is known to exist where multiple data series break at the same point and hence steady-state relationships continue to exist before and after a break (Hendry and Massmann, 2007). Hence structural change need not force us to abandon all hope of finding steady-state relationships.

Our approach is empirical in nature, building from economic theory. We seek to detect steady-state relationships using the multiple-equation cointegration approach of Johansen (1995). Using this approach we are able to model macroeconomic variables without a priori assuming exogeneity of many of the variables in our model. Given the complex nature of macroeconomies, this is highly desirable, as we are able to avoid endogeneity bias. The expected steady-state relationships of economic theory can be represented by cointegrating relationships, or vectors, in this framework. The multiple-equation framework allows us to detect for many possible steady-state relationships, again corresponding to the complex nature of macroeconomies: We can test for standard textbook macroeconomic relationships, and we can learn whether different policy tools can co-exist together.

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<sup>1</sup> See Shu and Ng (2010), who use a narrative approach to examine the PBC's monetary stance.

We try to address two questions. First, following Cheung et al. (2007), we want to know how much monetary policy independence the PBC enjoys with monetary independence understood in a narrow sense as the PBC's ability to conduct its own interest rate policy without having to follow any outside influences (most notably not having to follow interest rate policy conducted elsewhere, such as the US). To investigate this, we conduct a detailed analysis of interest rates in China. In particular, we investigate international parity linkages via relationships with non-deliverable forwards and the spot exchange rate, but also internal interest rate relationships to ascertain whether via administrative interest rates the PBC is able to conduct policy that is effective (i.e. impacts interest rates).

Second, we want to know how effective the PBC's interest rate policy and the other monetary policy tools it has used (namely changes in the reserve requirement ratios and open market operations) have been in managing monetary growth and containing inflation. For this purpose, we estimate a monetary model for China which includes the PBC's policy rate, the required reserve ratio, a measure of the PBC's open market operations as well as macroeconomic indicators that policy might be expected to respond to, namely inflation, economic activity, growth in broad money and growth in foreign currency reserves. Via this analysis we can shed light on how policy tools have been used in the context of the macroeconomy, and how effective these tools have been.

Our results indicate that China has been able to largely insulate its monetary policy from international monetary movements. However, in terms of monetary instruments, the interest rate tool does not seem to exert particularly much influence on the macroeconomy. Rather, the PBC has made more extensive use of less market-based policy tools like reserve ratio requirement. Money growth targeting appears to be important alongside inflation targeting and GDP growth targeting.

The remainder of this paper is organised as follows: Section 2 will provide a brief overview of Chinese monetary and exchange rate policy. Section 3 will introduce our econometric methodology and Section 4 presents our econometrics results in two parts: in Section 4.1 we consider China's monetary policy independence before in Section 4.2 we investigate China's monetary policy in terms of policy tools and target macroeconomics variables. Section 5 concludes.

## **2. Brief Overview of China's Monetary and Exchange Rate Policy**

The PBC's objective of monetary policy is "to maintain the stability of the value of the currency and thereby promote economic growth".<sup>2</sup> According to the PBC, "[t]he monetary policy instruments applied by the PBC include reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending, open market operation and other policy instruments specified by the State Council".<sup>3</sup>

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<sup>2</sup> <http://www.pbc.gov.cn/english/huobizhengce/objective.asp>

<sup>3</sup> <http://www.pbc.gov.cn/english/huobizhengce/instruments.asp>

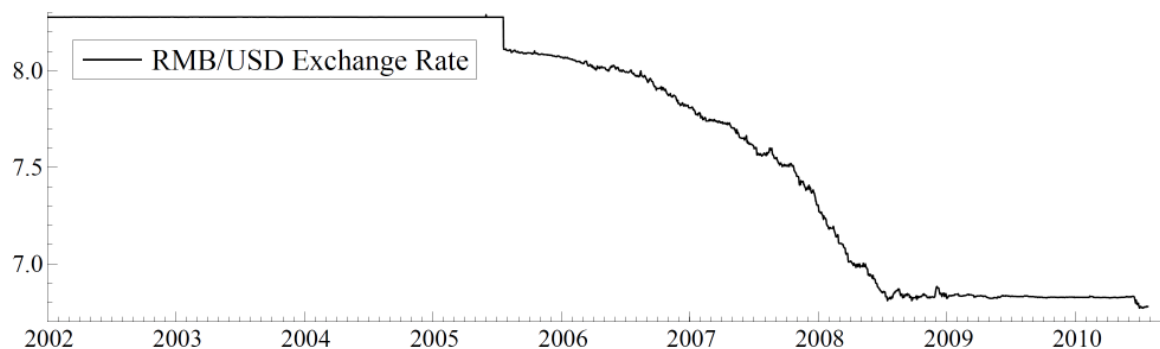


Figure 1: The exchange rate between the Chinese renminbi and the US dollar between 2002 and 2010.

In practice, as pointed out by Koivu (2009), the foundations of China's monetary policy have been a fixed exchange rate, strict controls on capital flows and a wide selection of administrative and quantitative policy tools. Figure 1 displays the exchange rate of the Chinese yuan against the US dollar. China fixed its exchange rate at 8.28 yuan to the dollar from 1994 to 21 July 2005, when it abandoned the tight dollar peg and adopted an undisclosed basket exchange rate regime under which it allowed a small and tightly controlled appreciation of the yuan against the dollar. Between July 2005 and July 2008, the yuan appreciated by 21 percent against the dollar. In July 2008, in the face of the global financial crisis, China returned to the tight peg against the dollar, now at 6.8 yuan to the dollar. In June 2010 the PBC relaxed the peg, although the permitted change in the exchange rate has been negligible thus far.

Throughout this time, China has administered tight capital controls. According to the Chinn-Ito (2008) index for financial openness, which measures a country's international financial openness on a scale from -2.54 to 2.54 (with -2.54 indicating a completely closed capital account and 2.54 full liberalisation), China's degree of capital account openness has remained unchanged at -1.13 since 1993.<sup>4</sup>

As noted above, the PBC uses various instruments to achieve its monetary objective. However, as will be shown later in our empirical analysis, not all instruments have been effectively made use of. In particular, several studies observe the absence of a major role for interest rates in the Chinese economy, as compared to advanced economies (Laurens and Maino, 2007; Mehrotra, 2007; Prasad, 2008; Geiger, 2008; Koivu et al., 2008; Koivu, 2009, e.g). Although the PBC sets several interest rates (central bank lending rate, rediscount rate and benchmark rates for different maturities of deposits and loans), in practice, the role of interest rates has been limited in pursuing the objective of monetary policy. Laurens and Maino (2007) maintain that there are several potential obstacles to the effectiveness of interest rates as an operating target for monetary policy conduct in China. First, they point out that some of the characteristics of China's financial sector may limit the effectiveness of the interest rate transmission channel for monetary policy. In particular, the effectiveness of the transmission channel is hampered due to insufficient progress in establishing a commercially driven financial sector as well as market segmentation of the banking sector and money markets.<sup>5</sup> Moreover,

<sup>4</sup> The index, which has been updated to 2008, is available on the Chinn Ito-Index website: [http://web.pdx.edu/~ito/Chinn-Ito\\_website.htm](http://web.pdx.edu/~ito/Chinn-Ito_website.htm)

<sup>5</sup> China has a two-tier commercial banking system which features commercial banks that are subject to prudential ratios and international standards of portfolio risks as well as policy lending banks which are not subject to similar regulations. The segmentation of the money market is another obstacle to greater reliance on

Laurens and Maino argue that the PBC does not yet have in place the monetary framework and instruments to conduct fully-edged market-based monetary policy.

However, as pointed out by Yi (2008), the PBC's approach to financial macro-management has gradually changed since the 1990s and the PBC has been trying to advance the reform of the interest rate system and strengthen the role of interest rates. For instance, the band of deposit and lending rates has been widened and the lending rate ceiling and deposit rate floor have been abolished. Yi maintains that with this improvement of the central bank interest rate system, the PBC is now better able to guide the market interest rate and that market participants have become more sensitive to interest rate changes. In any case, while the PBC has been generally reluctant to use the interest as a policy tool, it did increase the use of the interest rate instrument when trying to contain accelerating inflation in 2006-2007 (Koivu 2009), and slumping output in the face of the global financial crisis.

