Modelling Monetary Transmission and Policy in China

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Abstract:

This is an empirical investigation of how monetary policy has been transmitted into the macro economy of China. It forms part of a work on building a macroeconometric model of China. Econometric modeling reveals that the Chinese monetary system follows basically the Polak model with three types of effective monetary policy instruments: interest rates, the required reserve ratio, and a direct quantity control rule of the base money supply. Model simulations show that these instruments are most effective in affecting monetary aggregates and prices but are least effective in affecting the real economy in the long run.

Key words: money demand and supply, monetary policy instruments
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I. Introduction

The study aims at determining empirically how monetary policy has been transmitted into the macro economy of China. It is built on and also forms part of a quarterly macroeconometric model of China developed by the Economics and Research Department of Asian Development Bank jointly with the Institute of World Economy and Politics of the Chinese Academy of Social Sciences. The task requires us to search for the appropriate models for the key money aggregates to capture the essential characteristics of the banking system and to identify the monetary policy instruments that have been effective and the channels through which these instruments feed into the economy.

The paper is organized as follows: Section II provides a background overview of the Chinese banking system mainly for the period since 1990. Section III describes the results of our modeling search, i.e. the econometric equations that we have obtained to describe key money aggregates. Section IV presents results of monetary policy simulations for the purpose of evaluating the effectiveness of policy interventions. The final section concludes with a summary of the results and its implications.

II. Overview of the Chinese Banking System

The Chinese banking system has undergone considerable reforms over the past two decades. The section presents an overview of the banking sector development and a brief description of the evolving monetary policy instruments used by the central bank, i.e. the People's Bank of China (PBC), in order to pave way for the modeling search section. Since our data sample starts from 1992, we shall focus our description to the 1990s.

2.1 Evolution of the Banking System

The banking sector reforms in China lagged behind real sector reforms for more than a decade. Although the PBC was established as a separate central bank as early as 1983, its commercial banking activities were delegated to the four state-owned large banks, i.e., the Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), the Bank of China (BOC), and the People's Construction Bank of China (PCBC). The role of the

PBC as the central bank, as generally perceived internationally, was not legally reinforced until 1995, when the *Central Bank Law* was enacted. The law empowers the PBC to formulate and implement monetary policies; issue and manage the domestic currency; approve the establishment of and oversee the operations of the financial institutions; hold and manage the country's foreign reserves; control the operation of the payment and clearing system; engage in international activities as the country's central bank; and perform other duties stipulated by the State Council (Isonolaw Research Centre, 2001). Albeit, the PBC enjoys less autonomy than its western counterparts as it answers directly to the State Council.

Also enacted at the time when the *Central Bank Law* was brought in, was the *Commercial Bank Law*. The latter establishes a *de facto* two-tier commercial banking system comprised of (i) commercial banks subject to prudential ratios and other international standards of portfolio risks and (ii) policy-lending banks[1], which are not subject to this law but whose operations are guided by individual charters (Mehran *et al*, 1996). Furthermore, the Law explicitly separates the activities of the commercial banking industry and the securities industry – prohibiting commercial banks to engage in trust and investment and stock trading, as well as investing in real estate, non-bank financial institutions and enterprises (Shi, 2001).

The enactment of these two major laws marked the beginning of the banking sector reforms and the financial sector modernization on a serious scale. In 1996, the interbank market was unified via a computer network system. In 1997, foreign banks were allowed to enter and conduct limited banking business. With the accession of China into the WTO in 2001, a commitment to relax this restriction was made. More commercial banks and non-bank financial institutions surfaced since these reforms. To date, there are more than 40,000 financial institutions operating in China (EIU, 2003). However, with an immature equity and bond capital market, the country's financial system primarily depends on the banking sector. Figure 1 shows the present position of the total assets of banks and non-banking financial institutions (NBFIs).

The 1997 Asian financial crisis made the Chinese government feel the urgency of speeding up the banking sector reforms. In 1998, the PBC was prohibited from direct lending to the government; the old credit plan for both working capital loans and fixed investment loans

[1] Three policy-lending banks were established: Agriculture Development Bank of China, Export-Import Bank of China, and State Development Bank of China.

were replaced by a referenced target that banks used to determine the amount they would allocate for lending. To date however, the central government still exerts some influence in the state bank's allocation of credit, as Article 41 of the Commercial Bank Law stipulates that wholly state-owned commercial banks will provide loans for projects approved by the State Council (Shirai, 2001).

2.2 Evolution of Monetary Policy Instruments

The active use of monetary policy instruments by the PBC is a quite recent phenomenon. For a long time, the money supply system passively accommodated the government's investment plan via the credit plan for a long time, *e.g.* see (Mehran *et al*, 1996). From a macro viewpoint, the PBC can make use of three types of instruments to affect money aggregates and hence the economy: interest rates, required reserves and base money supply.

Interest rates are still under the strict control of the PBC, which sets up over 20 different rates, unlike in many other countries. Adjustments to these rates occur very infrequently, as shown in Figure 2, making interest rates not yet a very effective type of policy instruments. Recently, the PBC has initiated to slowly liberalize the interest rates by allowing for a floating band of commercial lending rates, with centrally controlled ceiling rates.[2] Beginning 2004, the lending rate ceiling for commercial banks and urban credit cooperatives was 1.7 times of the benchmark rate. Rural cooperatives were allowed twice the benchmark rate. The floor remains at 0.9 times the benchmark rate.

Required reserves have been used by the PBC more often than interest rates. Initially, the requirement was differentiated by type of deposits. Later on, it was made uniform across domestic currency deposits. Commercial banks were also required to maintain excess reserve accounts at the PBC. At first, these accounts were subject to different interest rates until March 1990 when interests for both required and excess reserves were made the same at 7.92 percent. However from August 1996 to February 1998, the rates were again made different for both. Since September 21, 2003, all financial institutions taking deposits from the public are subject to a required reserve ratio of 7 percent, while cooperatives are subject to a 6 percent

[2] In its 2003 Monetary Policy Report, the PBC affirmed its commitment to pursue market-based interest rate reforms (PBC, 2003)

ratio. Recently, these ratios have been raised and differentiated required reserve ratios have been introduced as part of the PBC's effort to curb rapid credit growth.

Monitoring and adjusting base money supply is a key task of the PBC that has been increasingly carried out by market means, such as open market operations and bill issuance. However, the essential question of how much freedom the PBC has in actively manipulating the base money to make it an effective monetary policy instrument remains. To seek an answer to this question, let us examine the structure of the PBC's balance sheet. Figure 3 provides a sketch of the balance sheet focusing on the demand (liabilities) and supply (assets) sides of base money.

We can see from the liability side of Figure 3 that base money, *Mb*, is composed of currency, *M0*, and reserves, *RRS+ERS*, by the financial institutions.[3] It is commonly acknowledged that central banks have no active control over the currency as it is demand driven, mainly by broader based money aggregates, such as *M1*. As for the reserves, the required reserve part is certainly under active control, with the instrument being the required reserve ratio; the excess reserve part is affected by the required reserve imposition but should not be directly controllable by the PBC.

The base money feeds into the banking system through the assets management, or more precisely the management of foreign currency reserves and domestic credits to the financial institutions, of the PBC. As China is under the fixed foreign exchange rate regime with the RMB pegged to the US$, the PBC is quite passive over the size of its foreign currency reserves. In fact, it has been suffering from sizeable growth of its foreign reserves in recent years, from US$21,199 Mn in end-1993 to US$403,251 Mn by end-2003 (see also the upper right panel of figure 4). The PBC relaxed the requirement of centrally retaining all the foreign assets in 1998 in an attempt to sterilize the impact of its growing net foreign assets. Under the circumstances, active control of the credits to financial institutions would appear possible only via the adjustment of the required reserves from the liability side, as base money supply should equal to its demand.

Interestingly however, the PBC has been able to supply more base money than its base money demand if we analyze its balance sheet closely. Notice from the sheet the item

[3] Notice the different definitions of M0 and reserve money by the PBC and the international standard as used by the IMF.

'deposits by non-financial institutions' (mainly postal savings and institutional deposits). This item is treated as part of 'Reserve Money' but not as base money. As the non-financial institutions borrow very little from the PBC, the PBC can easily use their net deposits to finance financial institutions, since the government is now prohibited from directly borrowing from the bank (see the upper left panel of Figure 4). Indeed, the borrowed reserve by, *i.e.* claims on, the financial institutions remains larger than their actual deposits and the share of non-borrowed base money shows a gradual decrease till the late 2003, as shown in the lower panels of Figure 4. It looks that the PBC has been able to exercise quantitative control of base money supply, *MbS*, via the inequality between *Mb* and *MbS*, in addition to controlling *RRS*.

III. Modeling Monetary Transmission and Policy

Two objectives guide the modeling search. The first is to find appropriate equations that will explain major money aggregates; the second is to identify which policy instruments exhibit significant roles in channeling monetary policies into the economy.

Previous empirical studies of money aggregates in China show that there exist fairly stable money demand equations since the reforms, e.g. see (Qin 1994) and (Girardin 1996). These results suggest that the essence of the Polak model is likely to be applicable to the China case, see (Polak 1957; 1997) and also (Schaechter 2001). The Polak model is built mainly upon the liability side of the banking sector balance sheet. We follow this approach and designate the money demand equation for *M1*, the most liquid part of money aggregates, as the key link between the banking sector and the real sector. As broad money (*M2*) is the sum of *M1* and quasi-money, *M2* is explained once quasi-money is explained by household potential savings, *i.e.* household income net of consumption, see (Qin 2003). As for the assets side of the balance sheet, net foreign assets are explained by the trade balance and FDI, and domestic credits by M2 minus net foreign assets. The possible impact of the three types of monetary policy instruments, as described in the previous section, is taken into consideration when we specify and estimate individual monetary equations. In particular, the ratio *MbS*/*Mb* is used as the third type of quantitative instrument. A sketch of the above modeling plan is given in Figure 5.

In terms of econometrics, we follow the well-established general $\rightarrow$ specific dynamic modeling approach, e.g. see (Hendry 1995) and (Wallis 1995). We adopt the equilibrium-correction model (ECM) as our equation form mainly for its convenience for economic

interpretation and its flexibility on the time-series properties of individual explanatory variables.[4] Recursive least squares (RLS) method is used extensively during the model search to ensure within-sample coefficient constancy. The sample data starts from the first quarter of 1992, though many monetary series start from the first quarter of 1994. A detailed description of the variables and their data sources are contained in the Appendix.

Now, let us start from the equations explaining the money aggregates, *M1* and *M2*. As mentioned earlier, *M1* is fundamentally demand driven. Possible effect of monetary policy instruments is also taken into consideration during the model search. The search results in the following simple and data-congruent equation:

$$\begin{aligned}\Delta \ln\left(\frac{\hat{M1}}{P_Y}\right)_t &= \underset{\substack{(0.0401)\\(0.0502)}}{0.1177} + \underset{\substack{(0.0233)\\(0.1332)}}{0.335}\left(SQ_1 + SQ_2\right) + \underset{(0.0159)\ (0.1793)}{0.08698}\, SQ_3 + \underset{(0.04006)\ (0.493)}{0.9532}\,\Delta \ln\left(\frac{Y}{P_Y}\right)_t \\ &+ \underset{\substack{(0.055)\\(0.4025)}}{0.6725}\,\Delta \ln\left(\frac{Y}{M1}\right)_{t-1} + \underset{(0.0703)\ (0.2073)}{0.1644}\,\Delta_2 \ln\left(\frac{MbS}{Mb}\right)_t - \underset{(0.0363)\ (0.0602)}{0.2432}\, EC_{t-1} \qquad (1)\end{aligned}$$

$$EC_t = \ln\left(\frac{M1}{Y}\right)_t + 0.3\left(Rsh - Inf\right)_t - 0.03\ln\left(\frac{MbS}{Mb}\right)_t$$

where P_Y denotes GDP deflator, *Y* denotes nominal GDP, *Rsh* short-run interest rate, *Inf* inflation rate based on CPI, *SQ* quarterly seasonal dummy, and where *EC* stands for 'error-correction' or 'equilibrium-correction' and embeds the long-run equilibrium relation. The statistics in the first row below the estimated parameters are standard errors, and those in the second row the Hansen parameter constancy test statistics (the 5% critical value being 0.47). The Summary diagnostic test results are reported in Table 1.