While the PBC has been making efforts to shift from direct to indirect control – for example through the abolition of credit ceilings on 1 January 1998 – the transmission mechanism continues to rely on measures affecting the quantity of loans and money supply, instead of prices such as interest rates (Nagai and Wang, 2007). The PBC sets annual intermediate and operational targets for money supply growth (M1 and M2) and base money and in recent years it has also announced a target for credit growth. The money supply is then controlled by setting the reserve requirement ratio and deciding on central bank lending.<sup>6</sup>

Koivu (2009) points out that since summer 2003, expanding capital inflows have increased liquidity in China's financial markets and have made the conduct of domestic monetary policy more complicated. A particular challenge was the growth of reserve money, a consequence of frequent intervention in the foreign exchange market in order to maintain the dollar peg. The PBC responded by raising bank reserve requirements and imposing lending restrictions in an attempt to decouple reserve money growth from broad money growth (Glick and Hutchison 2009). The PBC has also tried to control market liquidity via open market operations (OMO) by selling central bank bills to commercial banks.<sup>7</sup> According to Yi (2008), the role of OMO has been strengthened in the daily adjustment of base money and they have become a major instrument.

Last but not least, the PBC continues to use administrative policy tools to guide financial market developments. Even after the abolishment of credit plans, which formed the basis of bank lending until the end of 1997, the PBC continues to issue lending guidelines for commercial banks. The so-called window guidance policy, which involves the issuance of direct guidelines and orders to

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interest rates as policy tools. China's money market consists of three main sub-markets: the interbank market, the interbank bond market and the bond repo market. The segmentation between these markets implies that monetary policy actions of the PBC in the interbank market cannot migrate to the other components of China's money market.

<sup>6</sup> Koivu et al. (2008) use a McCallum rule based on money supply for modelling the implementation of Chinese monetary policy and come to the conclusion that such a rule is reasonably capable of modelling the PBC's focus on monetary aggregates as intermediate policy targets. Although Geiger (2008) maintains that the PBC has often missed its exact targets for monetary growth, Koivu et al. point out that monetary developments have closely followed the major trends in central bank targets and that the ultimate targets of China's monetary policy – low inflation and rapid growth – have been simultaneously achieved since the mid-1990s.

<sup>7</sup> The origin of the OMO traces back to the interbank foreign exchange transactions which were started in 1996 (Nagai and Wang 2007). The OMO had for a long time been centred on government bonds and treasury bonds. However, it became difficult to rely on those securities because the variety of government bonds was limited and the outstanding amount of treasury bills was small. In April 2003, the PBC began to issue central bank papers as a new tool for OMO.



commercial banks, was intensified due to rapid credit growth in 2003 and again in 2007 (Koivu et al. 2008).<sup>8</sup> With this brief outline of Chinese monetary policy, we now move on to econometrically examine what is driving Chinese interest rates and the role of the various monetary policy instruments in actual Chinese monetary policy making.

### 3. Empirical Methodology

The approach taken in this paper, as indicated in the Introduction, is empirical. Shaped as much as possible by economic theory and institutional knowledge regarding China, we attempt to understand more about the Chinese economy by investigating the data. We are under no illusions regarding the difficulty of this task: Lack of data, quality of available data and massive structural change inside and outside of China complicate our task. Nonetheless we see value in adopting such an approach, hopefully to augment the discussion and analysis taking place elsewhere with regard China's monetary system.

We seek a methodology that can as best as possible cope with the types of data available for China: Non-stationary time series that are dynamically connected through the macroeconomy. By using cointegration methods (Engle and Granger, 1987) we can cope with non-stationarity and other degrees of high persistence whilst still retaining economic theory coherence, and by using multiple-equation methods (Johansen, 1995) we can cope with the endogeneity inherent in the macroeconomy.

We specify a  $p \times 1$  data vector  $X_t$ , which contains  $p$  variables measured at time  $t$ . The VAR model with  $K$  lags is written as:

$$X_t = \Pi_0 + \sum_{k=1}^K \Pi_k X_{t-k} + \varepsilon_t, \varepsilon_t \sim N(0, \Sigma) \quad (1)$$

where  $\Pi_k$  are  $p \times p$  matrices of regression coefficients, and  $\varepsilon_t$  is a  $p \times 1$  vector of residuals. The data vector is assumed to contain variables that are at most integrated of order one, so have unit roots. Some variables in  $X_t$  can be stationary although for this exposition we'll assume that all variables have unit roots hence  $X_t \sim I(1)$ .<sup>9</sup> The VAR model can be reformulated into a vector error-correction form:

$$\Delta X_t = \Pi_0 + \Pi X_{t-1} + \sum_{k=1}^{K-1} \Delta X_t + \varepsilon_t, \quad (2)$$

where  $\Delta$  is the difference operator such that  $\Delta X_t = X_t - X_{t-1}$ , and  $\Pi = \sum_{k=1}^K \Pi_k - 1$ . Because we assume  $X_t \sim I(1)$  then  $\Delta X_t \sim I(0)$  and since the error term  $\varepsilon_t$  is also assumed stationary, then for (2) to balance we need  $\Delta$  to be of reduced rank. If we denote the reduced rank of  $\Pi$  by  $r$ , then there exist two  $p \times r$  matrices and such that  $\Pi = \alpha\beta'$  and so:

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<sup>8</sup> The window guidance policy is actually carried out by the PBC in conjunction with the China Banking Regulatory Commission (CBRC). See Geiger (2008).

<sup>9</sup> Simply they will be found to be cointegrating vectors.

$$\Delta X_t = \Pi_0 + \alpha \beta' X_{t-1} + \sum_{k=1}^{K-1} \Delta X_{t-k} + \varepsilon_t. \quad (3)$$

In (3)  $\beta' X_{t-1}$ , which are  $r \times 1$  are the  $r$  cointegrating vectors, or steady state relationship, implied by the reduced rank  $r$  of the economic system.

Our procedure in this paper is that recommended by Johansen (1995) and Juselius (2007), to start generally by modelling the VAR model in (1) and ensuring that the model satisfies the independent Normality assumption placed on the error term. From Rahbek and Mosconi (1999) it is known that only autocorrelation and non-Normality in the residuals (so not heteroskedasticity) affect the trace test for cointegrating rank and subsequent coefficient estimates, and hence we focus only on these two tests. Following this we conduct the trace test for cointegration rank to determine  $r$ , before imposing the rank and analysing the resulting cointegrating vectors  $\beta' X_{t-1}$  and the adjustments of each variable to the cointegrating vectors, described in the matrix.

The important thing to emphasise is that as much as possible we let the data speak freely. It may be considered somewhat foolish to even attempt to enter into the murky depths of the economic data of China; questions can be raised not just about its accuracy but also about its generation, since China is not a market economy and much appears to happen as a result of what are euphemistically referred to as “administrative measures”. It may be asserted by some that in this kind of context, only “expert judgement” can possibly provide any useful insight. We disagree with this stance. The judgemental forecasting literature has adequately revealed the subjective biases that even “expert” forecasters exhibit when altering the forecasts provided before them, and in particular noted their inability to recognise longer-term time trends in economic data in making errors. We do not reject expert advice, it must also be asserted; we are fully dependent on this in forming our econometric models. Our standpoint however is what we see as constructive; we wish to augment the existing analysis of the Chinese monetary system with some hard-edged numbers, where possible. We recognise this is not an easy task with the aforementioned administrative measures, but we nonetheless believe it to be a useful task. It can help us gain some idea of how the system fits together, about marginal effects, about the endogeneity and exogeneity of variables, and about the efficacy of policy.

Juselius (2007) is transparent and clear about the difficulties of empirical work. The assumptions we make on our error terms are often violated, which naturally raises the difficult question of what can really be learnt from empirical investigations. This difficulty is all the greater given the object of our empirical interest is China; the potential difficulties of the integrity and quality of data collection, allied with the length of time series collected, makes the task yet more difficult. As mentioned, some model misspecifications do not result in problems for subsequent analysis, but others do. Many more subtle misspecifications are often ignored in empirical papers, such as structural uncertainty. Again, given the immense speed at which China is industrialising, the likelihood of structural breaks and instability in the data is multiplied on a grand scale. Our aim in this paper is thus not to present an empirical analysis as the definitive insight on how Chinese monetary policy operates: This would be difficult in a more stable, Western-style economy, let alone China. Instead, we simply seek to shed some light on what may be taking place in China, and to some extent present a cautionary note on attempting to read too much into patterns that might be seemingly apparent from the data in that country. It is our hope that this analysis is one further step on the road towards a better understanding of Chinese monetary policy.

Our methodology allows us to uncover constancies if they exist in the data. An economy undergoing such dramatic structural change as in China may be expected to display little if any steady-state, stationary relationships. If this is so, our econometric methods will show this. We now proceed to answer our two questions regarding the independence of monetary policy and its internal nature, and in each section we will describe the data we are using, and what we expect to find. Our strategy for investigating monetary policy arrangements in China is similar to that of Johansen and Juselius (2003) who consider inflation targetting in the US; they first establish the link between the policy tool (the Federal Funds Target Rate) and the interbank interest rate (the Effective Federal Funds Rate) before analysing the effective rate's influence on macroeconomic outcomes. Here we first consider whether Chinese policy tools (administratively-set interest rates) are able to exert a dominant influence on the market-orientated interest rates before considering the impact of those monetary policy tools more generally on economic activity.