M2 is estimated via quasi-money (*M2* - *M1*). The model search leads us to:

$$\begin{aligned}\Delta \ln\left[\Delta\left(\hat{M2} - M1\right)_t\right] &= -\underset{\substack{(0.112)\\(0.1445)}}{0.1429} + \underset{(0.209)\ (0.093)}{0.6485}\,\Delta \ln Sp_{t-1} + \underset{(0.095)\ (0.256)}{0.1922}\,\Delta Rd_t - \underset{(0.136)\ (0.049)}{0.4185}\, SQ_2 \\ &- \underset{\substack{(0.154)\\(0.255)}}{0.548}\ln\left(\ln\frac{\Delta\left(M2 - M1\right)}{Sp} - 0.05Rd\right)_{t-1} \qquad (2)\end{aligned}$$

[4] The weak power of unit root tests is a well-known problem for small-sample time series. An ECM has the advantage of only requiring all the variables, in the specification as they enter the regression, to be weakly stationary, which normally holds because all these variables are specified in some kind of differenced form, including the EC (error-correction) term.

where *Rd* denotes one-year time deposit rate and *Sp* aggregate household savings potential, which is derived from the aggregate income and consumption equations for the household sector of the PRC model, see also (Qin 2003). Summary diagnostic test results are reported in Table 2.

Both interest rates and the quantitative instruments, *MbS/Mb*, appear in (1) and/or (2). Since the interest rates have not been adjusted often, we regard them as exogenous variables.[5] But we have to model both *Mb* and *MbS*. Here, we are particularly interested in finding out whether the adjustments of this quantitative instrument have followed any policy rules, such as the Taylor rule (1993) of targeting interest rate to smoothen the inflation gap and the GDP gap.

Let us first examine *Mb* by its components: *Mb=M0+RRS+ERS*. An obvious monetary instrument is the imposed required reserve ratio, *rRR*. Since *rRR* has not been adjusted very often (see the left panel of Figure 6), we have to leave it as exogenous just as the interest rates. Excess reserves should result from the decisions of commercial banks, whereas currency issue should be largely demand driven in accordance with the Polak model. Hence:

$$
\begin{aligned}
& M0 = f(M1) \\
(3) \qquad & RRS = (M2 - M0) \cdot rRR \\
& ERS = (M2 - M0) \cdot f\left(rL, \frac{M1}{Mb}\right)
\end{aligned}
$$

where *Rb* denotes central bank base interest rate and *Rl* the loan rate. Both rates are assumed exogenous. Only *M0* and *ERS* need econometric work, but neither is a policy instrument.

For *M0*, we follow the literature (*e.g.* see Brunner and Meltzer 1990; Papademos and Modigliani 1990) and let it be dependent on *M1* with a fixed cash ratio plus a gradual downward trend in the ratio to capture the impact of technical progress, such as electronic transactions, which reduces the demand for cash in the long run:

$$
(4) \qquad M0 = (a_0 + a_1 \ln T) M1 \qquad a_1 < 0
$$

where *T* denotes a linear time trend dummy. Since (4) is a nonlinear equation, we obtain the dynamically specified equation of it by two steps. The first step is to use nonlinear least squares method to estimate (4). The second step is to take the fitted result as the EC term in the dynamic specification search. The resulting equation of the search is:

[5] In the China model, deposit and loan rates are linked to the base rate to facilitate forecasting.

$$\Delta \ln \hat{M}0_t = \underset{(0.0828)}{0.9593}\,\Delta \ln M1_t - \underset{(0.008)}{0.0666}\,SQ_2 - \underset{(0.0718)}{0.284}\,EC_{t-1}$$
$$\underset{(0.116)}{\qquad}\qquad\qquad\underset{(0.17)}{\qquad}\qquad\underset{(0.061)}{\qquad}$$

(5)

$$EC_t = \ln M0_t - \ln\left[\left(\underset{(0.022)}{0.58} - \underset{(0.006)}{0.08}\ln T\right)M1\right]_t$$

The diagnostic test results are given in Table 2.

As for *ERS*, we use the ratio $\frac{ERS}{M2-M0}$ as the dependent variable in view of fact that this ratio is what many Chinese economists have monitored. By definition, this variable should be stationary through time. Dynamic specification and model reduction results in a simple partial-adjustment equation with respect to the narrow money multiplier, *M1/Mb*, and one-year lending rate premium, *Rl*:

$$\left(\frac{\hat{ERS}}{M2-M0}\right)_t = \underset{(0.0378)}{0.2175} - \underset{(0.0028)}{0.02187}\left(SQ_1 + SQ_2 + SQ_3\right) + \underset{(0.1262)}{0.2248}\left(\frac{ERS}{M2-M0}\right)_{t-1}$$
$$\underset{(0.051)}{\qquad}\qquad\underset{(0.064)}{\qquad}\qquad\underset{(0.091)}{\qquad}$$

(6)

$$- \underset{(0.0014)}{0.006}\,rRR_t + \underset{(0.0027)}{0.0066}\,\Delta Rb_t - \underset{(0.0126)}{0.05046}\left(\frac{M1}{Mb}\right)_{t-1} - \underset{(0.0035)}{0.01015}\left(Rl - Rb\right)_{t-1}$$
$$\underset{(0.0427)}{\qquad}\qquad\underset{(0.0203)}{\qquad}\qquad\underset{(0.073)}{\qquad}\qquad\underset{(0.062)}{\qquad}$$

Diagnostic test results are in Table 3.

Let us now turn to the modeling of the quantitative instrument *MbS*/*Mb*. This is our focal equation where possible policy rules are to be identified.[6] From the right panel of Figure 6, we observe signs of 'reversed liquidity effect', *i.e.* changes of short-run interest rates lead to opposite changes in the base money supply. This suggests that the PBC has been actively using quantity intervention as a substitute for interest rate intervention. We modify this instrument to *rMb* = (*MbS/Mb-1*) and refer to it as the excessive base money supply variable. Simple Taylor rule (1993) means:

$$rMb^*_{t+1} = r\overline{Mb} + b\left(Z_t - Z^*\right) = a + bZ_t \qquad a = \left(r\overline{Mb} - bZ^*\right); b < 0 \tag{7}$$

where rMb^*_{t+1} and $r\overline{Mb}$ denote the future targeted value and the mean value of *rMb* respectively, Z_t a set of targeting variables such as inflation and GDP gap, and Z^* the targeted values of Z_t. Notice that an estimate of Z^* can be derived from the estimates of a and b.

[6] For more detailed discussion on the actual central bank practice of targeting rules, see Svensson (2003).

Two points are worthy of further consideration. One is that actual policy decision involves adjustment cost. That should be identifiable from dynamic specification of (7). The other is that the PBC may choose to use other instruments, such as interest rates and reserve ratio, rather than this quantitative instrument at times, as it is likely that PBC will move towards more indirect control methods in the future. We thus add a policy dummy variable, $0 \le q_t \le 1$, to compound the targeted $q_t \cdot rMb_t^*$, in order to allow for such choices. This variable is especially useful for policy simulation.[7] Obviously, the quantitative instrument is fully used when q_t=1, and is abandoned when q_t=0.

The addition of q_t complicates the estimation procedure. To simplify the matter, we adopt a two-step procedure. In the first step, we follow the dynamic specification modeling process for (7) while assuming q_t=1. Once we have obtained the dynamic model of (7), we try to obtain q_t estimates from the fitted values by the natural cubic spline smoothing method.

Both GDP gap[8] and inflation are tried as the targets during the first step. The former drops out as insignificant, leaving us with the following partial-adjustment model:

$$\hat{rMb}_t = \underset{(0.162)}{0.0625} + \underset{(0.154)}{0.5573} rMb_{t-1} - \underset{(0.144)}{0.2242} Inf_{t-3} \qquad (8)$$

(0.0189) (0.144) (0.076)

This equation shows an interesting delegation of targets between the monetary and fiscal policies, as smoothing GDP growth and reducing unemployment are found to be the key targets in the government budgetary investment equation of the China model, see (He and Qin 2004). We have also considered the possibility that monetary policy may react to the targets in an asymmetric manner, by adding quadratic terms of the targets into the equation, see (Surico 2003), (Mohanty and Klau 2004). However, none of the quadratic targets are significant.

It is well-known that a partial-adjustment model can result from minimizing a one-period quadratic cost function:

$$C = (rMb_t - rMb_t^*)^2 + d\left(rMb_t - rMb_{t-1}\right)^2, \quad d > 0$$
$$\Rightarrow \quad \Delta rMb_t = -\frac{1}{1+d}\left(rMb - rMb^*\right)_{t-1} \qquad (9)$$

[7] The alternative is to adjust the error term of the equation without adding this dummy variable.
[8] In the China model, the GDP gap is defined as the ratio of GDP to the long-run GDP trend estimated from an aggregate production function.

where d is the adjustment cost parameter. The long-run target represented in the bracket turns out to be inflation of half a year ago, *i.e.* $Z_t = Inf_{t-1}$ in (7). Transforming (8) in accordance with (9), we get:

$$\Delta \hat{rMb}_t = (0.5573-1)\left(rMb - \frac{0.0625}{1-0.5573} + \frac{0.2242}{1-0.5573} Inf_{-2} \right)_{t-1}$$

The above equation implies $\hat{d} = 1.26$ in (9), $\hat{a} = 0.14$ and $\hat{b} = -0.5$ in (7). The latter two estimates allow us to derive, according to (7), the target inflation rate to be around 1% on the basis of the mean of *rMb* which is around 0.135 during 1998-2002.[9]

In the next step, we assume the sample values of q_t to be:

$$(10) \qquad \hat{q}_t = \begin{cases} S\left(\frac{rMb_t}{\hat{rMb}_t}, 30\right), & \forall S\left(\frac{rMb_t}{\hat{rMb}_t}, 30\right) < 1 \\ 1, & \forall S\left(\frac{rMb_t}{\hat{rMb}_t}, 30\right) \geq 1 \end{cases}$$

where the function $S(x_t, j)$ is the natural cubic spline smoothing function for x_t with a bandwidth parameter of j=30. Hence the final estimated equation of *rMb* is:

$$(8') \qquad \Delta \hat{rMb}_t = -0.4427 q_t \left(rMb_{t-1} - 0.14 + 0.5 Inf_{t-3} \right)$$

IV. Policy Simulation and Economic Implications

To investigate the effect of monetary policies, we incorporate the equations described in the previous section into the China model and run a number of model simulations. The simulations are designed to reflect the recent trend of tightening monetary policy in China. The simulation period is 2005Q1 to 2010Q4. Three scenarios are run to examine the effect of the three instruments respectively, i.e. *Rb*, *rRR* and q_t. Before running the scenarios, we obtain the simulation base by making the last sample values of the three variables constant through the simulation period. The results of the simulations are presented by the differences between the various scenarios and the base in terms of the year-on-year growth rates of the economic indicators of interest, except for those that are already in rates, such as interest rates.

[9] The target seems very low but the economy was in deflation during this period.

The first simulation examined the effects of interest rate adjustment. Specifically, we let the central bank base rate to increase by 10% in one step from 2005Q1. Figure 7 plots the impact of this one-step base rate shock to a number of major macro variables, such as M1, real GDP (GDP_C), employment, private consumption, gross capital formation, consumer price index (CPI) and investment price index. From the upper left panel of the figure, we can see that the impact is concentrated on the M1 growth, dampening it by over 0.1% within three years with a very gradual recovery. This is mainly brought about by a more rapid and stronger adjustment in base money, *Mb*, as shown in the lower left panel. The price effects of the shock are oscillating but extremely small, as shown in the upper right panel. Since broad money, *M2*, and savings are relatively less affected by the rise of the base rate, growth in fixed investments is inactive temporarily and then oscillates in the opposite direction to the price movement (see lower right panel). The corresponding impact on the growth rate of private consumption is further lagged and milder. Indeed, it is discernible that the impact of a base rate shock to the real sector is really small, e.g. virtually zero for employment growth and below 0.01% for the real GDP growth rates as shown from the upper panels. These results are generally consistent with the hypothesis of long-term money neutrality, i.e. any unexpected permanent changes in the level of base money supply do not significantly affect real output and employment in the long run, e.g. see Lucas (1996), Bullard (1999). Notice, however, that our current simulation does not form a direct test of the neutrality hypothesis, as the base rate shock is not totally unexpected although it actually affects a long-term reduction in *Mb*.[10]