## **4. Empirical Output**

### **4.1 Policy Independence and Interest Rates in China**

#### **4.1.1 Economic Theory Background**

As with any economy, state-administered or market-based, there are plenty of interest rates that might be used to investigate monetary policy. Some naturally will be more useful and informative to be used than others, and as such we seek to understand which rates should be considered most informative. We attempt to do this by considering some of the major administratively set interest rates, and some of the most important market-determined interest rates. In a standard Western market economy, the interbank interest rate is the obvious choice to consider monetary policy because such rates reflect macroeconomic and liquidity conditions, and also naturally because monetary policymakers seek to influence these interest rates to particular ends. Porter and Xu (2009) provide a description of the interaction between administratively-set interest rates and more market-orientated rates in China, and note that the market-determined interbank and repo rates are strongly influenced by the administratively-set retail interest rates for savings and deposits.

Thus we have at least two objectives in this subsection. We wish to consider the extent to which the Chinese interbank rate is insulated from world events via its fixed exchange rate peg and capital controls, but also the extent to which it is determined internally via these administratively controlled interest rates. A standard consideration of the Chinese interbank rate and its international movements, via uncovered interest rate parity amongst other things, may provide a somewhat distorted impression of how the interest rate moves, particularly if internal movements are more important, and hence we combine the two possible analyses in order to yield a clearer picture of monetary dynamics in China. This pre-empts our analysis of monetary policy tools by yielding insight on which tools, if any, are more appropriate for use. Porter and Xu (2009) investigate their hypothesis of influence from one interest rate to another using a single-equation GARCH model and find that the interbank interest rate is influenced, as expected, by the savings and deposit interest rates. In this Section we investigate the same question using the multiple-equation methods of the cointegrated VAR model; although we do not explicitly model the ARCH likely present in the interest rate series, we are able to capture any endogeneity between the interest rate series via these methods, and we can investigate which interest rates exert the most influence via the adjustments to cointegrating vectors found.

We are at first interested in the policy dependence, or otherwise, that China exhibits in its monetary policymaking; such information helps paint the picture of Chinese monetary policymaking. A reasonably standard mechanism for establishing independence amongst market-based industrial economies is to consider interbank interest rates; relative to some other economy, say economy B, how do domestic interbank interest rates vary? If domestic rates merely follow the rates in this economy B, then domestic monetary policy cannot be described as being independent: It is following the monetary movements in economy B. The domestic economy could simply be reacting to common macroeconomic shocks, yet if the economy systematically follows economy B in responding to these shocks, it implies the argued dominance. Were the economy to display independence we would expect not to find cointegrating relationships between the economies. This approach has been taken by Edison and MacDonald (2003) and Reade and Volz (2010) for pre-EMU Europe and searches for cointegrating relationships between the interbank interest rates of Germany and each individual European nation. The uncovered interest rate parity (UIP) condition is:

$$(1 + R_{s,t}) = \frac{E_t(S_{t+s})}{S_t} (1 + R_t^*) = \frac{F_t}{S_t} (1 + R_{s,t}^*), \quad (4)$$

where  $R_{s,t}$  is the domestic interest rate on assets with maturity after  $s$  time periods,  $R_{s,t}^*$  is the overseas interest rate on the same maturity of assets,  $S_t$  is the spot exchange rate of the domestic currency in terms of the overseas currency, and  $F_t$  is the forward exchange rate, equal to the expectation at time  $t$  of the spot exchange rate at time  $t + s$ .

Taking logs of (4) and using the approximation that  $\log(1+x) \approx x$  for small  $x$ , we get:

$$R_{s,t} = f_t - s_t + R_{s,t}^*, \quad (5)$$

where lower case letters denote the logarithm of a variable. Often investigations of interest rate co-movements in the context of fixed exchange rate systems will use the assumption that the fixed exchange rate implies that  $E_t(S_{t+s}) = S_t$  and hence the exchange rate terms cancel out of (4). However, Figure 2 plots spot and forward exchange rates for China, a country that for most of its recent economic history has implemented a fixed exchange rate system.<sup>10</sup> From the plot, long before the RMB was allowed to appreciate in July 2005 there was an expectation that it would. The exchange rate was no longer credible and as such the forward and spot exchange rate terms in (4) will not cancel for our sample.

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<sup>10</sup> We should write “forward” because China does not provide such markets in the RMB, meaning that investors wishing to hedge positions are forced to “unofficial” providers of forwards, also known as non-deliverable forwards (NDFs). Our forward rates are provided by Reuters and described as forward rates, although they are almost identical to the NDFs that we have access to via Tullett Prebon from 2006 onwards.

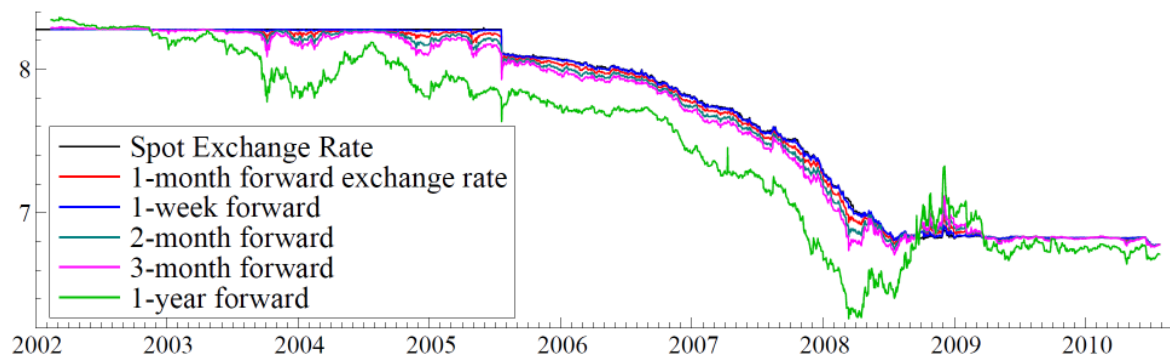


Figure 2: Spot and forward exchange rates for RMB/USD.

Given economic theory, we might expect that (5) be satisfied in the economic data, yet repeated empirical studies have shown a failure of the condition. Furthermore, apart from estimation over very short time horizons (Chaboud and Wright, 2005) or very long ones (Chinn, 2006). Nonetheless, the important question we are concerned about is whether interest rates in China are forced to follow such a relationship, or whether some deviation is possible. Considering UIP instead of a simple interest rate parity condition that excludes exchange rates gives a richer picture of policy dependence; it may be that China's interest rates don't react to the US interest rate, but that may be because of capital controls. When running a fixed exchange rate system, economic theory tells us that the interest rate must be used to defend the exchange rate peg. Including the exchange rate and expectations regarding that exchange rate, we have a richer picture of interest rate movements. When combined with other domestic interest rates, that picture is yet richer; is the interbank rate influenced by international, exchange-rate-related movements fundamentally, or internal factors such as the administratively set interest rates? By considering these two possibilities together we can get some idea of what impacts interbank rates most, and fundamentally whether China has any degree of monetary policy independence (defined as the ability to conduct one's own monetary policy unencumbered by the policies of other countries, notably the US).

Naturally, a criticism of this approach is that China does not operate a market economy and hence its interbank market is not really a market. Naturally, if this is the case then we would not expect China's interbank rates to follow anything even closely resembling UIP; hence our analysis is still relevant and appropriate for investigating China's monetary policymaking framework.<sup>11</sup> Furthermore, by modelling UIP within the context of a range of Chinese interest rates we can conduct a number of interesting analyses regarding Chinese insulation from international movements.

<sup>11</sup> Others, such as Cheung et al. (2007), have followed this methodology in previous studies investigating China.