In the second scenario, we assume a step adjustment of the required reserve ratio from the 7.5% in the base to 8% from 2005Q1. The simulation results are plotted in Figure 8. We see from the upper left panel that this step shock generates a small rise in the *GDP* growth rate, which peaks at about 0.08% in 2-3 years and then gradually dissipates towards the end of the simulation period. Meanwhile, the impact of this shock on employment growth rates remains virtually negligent albeit a small positive increase of 0.01% since 2008, as shown in the upper right panel. As expected, the largest impact of this policy shock is on the sum of the required

[10] There is a relatively rich literature attempting to test empirically the theory of money long-run neutrality, e.g. see (Bernanke and Mihov 1998) and (Bullard 1999). Methodologically, the key difficulty in these tests is to separate out the *purely unexpected* policy shocks and their impact. In our view, it is practically impossible to use any statistical means to filter out part of policy shocks and interpret that as economically unexpected policy adjustment. We choose to make our present simulation scenario closely related to the current economic situation in China.

reserves and the excess reserves, and hence base money (see the lower left panel). The quick adjustment of base money leads to a cyclical movement in the M1 growth rate within ±0.05%, as shown in the upper left panel. The price effect of this policy shock is deflationary, with the investment price leading about 2-3 quarters ahead of CPI (see the upper right panel). Another interesting feature of this scenario is the interest rate effect, as shown in the lower right panel. This result exhibits a significant liquidity effect, i.e. an increase in the reserves and hence in base money gradually builds up a downward pressure for the short-run interest rate of about –0.006%.

The third scenario is on controlling the use of the quantitative instrument *rMbS*. Here, we propose a gradual reduction in the PBC's use of this direct quantitative money supply instrument by assuming that $q_t = 0.98q_{t-1}$ beginning 2005Q1. The resulting impact of this policy adjustment is illustrated in Figure 9. The effects of this policy adjustment on GDP and employment growth are very small but positive. The largest impact is on *M1*, contracting its growth rate by almost 2.5% at its peak and leveling off to around 0.5% (see the upper left panel). This slowdown in *M1* growth is also noticeably reflected in that of the *M2*, unlike what has happened in the first scenario. The price effect of this policy adjustment is also deflationary, but with a slower pace and a smaller scale in comparison to what happens in the second scenario. On the other hand, the downward pressure that this policy adjustment builds upon the short-run interest rate is faster and stronger than the previous scenario. It exceeds 0.015% in 2006 and settles at about 0.01% at the end of the simulation period (see the lower right panel). Reduction in the interest rates and the deflation apparently stimulate the fixed investment growth to about 0.1%. The overall results of this scenario suggest that there is little negative impact on the macro economy if the PBC chooses to gradually phase out of this quantitative monetary policy instrument.

The three scenarios are all designed on the same basis of a tightening monetary policy. However, the simulations show that somewhat different results can be achieved by using different instruments even though the policy aim is the same. Comparison of the different results can provide policy makers with very useful information as to what is the appropriate instrument to use. Let us concentrate our comparison on three major macro indicators: real GDP growth, *M1* growth and inflation. The GDP effect is virtually neutral in the long run when the interest rate is used as the tightening instrument. But it is positive with the other two

types of instruments, with the positive effect by the phasing out of the quantitative instrument most stable and lasting (0.03% from 2008 onwards). The use of the required reserve ratio generates a more or less neutral impact on *M1*, whereas the other two instruments bring about a definite reduction in the *M1* growth, with the phasing out of the quantitative instrument being the more powerful one of the two. As for inflation, the impact of interest rate seems largely neutral in the long run whereas the deflationary impact of the required reserve ratio is the largest. Therefore, interest rate control would be preferable if the government wants to tighten money supply regardless of long-term economic growth and inflation. On the other hand, the use of the required reserve ratio appears to be the most appealing if the government is facing inflationary pressure and downturn in the economic growth.

V. Conclusions

Several features stand out from the estimated equations of the banking sector. First, the monetary system confirms basically the Polak model, *i.e.* money aggregates are fundamentally demand driven by the real economy. Second, monetary policies and base money supply have been cautious and accommodating to the demand of the economy, as shown from the relative constancy of the estimated equations, in spite of various banking reforms during the 1990s. Third, an interesting Chinese characteristic of the system is the inequality between base money and base money supply. This inequality is closely related to the relationship between the central bank and the financial sector, but reflects essentially the heavy involvement of the PBC in quasi fiscal activities, since the financial sector is virtually state owned and has been acting as the financier of the government fiscal policies, especially at the regional level.

Three types of policy instruments are identified in the modeling experiment: the required reserves ratio, interest rates, and a quantity instrument controlling direct base money supply. Simulations of each instrument independently, under the general principle of tightening monetary policy, reveal that the effects can vary with the choice of the instrument. Nevertheless, the overall impact of these instruments on the real sector of the macro economy is small and insubstantial. This suggests that monetary instruments alone are not really effective policy tools for controlling the real sector indicators, especially in the long run, such as fixed investment and employment.

Appendix: Data Sources and Variable Definitions

Variable	Definition	Unit	Data Source
M0	Currency in issue	100 million RMB	Balance sheet of the monetary authority, PBC
Mb	Base money = *M0* + deposits by financial institutions	100 million RMB	Balance sheet of the monetary authority, PBC
MbS	Base money supply = net foreign assets + net government claims + borrowed reserve by financial institutions	100 million RMB	Balance sheet of the monetary authority, PBC
rRR	Required reserve ratio	%	PBC
ERS	Excess reserve = *Mb - M0 - rRR(M2-M0)*	100 million RMB	Derived
M1	Narrow money aggregate	100 million RMB	Banking Survey, PBC
M2	Broad money aggregate	100 million RMB	Banking Survey, PBC
Y	GDP	100 million RMB	China Monthly Economic Indicators
Py	GDP deflator in 1992 base year	1992 = 1	China Monthly Economic Indicators
Inf	Year-to-year inflation rate in terms of CPI	%	China Monthly Economic Indicators
Rb	Interest rate on demand deposits	%	PBC
Rsh	Interest rate on demand deposits	%	PBC
Rd	Interest rate on 1-year savings deposits	%	PBC
Rl	Interest rate on 1-year loans	%	PBC
Sp	Household saving potential	100 million RMB	Derived from the household income and consumption equations of the PRC model

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References

Bernanke, B. S. and Mihov, I. (1998) The liquidity effect and long-run neutrality. *National Bureau of Economic Research Working Paper*, 6608.