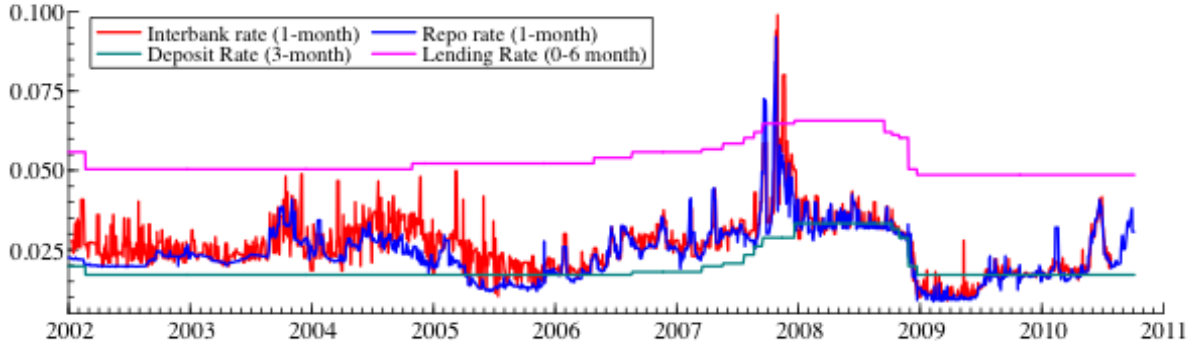


Figure 3: Market-orientated (interbank and repo) and administratively set (deposit and lending) interest rates for China. Source: PBC

We denote the interbank interest rate as  $r_{i,t}$ , the repo interest rate  $r_{r,t}$ , the lending rate  $r_{l,t}$ , the deposit rate as  $r_{d,t}$ , the US interbank interest rate as  $r_{i,t}^*$ , the spot exchange rate as  $s_t$  and the forward exchange rate as  $f_t$ , and hence our data vector is:

$$X_t = \begin{pmatrix} r_{i,t} \\ r_{r,t} \\ r_{l,t} \\ r_{d,t} \\ r_{i,t}^* \\ f_t \\ s_t \end{pmatrix}. \quad (6)$$

Based on the discussion of internal Chinese interest rates, we expect to find one cointegrating vector pertaining to this, and we expect the coefficients of that cointegrating vector to be homogenous of degree zero: So that all the rates move together. We may also expect to find a cointegrating vector relating to the UIP condition, with a coefficient of something in excess of unity using previous studies as a guide. We may also find that each Chinese interest rate enters into some kind of UIP relationship with the US, and this will be a test of the policy independence of China. On the other hand, identifying a cointegrating vector for domestic monetary movements, and one for international ones will give some idea over which set of influences are most important for interest rate determination in China.

#### 4.1.2 Data

The Chinese and US interbank interest rates are plotted at a 1-month horizon in Figure 4, and the four domestic interest rates mentioned in the previous section are plotted in Figure 3. It would appear that the co-movement between the Chinese and US interest rates is limited to the latter part of the sample, post-financial crisis. Considering the domestic interest rates, we again aim for a 1-month horizon which is simple for the interbank and repo rates, but for the administrative rates we have to take the 3-month time deposit interest rate and the 0-6 month lending rate due to availability. The

market rates generally lie inbetween the two administratively set rates. The period over which data are available for all series is 2000:5 to 2010:6, yielding 122 observations.

Turning to exchange rates (Figures 1 and 2), we immediately meet with difficulties. The change in exchange rate policy in 2005 between a fixed exchange rate and a managed floating exchange rate and the subsequent re-establishment of a fixed exchange rate in mid-2008 are very apparent in Figure 2. Modelling the entire period will not cause problems if all the variables also break at the same time (Hendry and Massmann, 2007); it's clear from Figure 2 that the forward exchange rates also break at this time, although from the plot of interbank interest rates in Figure 4 it is not clear that the interest rates also exhibit breaks at these points.

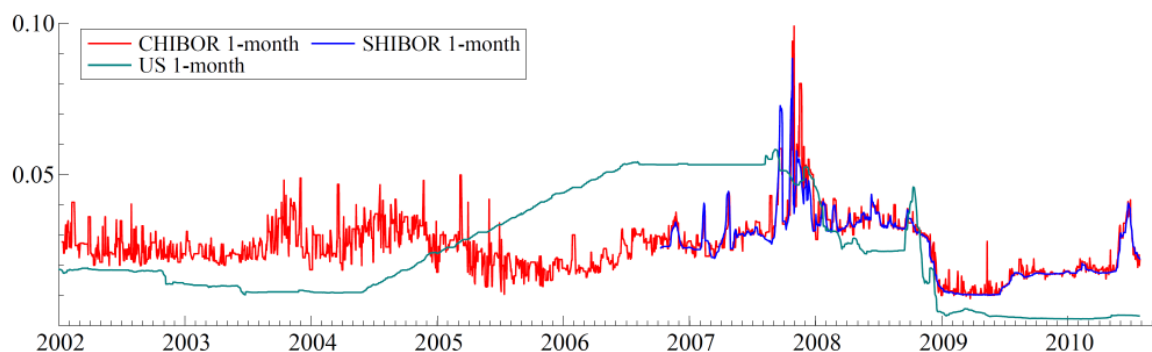


Figure 4: Interbank interest rates for the US and China. Note: CHIBOR is the China interbank rate, and SHIBOR is the Shanghai interbank rate (the latter employs market makers and hence is smoother). Source: PBC.

The next difficulty is which interbank rate to employ for China; the China interbank rate (CHIBOR) or the Shanghai interbank rate (SHIBOR); the latter only began in late 2006 but that market employs market makers and hence yields a smoother interbank series.<sup>12</sup> Both are plotted in Figure 4. However, the short time period is a constraint to conducting analysis using the series; although we have daily data and hence hundreds of observations, it still remains that the actual time period covered is short, and potentially too short in which to detect long-run relationships. We conducted unreported cointegration analysis on the CHIBOR and SHIBOR interest rates and found that the two are strongly cointegrated and hence we use the longer CHIBOR series in the models in this paper.

### 4.1.3 Econometric Output

Estimating each model individually (a UIP model and a domestic rates model) yields two models that roughly accord to prior expectations: China is somewhat isolated from world events and its interbank rate is dictated by administrative interest rates.

We'll first briefly cover the two individual models and draw out their implications, before attempting to bring the two analyses together to put each into its own context.

<sup>12</sup> Porter and Xu (2009) have a short section explaining the difference between the SHIBOR and the CHIBOR.

Considering China in the wider world, we attempt to construct a UIP model. Modelling with 10 lags, we find that a rank of two is appropriate.<sup>13</sup> The resulting system is:

$$\begin{pmatrix} \Delta r_t \\ \Delta r_t^* \\ \Delta f_t \\ \Delta s_t \end{pmatrix} = \begin{pmatrix} -0.046 & -0.087 \\ (0.009) & (0.020) \\ 0 & 0 \\ -0.004 & -0.024 \\ (0.002) & (0.006) \\ 0 & -0.023 \\ & (0.003) \end{pmatrix} \begin{pmatrix} r_t - r_t^* + 4.17 f_t - 3.89 s_t - 0.56 \\ (0.68) & (0.67) & (0.06) \\ s_t - f_t + 0.38 r_t - 0.01 \\ (0.07) & (0.002) \end{pmatrix}. \quad (7)$$

The parity relationships found are distinctly odd – which to a large extent conforms to finding in the literature at this short time horizon (e.g. Froot and Thaler, 1990). Various different attempts at identification only supported this initial observation. The first cointegrating vector (the top row in the right-hand vector) is the most similar to UIP with a (1,-1) restriction imposed on the two interest rates, and a near-(1,-1) relationship for the spot and forward exchange rates (although these coefficients cannot be restricted to be equal to each other). However, as has often been found in the most spectacular of UIP-failures, we find that the sign on the exchange rate differential ( $f_t - s_t$ ) is of the wrong sign and significantly larger than zero. The second relationship, where a (1,-1) relationship is imposed on the two exchange-rate variables, has an insignificant overseas (US) interest rate effect and hence that coefficient is restricted to be zero. Neither of these relationships makes particularly much economic sense other than as fragments of parity relationships, perhaps highlighting the Chinn (2006) story of confounding shorter-term macroeconomic policy impacts. Nonetheless, both relationships do show that the Chinese interbank interest rate is involved in international monetary movements. Without considering the adjustment coefficients however, we cannot tell whether China adjusts to these movements, or exerts some influence over them.

From the adjustment coefficients (the first right-hand-side matrix in (7) where each column refers to a row in the matrix) China doesn't appear to exhibit particularly much independence, adjusting in a corrective manner to both relationships. The half-lives of adjustment may seem long, but we are modelling daily data and these half-lives are smaller than many pre-EMU European nations as found by Reade and Volz (2010).<sup>14</sup> Considering the other variables and their adjustment, the US interbank rate is weakly exogenous and hence, as might be expected, the US interest rate drives the system; this is a sign of some degree of policy dominance that the US is able to exert. The two exchange rate variables adjust to the second cointegrating vector, but the spot rate adjusts insignificantly to the first cointegrating vector. In Figure 5 the two cointegrating vectors are plotted; they are zero in equilibrium, and hence we see that over the sample the two vectors are stationary. However, from the plot there are prolonged deviations from zero, hence long periods where the Chinese interest rate could deviate from these equilibrium relationships; in a fixed or managed exchange rate system, it is difficult to reconcile this possibility of deviation without the co-existence of capital controls. Hence we conclude that while there is some evidence for a lack of policy independence, it would appear that in practice Chinese monetary policy is insulated from global monetary movements, and US monetary policy in particular.