Brunner, K. and Meltzer, A. H. (1990) Money supply. in B. M. Friedman and F. H. Hahn eds. *Handbook of Monetary Economics* vol. 1, Amsterdam: North Holland.

Bullard, J. (1999) Testing long-run monetary neutrality propositions: lessons from the recent research, *The Review of Federal Reserve Bank of St Louis* **81**: 57-77.

Economic Intelligence Unit (2003) Country Finance: China. Available at http://db.eiu.com.

Girardin, E. (1996) In search for a stable demand for money function for China. *Economics of Planning* **29**: 169-84.

He, X-H. and Qin, D. (2004) Aggregate Investment in People's Republic of China: Some Empirical Evidence. *Asian Development Review* **21**: 99-117.

Hendry, D. F. (1995) *Dynamic econometrics*, Oxford: Oxford University Press.

Isonolaw Research Centre (2001) Banking System and the Central Bank Law. Available at http://www.isonolaw.com/jsp/banking/banksys

Lucas, R. E. (1996) Nobel lecture: Monetary neutrality. *Journal of Political Economy* **104**: 661-82.

Mehran, H., Quintyn, M., Nordman, T. and Laurens, B. (1996) Monetary Exchange System Reforms in China: An Experiment in Gradualism. *IMF Occasional Paper* no. 141.

Mohanty, M. S. and Klau, M. (2004) Monetary policy rules in emerging market economies: Issues and evidence. *BIS Working Papers*: 149.

Papademos, L. and Modigliani, F. (1990) The supply of money and the control of nominal income. in B. M. Friedman and F. H. Hahn eds. *Handbook of Monetary Economics* vol. 1, Amsterdam: North Holland.

Polak, J. J. (1957) Monetary analysis of income formation and payments problems. *IMF Staff Papers* **6**: 1-50.

Polak, J. J. (1997) The IMF Monetary model at forty. *IMF Working Paper*: 97/49.

People's Bank of China (2003) 2003 Monetary Policy Report. Available at http://www.pbc.gov.cn

Qin, D. (1994) Money demand in China: The effect of economic reform. *Journal of Asian Economics* **5**: 253-71.

Qin, D. (2003) Determinants of household savings in China and their role in quasi-money supply. *The Economics of Transition* **11**: 513-37.

Schaechter, A. (2001) Implementation of monetary policy and the central bank's balance sheet. *IMF Working Paper*: 01/149.

Shi, J-H. (2001) Financial Innovations in China, 1990-2000. *China Center for Economic Research Working Paper* no. E20001006.

Shirai, S. (2001) Banking Sector Reforms in the People's Republic of China: Progress and Constraints. Available at: http://www.unescap.org/drpad/publication/fin_2206/part3.pdf.

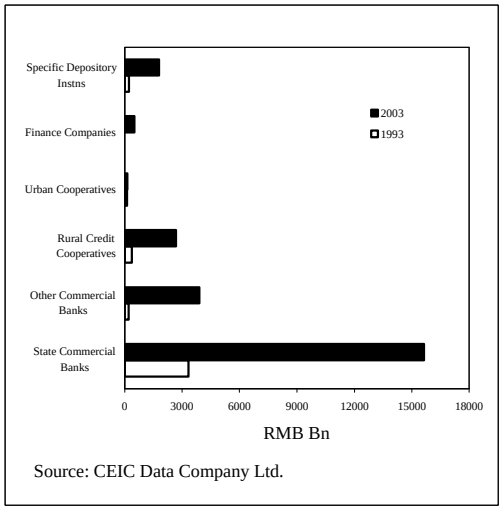
Svensson, L. E. O. (2003) What is wrong with Taylor rules? Using judgment in monetary policy through targeting rules. *Journal of Economic Literature* **41**: 426-77.

Surico, P. (2003) How does the ECB target inflation? *ECB Working Paper*: 229.

Taylor, John B. (1993) Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy* **39**: 195-214

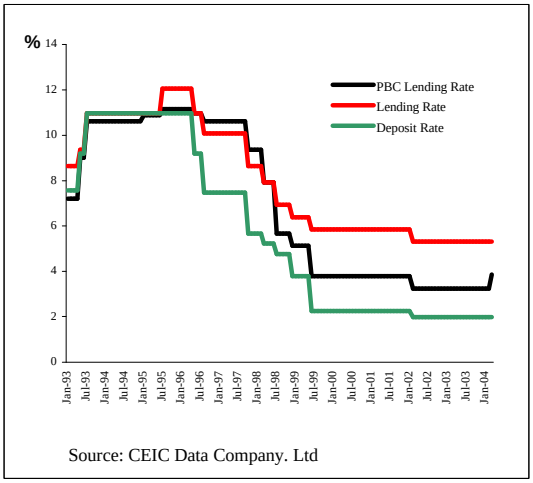
Wallis, K. F. (1995) Large-scale macroeconometric modeling. in M. H. Pesaran and M. R. Wickens eds. *Handbook of Applied Econometrics* Oxford: Blackwell, pp 312-55.

Figure 1. Total Assets of Banks and NBFIs



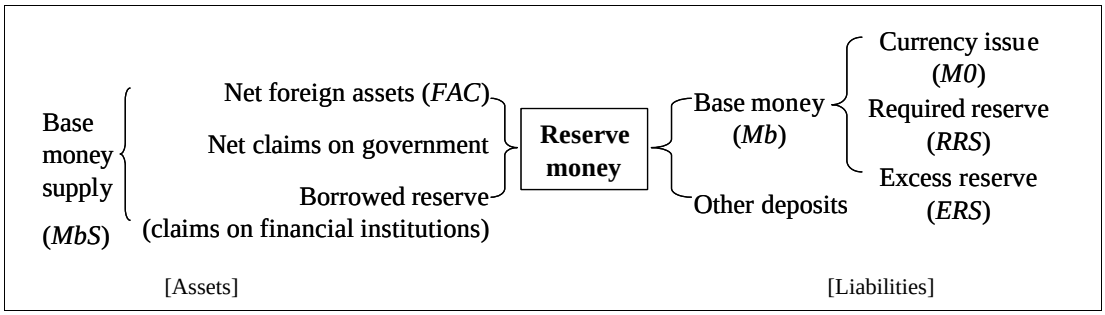
Source: CEIC Data Company Ltd.