<sup>13</sup> We are somewhat spartan with the details on modelling these data series in order to save space. Some misspecification tests failed in our models, but appropriate additional information was incorporated to support the chosen rank, and further details are available on request.

<sup>14</sup> Modelling over the entire sample including the pegged period pre-2005 leads to even more strange results, indicative of the strong influence the exchange rate regime plays for this model.



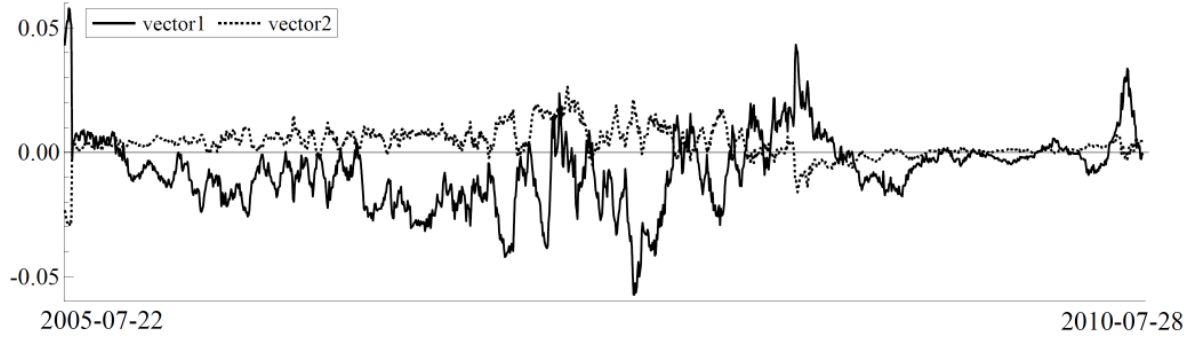


Figure 5: Cointegrating vectors for UIP model (7).

Naturally, it is also important to consider China's domestic monetary arrangements. At first we do this individually without considering the international dimension. Modelling over our entire sample (we suspect that the series under consideration co-break, if any breaking at all happens around the change in exchange rate regime; recursive analysis is unable to uncover evidence of a structural break around the time of the change), we employ ten lags and find via the rank test that a rank of one is appropriate.<sup>15</sup> The resulting system is:<sup>16</sup>

$$\begin{pmatrix} r_{i,t} \\ r_{r,t} \\ r_{l,t} \\ r_{d,t} \end{pmatrix} = \begin{pmatrix} -0.27 \\ (0.03) \\ 0 \\ 0 \\ 0 \end{pmatrix} \begin{pmatrix} r_{i,t} - 0.89 r_{r,t} - 0.99 r_{l,t} + 0.04 r_{d,t} - 0.005 \\ (0.05) \quad (0.23) \quad (0.08) \quad (0.003) \end{pmatrix}. \quad (8)$$

As in equation (7), we show the estimated  $\alpha$  and  $\beta'$  matrices in (8) on the right-hand side, and as a guide show the variables referred to on the left-hand side. The rank of the system is only one here, hence just one cointegrating vector appears, and there is only one column in  $\alpha$ . The homogeneity of degree zero restriction is rejected by the data here, and moreover we can see that the deposit rate ( $r_{d,t}$ ) is insignificant. The two other interest rate coefficients, on the repo rate and the lending rate, are near unity. This suggests that if both of these interest rates move by one percentage point, the interbank rate will need to move by almost two percentage points. However the more fundamental point is that indeed a steady state cointegration relationship exists between the administratively-set and market-orientated interest rates exists, as suggested by Porter and Xu (2009).

Using our multiple-equation approach we can also investigate adjustment to this vector via the matrix and we see that only the interbank interest rate adjusts to this vector. Hence the administrative interest rates drive the system along with the repo rate.<sup>17</sup> This largely corresponds to the descriptions provided by Porter and Xu (2009), although they propose that the repo rate also adjusts as opposed to driving the system. Most importantly perhaps, it displays the influence that the PBC has over the

<sup>15</sup> Despite the trace test being inconclusive, imposing rank one yields a next highest root of the system of 0.88 and hence we feel confident that rank one is the appropriate choice.

<sup>16</sup> The over-identifying restrictions included in this model are accepted with a Likelihood-Ratio test statistic of 2.04 and a p-value of 56.4%.

<sup>17</sup> A similar conclusion is found if we use a three-month horizon, the only difference being that in that situation the repo rate appears to also adjust to the administrative rates. These results are available on request from the authors.

monetary system in China, and hence their ability to effect monetary outcomes using the tools available to them. The size of the adjustment in this domestic model (8) is greater than in the international model (7), suggesting that the interbank interest rate is influenced more by domestic monetary movements than international ones.

In order to make a direct comparison between the two cases however it is better to try and consider the two together; Juselius (2007) promotes such a “specific-to-general” approach when using cointegrated VAR models; a key property is that any cointegrating vectors found in individual systems should be found when combining the information sets of the two individual models. Hence we attempt to model the domestic and international component of the Chinese monetary system by bringing together our two models thus far. The most important comparison that can be made in this model is between how the interbank rate responds to the international, UIP-like condition we found earlier, and how it responds to the domestic component just found.

Modelling the entire system gives us a seven-variable VAR, and we estimate again only over the post-2005 period due to including the exchange rate variables in this model. Rank testing suggests a rank of four or five (although, confusingly, the only imposed rank that doesn’t leave a near-unit next-largest root is rank one), and in order to enable us to identify the two vectors we found earlier, we impose a rank of four. The resulting system is:

$$\begin{pmatrix} r_{i,t} \\ r_{r,t} \\ r_{l,t} \\ r_{d,t} \\ r_{i,t}^* \\ f_t \\ s_t \end{pmatrix} = \begin{pmatrix} -0.36 & 0.09 & 0 & 0.005 \\ (0.05) & (0.02) & & (0.002) \\ 0.05 & 0 & -0.07 & -0.02 \\ (0.03) & & (0.01) & (0.003) \\ -0.03 & 0.04 & -0.03 & -0.005 \\ (0.03) & (0.03) & (0.02) & (0.003) \\ 0.05 & -0.04 & 0.03 & 0.002 \\ (0.03) & (0.03) & (0.02) & (0.003) \\ -0.20 & 0.19 & -0.13 & -0.02 \\ (0.03) & (0.03) & (0.02) & (0.003) \\ 0 & 0 & -0.02 & -0.004 \\ & & (0.003) & (0.001) \\ 0 & -0.01 & 0 & 0 \\ & (0.001) & & \end{pmatrix} \begin{pmatrix} r_{i,t} - 0.70 r_{r,t} + 0.18 r_{l,t} - 0.35 r_{d,t} - 0.01 \\ (0.01) & (0.04) & (0.05) & (0.002) \\ r_{i,t} - 0.24 r_{i,t}^* - 1.95 f_t + 1.99 s_t - 0.09 \\ (0.12) & (0.46) & (0.46) & (0.07) \\ r_{r,t} + 0.01 r_{i,t}^* - 6.52 f_t + 6.46 s_t + 0.09 \\ (0.33) & (1.25) & (1.25) & (0.18) \\ r_{l,t} - 2.20 r_{i,t}^* + 30.3 f_t + 29.4 s_t - 1.66 \\ (1.34) & (5.05) & (5.04) & (0.74) \end{pmatrix} \cdot (9)$$

With a rank-four system, the  $\alpha$  and  $\beta$  matrices are somewhat more complicated. As with (7), each column of  $\alpha$  contains the adjustment coefficients for all variables to the cointegrating vector in the corresponding row of the  $\beta$  matrix. So the first column of  $\beta$  contains adjustment coefficients for the cointegrating vector in the first row of  $\beta$ . The first cointegrating vector is the domestic interest rate relationship found in (8), and the second is the interbank UIP relationship, akin to what was found in (8). In the remaining two vectors we attempt to identify UIP-style relationships with the other interest rates, to investigate whether they are influenced by international movements.

The coefficient sizes in the domestic rate relationship are considerably smaller, and despite summing up to around 0.87, the restriction of homogeneity of degree zero is again rejected in the data; as can be seen, the estimate for the repo rate is very precise indeed and this likely contributes to the rejection of the homogeneity restriction. Nonetheless, the co-movement of interest rates appears a little more sensible in this vector. Considering the adjustments, we have not restricted the coefficients to zero here, but the lending and deposit interest rates have insignificant adjustment coefficients, while the repo rate coefficient is borderline significant, and the interbank interest rate adjustment (top left) is strongly significant: The interbank rate corrects 36% of any disequilibrium each period. Hence the same findings as before are upheld.