Figure 2. Movements of Interest Rates,
Jan 1993-Mar 2004 *(Based on 1-year rates)*



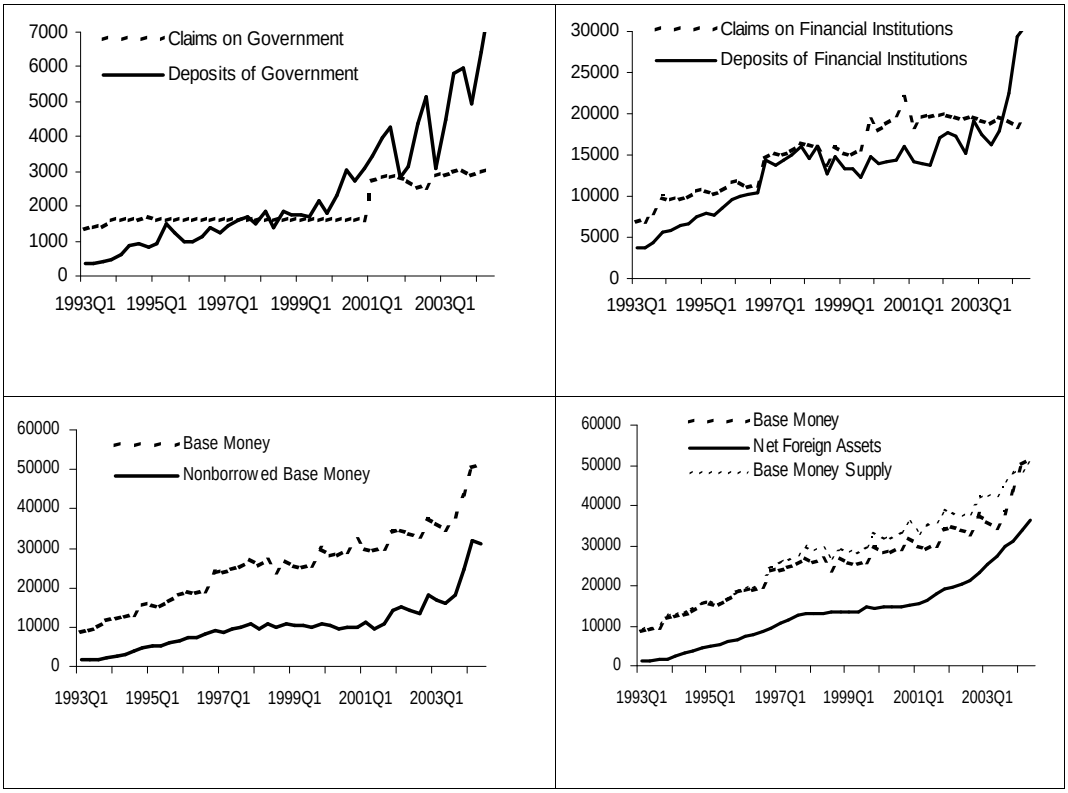
Source: CEIC Data Company. Ltd

Figure 3. Key structure of the balance sheet of the PBC



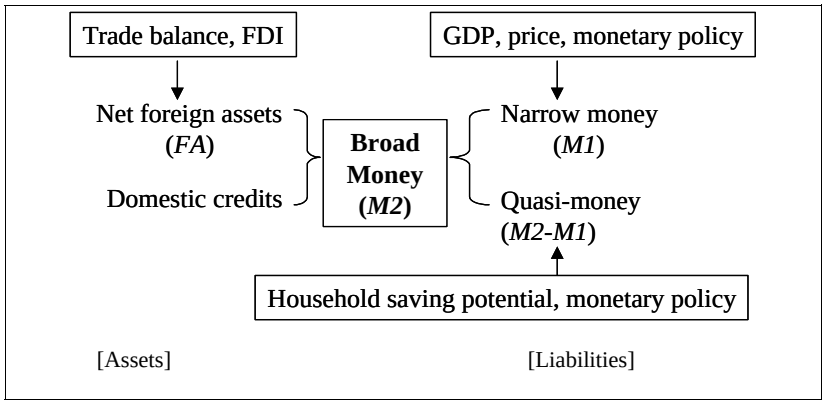
Note: *MbS* is defined as the sum of the net claims on foreign assets and on government plus borrowed reserve by the financial sector. It is more common internationally to refer to the sum of the required reserve and excess reserve as reserve money than what is denoted as reserve money here.

Figure 4. Aspects of the balance sheet of the PBC



Note: Non-borrowed base money is base money net of claims on financial institutions and is commonly known as the non-borrowed reserve.

Figure 5. Key structure of the balance sheet of the banking sector



Note: The liability side is linked to the real sector demand following the Polak model.