The second vector, the international monetary movements vector (UIP), yields a small coefficient of borderline significance on the US interest rate (at 0.24), and on the expected exchange rate appreciation term the coefficient is smaller and of the right sign. Most importantly, when considering the adjustments to this vector, we see that although the interbank rate does adjust, it does not do so in a correcting manner: If there is a positive disequilibrium then the interbank rate will increase and worsen the disequilibrium. That the adjustment coefficient, at 9% of the disequilibrium, is much smaller than the domestic adjustment, is irrelevant given that the adjustment is not correcting disequilibrium. The forward exchange rate is not adjusting to disequilibria here, but the US interest rate and the spot exchange rate do appear to adjust.<sup>18</sup> We devote little attention to the last two cointegrating vectors because our focus is on the interbank interest rate and its relationships domestically and internationally, but we do note in these last two vectors that again the US interbank rate comes in very insignificantly, while the coefficient on the expected exchange rate appreciation term is large and for the lending rate of the wrong sign. In all these cases, again the important factor is that the deposit and lending rates have insignificant coefficients of adjustment, and hence the administratively-set interest rates do not appear to be adjusting to either the domestic or international monetary movements, arguing in favour of China's policy independence.

As a result of these findings, we next proceed to model the Chinese monetary policy system focussing on the administratively set deposits interest rate alongside a number of other monetary policy tools.

## 4.2 Chinese Monetary Policy

### 4.2.1 Economic Theory Background

Having investigated the extent to which the PBC can conduct monetary policy insulated from external events we now move to consider monetary policy directly. We seek to determine how it is carried out by estimating policy rules, and we then investigate how effective it has been.

We can motivate the monetary policymaker with reference to some loss function:

$$L = \sum_{s=t}^{\infty} \beta_{s-t} W(\Delta p_t, \Delta y_t, \Delta e_t, \Delta m_t) \quad (10)$$

We might next specify that growth in the broad money supply, mechanistically, is a function of growth in the reserves held by the PBC and the credit expansion by banks (influenced negatively by the required reserve ratio) plus a constant amount printed by the PBC to accompany income growth. We also imagine some kind of Phillips Curve relationship exists between output growth and inflation: High growth is accompanied by high inflation and vice versa. We treat the stock market and exchange rate as exogenous in this model; the former is a random walk, the latter a fixed constant.

Hence we tentatively specify the PBC's problem as:

$$\min_{R_t, rrr_t, omo_t, res_t} L \text{ s.t. } (m-p)_t^d = \delta_0 + \delta_1(y-p)_t + \delta_2 R_t^d + \delta_3 R_t^f + \delta_4 \Delta p_t + \delta_4 \Delta e_t + \delta_4 \Delta s_t$$

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<sup>18</sup> These last two effects are clearly implausible since they suggest that the US interbank rate moves dependent on the Chinese monetary stance.

$$\begin{aligned}
\Delta m_t &= \alpha_0 + \alpha_1 \Delta res_t + \alpha_2 rrr_t, \\
\Delta p_t &= \beta_0 + \beta_1 \Delta y_t + \beta_2 R_t, \\
\Delta e_t &= \gamma_0, \\
\Delta s_t &= \varepsilon_t.
\end{aligned}$$

Solving this yields solutions for  $R_t$ ,  $rrr_t$ ,  $omo_t$  and  $res_t$  that are linear functions, provided that the loss function is quadratic (so the policymaker suffers proportionately more the further realisations of variables are from their targets). We allow the policymaker to choose the values of these tools as functions of all the macroeconomic variables mentioned thus far. Given this basic theoretical framework, we proceed to model monetary policy. Our  $X_t$  vector of variables is:

$$X_t = \begin{pmatrix} R_t \\ omo_t \\ rrr_t \\ \Delta res_t \\ \pi_t \\ \Delta y_t \\ \Delta m_t \\ \Delta e_t^e \end{pmatrix}. \quad (11)$$

The exchange rate variable is defined as RMB per US dollar, and hence an increase in  $e_t$  represents a depreciation of the RMB as more RMB are required to purchase a single US dollar. The actual variable included in the model is the expected exchange rate change,  $\Delta e_t^e$ , and this is the difference between a 1-year non-deliverable forward in the RMB and the contemporaneous exchange rate value.

We expect four cointegrating vectors to be found, representing each policy variable that is theoretically at the policymaker's discretion, namely the interest rate, the required reserve ratio, open market operations and reserve accumulation. We would also expect that each policy tool adjusts to its policy-identified cointegrating vector; in other words, once a shock has knocked the system out of equilibrium (where all vectors are at zero) we would expect that the policy tool would move in order to re-establish equilibrium. The Taylor-rule theory of monetary policy is perhaps clearest about this: the real interest rate should increase in response to a rise in inflation in order to bring inflation back down. Hence additionally we expect that the economic variable being targetted (in this instance, inflation) would respond to the cointegrating vector also; if not then this indicates that the particular choice of tool is inappropriate since the tool will not, via any changes made, have any impact on the target variable.

Of course, neither of these conditions might be found; violation of the first suggests that perhaps policy is being carried out for other reasons, reasons that cannot be represented in economic variables, such as the Window Guidance that the PBC provides. Then if the target variable does not respond, then this may indicate that the mechanisms that operate in more marketised Western economies may not function for China; i.e. an interest rate does not convey the kind of price signals it might be expected to in a more market-orientated economy and hence policy does not have the desired effect.

## 4.2.2 Data

All the data for our monetary policy model was acquired using Datastream, and the original source of our data was either the PBC or the National Bureau of Statistics in China.

Figure 6 plots the Chinese monetary policy interest rate (the rediscount rate) alongside its 1-month interbank on the left panel, and on the right panel the US target interest rate (the Federal Funds target rate) alongside both the actual Federal Funds rate and the interbank interest rate:<sup>19</sup> US market rates remain much closer to the target interest rate than is the case in China. This we suspect is related to the other tools that are used for monetary policy manipulation in China such as the required reserve ratio and open market operations to sterilise reserve accumulation.

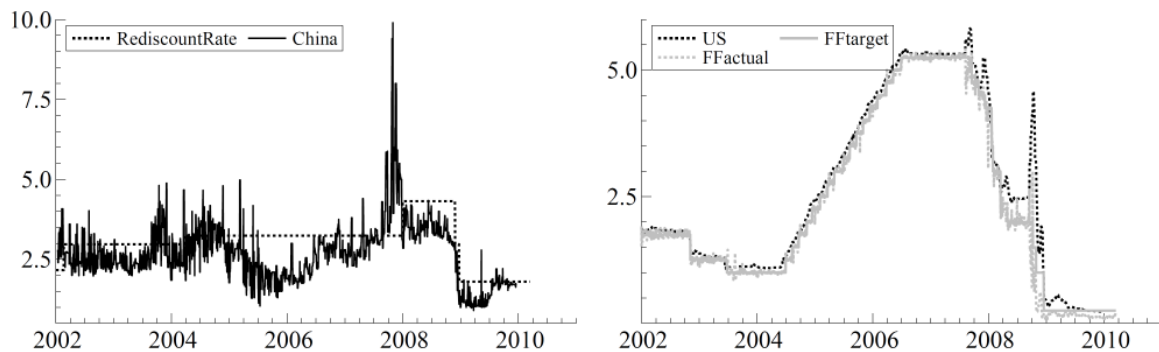


Figure 6: Monetary policy interest rates in China and the US alongside their respective interbank rates.

Figure 7 plots the variables related to our investigation of Chinese monetary policy. Due to the types of data series we wish to use, we must use data of a monthly frequency here. On the top panel the macroeconomic indicators we use are plotted: Inflation, output growth (proxied by industrial output growth) and money growth, while on the bottom panel what might be described as monetary policy tools are plotted: The rediscount interest rate, the required reserve ratio, the change in open market operations, and the change in the level of foreign reserves. As can be seen, some of the policy tools have periods with no variation. This makes these variables somewhat akin to dummy variables, which require particular attention when carrying out rank testing, but does not preclude them from our modelling exercise. We are seeking to understand the policy movements and hence policy rates such as the rediscount rate, and the required reserve ratio are more appropriate variables to include here.

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<sup>19</sup> As interest rates hit zero in 2008, the Federal Reserve Target rate became a target zone between 0 and 0.25%. We take the target, for the sake of argument, in this period as 0.25%.

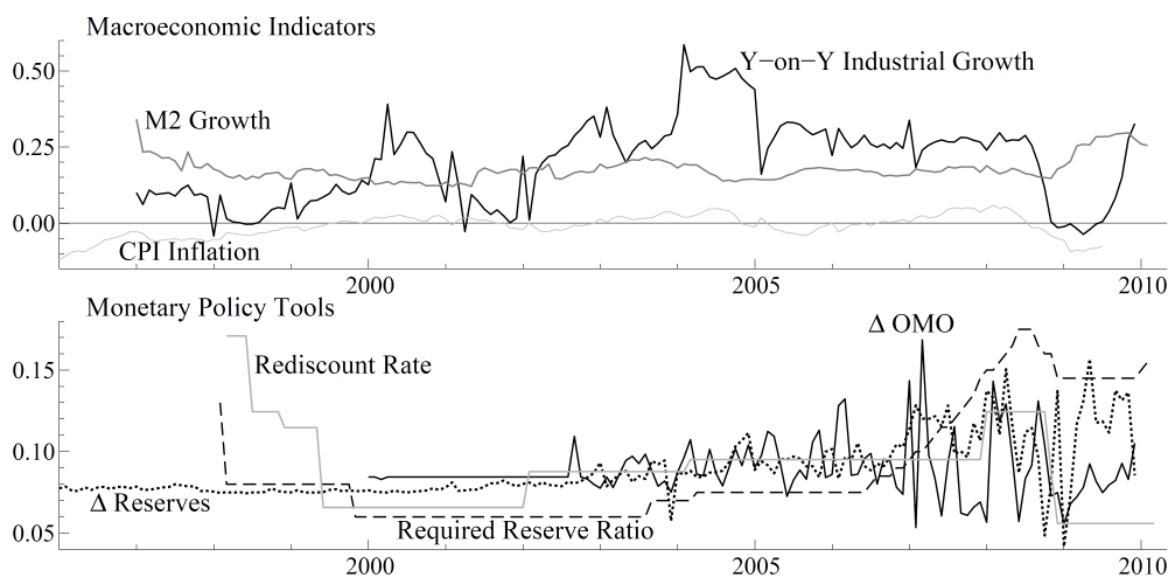


Figure 7: Data series included in the monetary policy model for China reported in Section 4.2.

### 4.2.3 Econometric Output

When we estimate the model, we include three lags to eradicate autocorrelation and yield a system in which only two of forty misspecification tests fail at the 1% significance and hence we can attribute those failures to statistic change and proceed. Although we expected a rank of four, as with the interest rate model in Section 4.1 we find that the rank test suggests something different. The trace test output is given in Table 1 and shows that rank two is the test outcome. Nonetheless, there are four eigenvalues (correlations between linear combinations of our variables and the first differences of them) above 0.25, which would appear to suggest reasonably strong correlation and hence cointegration. The decision is particularly difficult here because when a rank of four is imposed, the next largest root of the system is 0.97 suggesting that by allowing an extra stationary dimension in the system we have declined to impose a near-unit root to the unit circle (by choosing a lower rank). Nonetheless, if we impose rank of four we get the four cointegrating vectors plotted in Figure 9 and none of the vectors look particularly distinct and as such it seems reasonable to assume that if one of these is deemed stationary that all might be. Finally, as will be seen below, when we impose a rank of four not only do we get some economically coherent cointegrating vectors, we also find that there are significant adjustment coefficients for all four vectors, another sign that rank four is the right choice.

Having chosen a rank of four we need to then identify the four cointegrating vectors. As mentioned above, we seek to identify one cointegrating vector for each policy tool and hence we normalise each vector on the relevant tool, but we must also impose three other restrictions on each vector in order to identify it. For the discount rate, required reserve ratio and open market operations we exclude the other two tools from each cointegrating vector; however for open market operations and the reserve ratio we do not wish to omit reserves immediately because these tools may be used to sterilise the reserve accumulation. For these two tools we instead omit the expected exchange rate change, while for the discount rate we omit reserves, and for reserves we omit the three main monetary policymaking tools to identify.

Before presenting the model and interpreting it, we consider the stability of the model and present some recursive plots in Figure 8. From this plot, which considers the coefficients of the cointegrating vectors (yet to be identified), it seems that a reasonably stable model has been found: For essentially all the coefficients, the full-sample estimate lies within the confidence bounds of the first estimate (based on about a quarter of the full sample). Hence we can proceed to interpret the model with more confidence in the coefficient values it produces.

$r$	Eigenvalue	Log-likelihood	Trace test	p-value
0		2159.397	247.99	0.000 **
1	0.61609	2203.435	159.91	0.001 **
2	0.46632	2232.321	102.14	0.063
3	0.34725	2251.943	62.898	0.366
4	0.25778	2265.656	35.471	0.702
5	0.15212	2273.247	20.289	0.709
6	0.098566	2278.020	10.743	0.574
7	0.066027	2281.162	4.4583	0.360
8	0.047304	2283.391		

Table 1: Trace test output for monetary policy model.

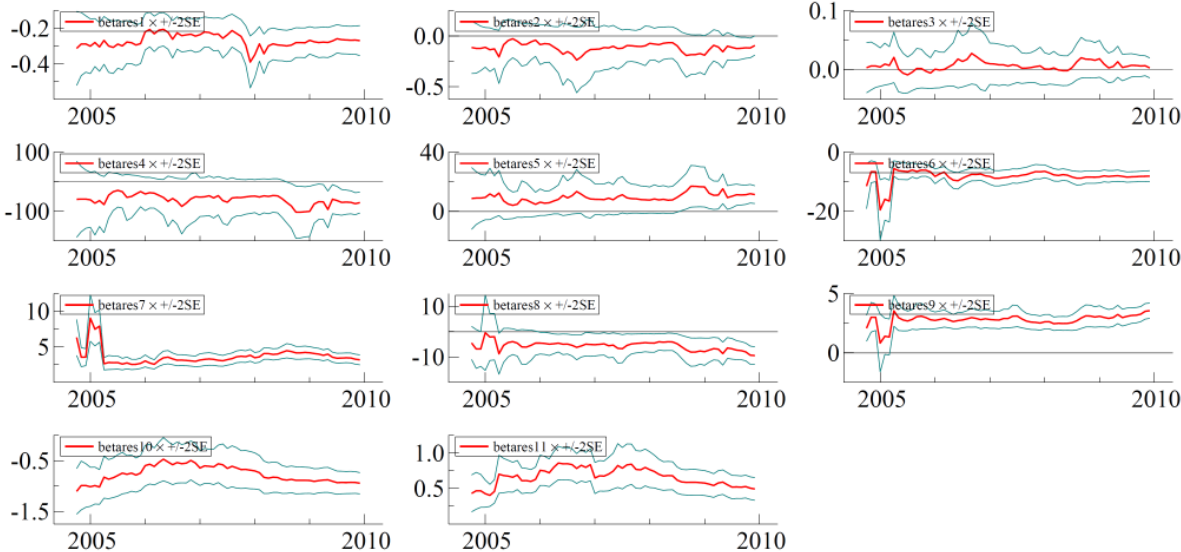


Figure 8: Recursive coefficient estimates for monetary policy model.

The resulting system yields a number of additional insignificant variables, which we omit where the Likelihood Ratio test of over-identifying restrictions allows. We also restrict adjustment coefficients to zero where they are insignificant, and the resulting system is:

$$\begin{pmatrix} \Delta R_t \\ \Delta omo_t \\ \Delta rrr_t \\ \Delta^2 res_t \\ \Delta \pi_t \\ \Delta^2 y_t \\ \Delta^2 m_t \\ \Delta^2 e_t^e \end{pmatrix} = \begin{pmatrix} -0.036 & 0.0005 & -0.003 & 0 \\ 13.95 & -0.062 & -0.279 & 0 \\ 0 & 0.014 & -0.111 & -0.515 \\ 0 & 0 & 0 & 0 \\ 0 & -0.001 & 0.008 & 0 \\ 0 & 0 & -0.064 & 1.162 \\ 0 & 0.004 & 0 & -0.203 \\ 6.054 & -0.040 & 0.221 & -0.529 \end{pmatrix} \begin{pmatrix} R_t - 0.38 \pi_t - 0.02 \Delta y_t - 0.09 \Delta m_t - 0.02 \Delta e_t^e + 0.005 \\ omo_t + 99.8 \Delta res_t - 180.3 \pi_t - 121.0 \Delta y_t - 34.96 \Delta m_t + 6.82 \\ rrr_t + 18.2 \Delta res_t - 39.9 \pi_t - 20.3 \Delta y_t - 5.07 \Delta m_t + 3.52 \\ \Delta res_t - 2.03 \pi_t - 1.49 \Delta y_t - 0.10 \Delta e_t^e + 0.07 \end{pmatrix} \quad (12)$$

Hence we have our four cointegrating vectors, one for each policy tool. As mentioned earlier, a first check regarding these policy vectors is whether or not the policy tool adjusts to the cointegrating vector. This can be ascertained from the leading diagonal of the matrix. The discount rate weakly adjusts (coefficient of -0.036 and t-statistic of about 1.6), while open market operations and the reserve requirement adjust more strongly (coefficients of -0.062 and -0.111 respectively). Reserve accumulation is weakly exogenous for the whole system, as shown by the row of zeros corresponding to the adjustment of reserves, and as such reserves do not adjust to disequilibria in the reserves cointegrating vector. This calls into question the interpretation of the final vector as a reserves vector since the value of reserves is determined outside the system of reference (presumably by the level of demand for Chinese exports). We leave discussion of this vector until later.

We consider the vectors individually in turn, beginning with the discount rate vector:

$$R_t = 0.38 \pi_t + 0.02 \Delta y_t + 0.09 \Delta m_t + 0.02 \Delta e_t^e - 0.005. \quad (13)$$

The discount rate weakly adjusts to this vector, suggesting that it is not being fully used in the standard, monetary policymaking manner. Additionally, the coefficient on inflation is less than unity, violating the Taylor principle and adding weight to the impression that the discount rate is not used for fighting inflation. The output coefficient, although of the right sign, is small and insignificant, while the money growth coefficient suggests a weak role in money aggregate targeting.

Next the vector for open market operations:

$$omo_t = -99.8 \Delta res_t + 180.3 \pi_t + 121.0 \Delta y_t + 34.96 \Delta m_t - 6.82. \quad (14)$$

Open market operations do adjust to this vector, closing 6% of any disequilibrium each month. The first coefficient on reserve accumulation is somewhat surprising as it might be expected that bonds would be issued in greater numbers the greater are reserves accumulated in order to sterilise the impact on the money supply. However, indirectly it would appear that open market operations have an impact: In response to an increase in inflation there is a large increase in OMOs, as is the case if output growth increases, and if the money supply increases so do OMOs. Hence given one imagines reserve accumulation accompanies an increase in output, some of which is exported, and that this and the increased money supply via reserves will have some inflationary impact, it would appear that overall OMOs are used to attempt this delicate balancing act of the macroeconomy.



The next vector is for the required reserve ratio:

$$rrr_t = \underset{(0.81)}{-18.2} \Delta res_t + \underset{(9.45)}{39.9} \pi_t + \underset{(3.58)}{20.3} \Delta y_t + \underset{(1.71)}{5.07} \Delta m_t - \underset{(0.85)}{3.52} \quad (15)$$

Again this tool responds to its cointegrating vector and so we can consider it as a policy tool: Each month it corrects 11% of any disequilibrium. Its coefficients are quite similar in sign and magnitude to those for the OMO vector: A seemingly wrong signed response to reserves is counteracted with appropriately signed coefficients on inflation, output and money growth, suggesting that this tool is used to conduct monetary policy.

Finally we consider reserves:

$$\Delta res_t = \underset{(0.62)}{2.03} \pi_t + \underset{(0.23)}{1.49} \Delta y_t + \underset{(0.02)}{0.10} \Delta e_t^e - \underset{(0.05)}{0.07} \quad (16)$$

Hence reserves increase alongside inflation reflecting their inflationary potential, alongside output growth reflecting their use in facilitating the exporting of goods, and positively with an expected appreciation since they are purchased to create supply of the RMB to counter any speculation that the currency will appreciate. The reserve requirement adjusts to this relationship and is the only tool to do so; reserves themselves drive the relationship. This would appear to imply that the reserve requirement is used as a tool against the inflationary consequences of reserve accumulation (as would be the case with unsterilised intervention), even if the reserve requirement vector has a seemingly wrong-signed response coefficient to reserve accumulation. The coefficient of 0.515 says that if reserves are too high for equilibrium (potentially driven by a shock to reserves), then the reserve requirement will increase to close half of this disequilibrium, hence restraining banks' ability to create extra credit. Output growth responds positively also, perhaps reflecting that reserve accumulation increases the money stock potentially raising demand for goods via cheaper credit (at home or abroad).

The cointegrating vectors themselves are plotted in Figure 9. These vectors are all zero when that relationship is in equilibrium and hence it is informative to consider how often these vectors are at zero or cross the origin. It is also informative to consider the sign of the disequilibrium. We can think of each vector conceptually as, where  $x_t$  is the value of the monetary policy tool at time  $t$ , and  $x_t^*$  is the optimal value of the tool at that point, as dictated by the values of the other variables in each policy rule:

$$x_t - x_t^* = 0 \quad (17)$$

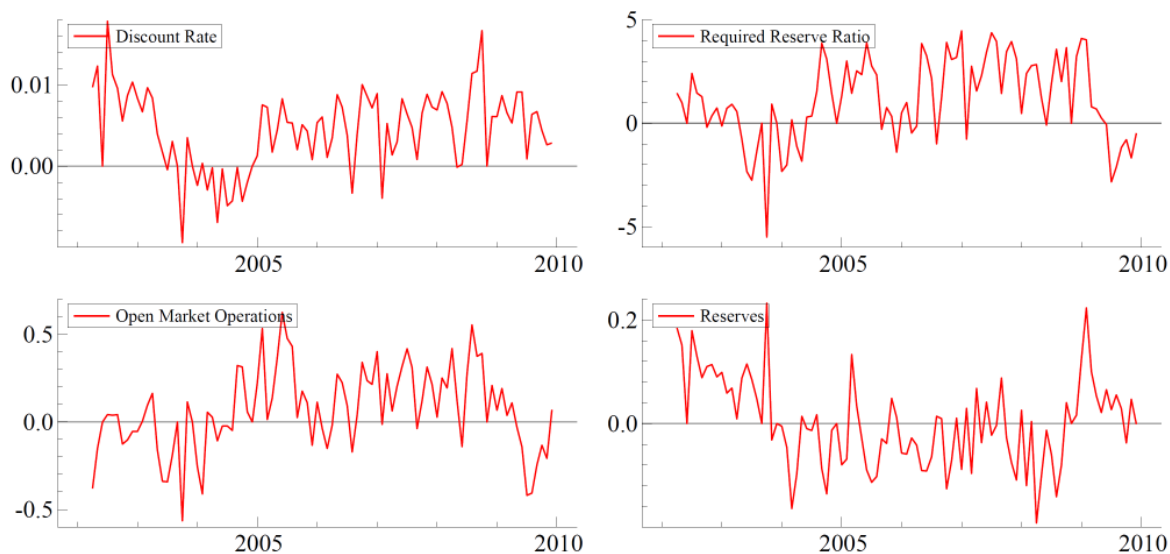


Figure 9: Cointegrating vectors for the monetary policy model.

We can think of policy being tight if the policy tool is above what its optimal value is, i.e., if  $x_t > x_t^*$  and hence when its cointegrating vector is positive. Hence from Figure 9 we learn that the discount rate (top left plot) has since 2005 generally been above what economic fundamentals would suggest it should be: policy as dictated by the discount rate is tight. It remained tight throughout the global economic crisis of 2007-09 also, notably. Interestingly from the required reserve ratio and open market operations tools, they only significantly loosened in early 2009 (presumably as a response to the global economic crisis) before tightening into 2010.

Hence to attempt to sum up the results of this section, it would appear that monetary policy has made more extensive use of OMOs and reserve requirements based on the extent to which these tools are used to respond to disequilibria. It would appear that monetary targetting is important alongside inflation targetting and any form of GDP growth targetting. In terms of impact on targetting variables, it appears that growth responds to reserve requirements, money growth to OMOs and inflation to both of these. The interest rate tool does not appear to exert particularly much influence on the macroeconomy despite the influence we noted for it in (9) on the interbank market.

## 5. Conclusions

In this paper we addressed two questions. First, we considered how much monetary policy independence the PBC has enjoyed. We understand monetary independence in a narrow sense as the PBC's ability to conduct its own interest rate policy without having to follow the Fed's lead. To this end, our analysis has investigated whether the Chinese money market rates are driven by US rates. We find evidence that China has been largely able to insulate its monetary policy from US policy.

Second, we investigated how effective the PBC's interest rate policy and the other monetary policy tools it has used have been in managing monetary growth and containing inflation. For this purpose, we estimated a monetary model for China which included the PBC's policy rate, the required reserve ratio, a measure of the PBC's open market operations as well as macroeconomic indicators

that policy might be expected to respond to, namely inflation, economic activity, growth in broad money and growth in foreign currency reserves. Our estimates suggested that the interest rate tool has not been effectively made use of. Rather, monetary policy has relied upon open market operations and the required reserve ratio for sterilising foreign exchange intervention and changes in the reserve requirement ratio to affect output growth.

We conclude that through the maintenance of capital controls and the reliance on monetary instruments other than the interest rate China has been able to exert relatively autonomous monetary policy. We nonetheless believe that the PBC's current monetary policy mix is suboptimal, since the interest rate is not effectively made use of, which arguably is a direct consequence of the constraints resulting from the exchange rate peg.

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