Figure 6. Required reserve ratio and ratio of base money supply to demand

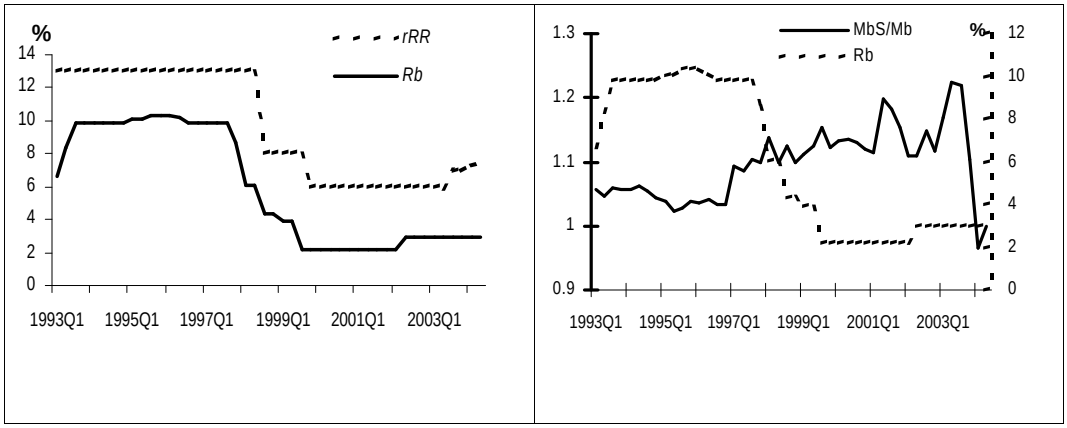
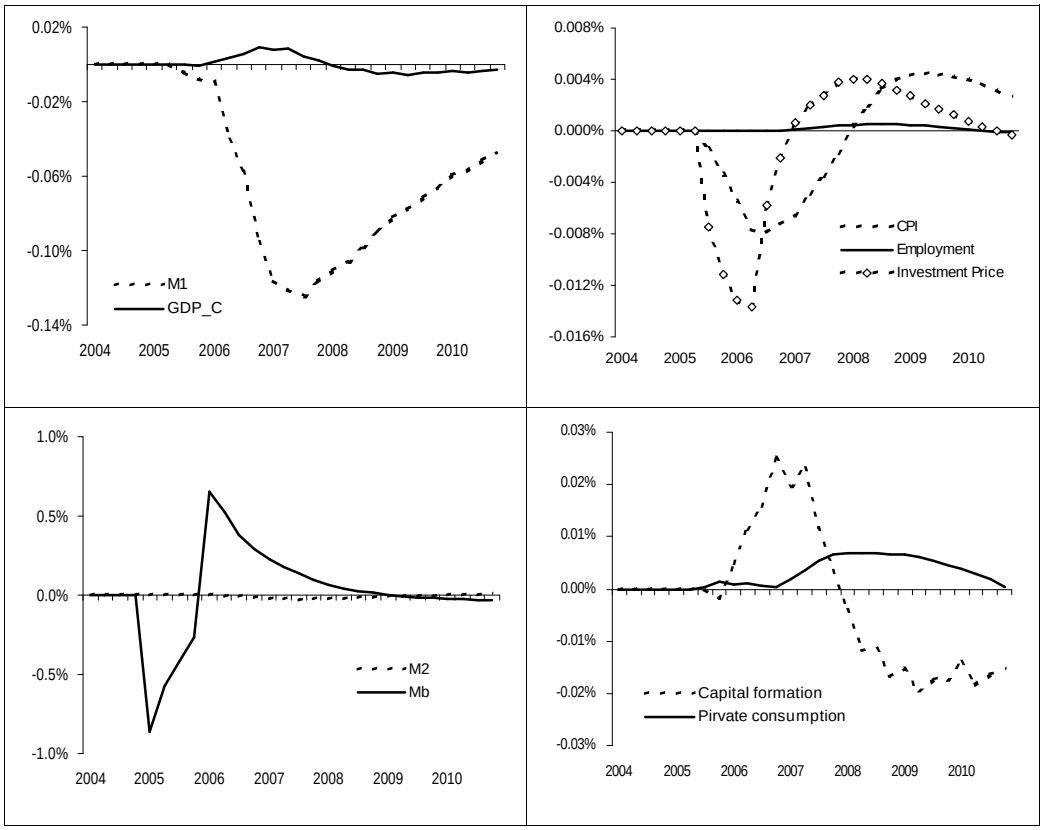


Figure 7. Simulation of interest rate effect

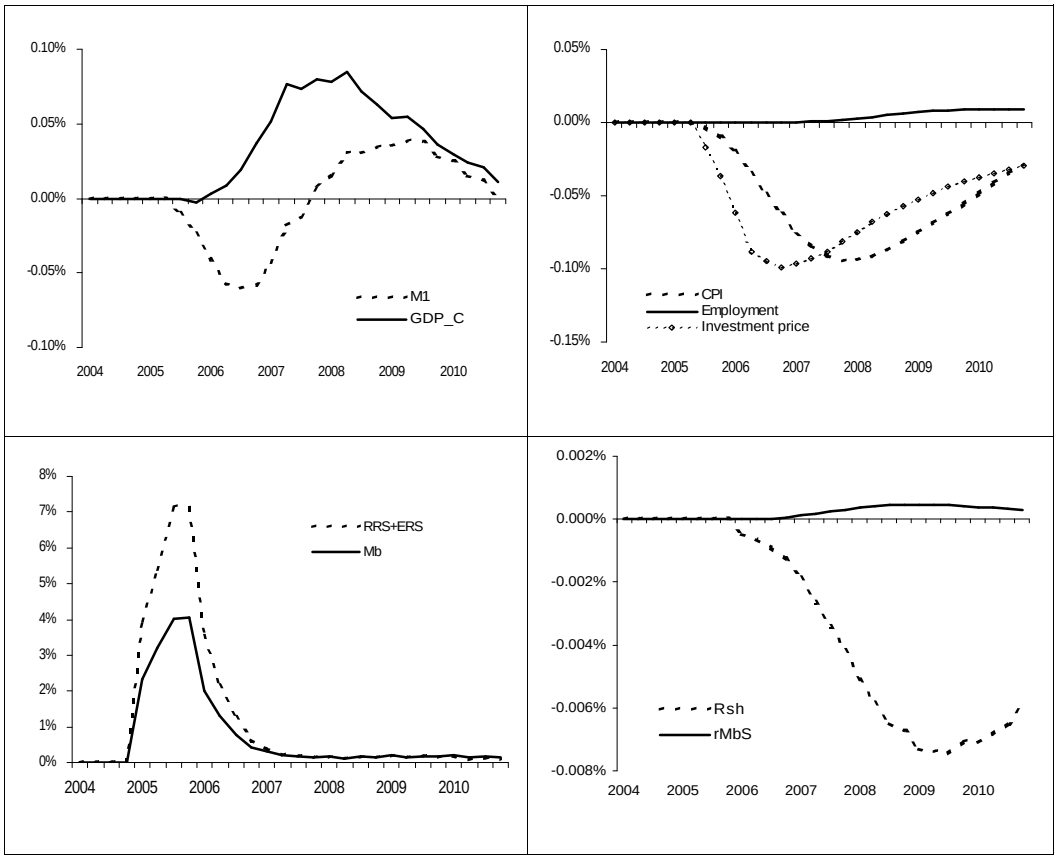
10% Step increase of base interest rate from default 2.97% from 2005Q1



Note: All the curves show year-on-year growth rates of the variables net of the base-run growth rates. Notice that the scales of the graphs differ substantially.

Figure 8. Simulation of required reserve ratio effect

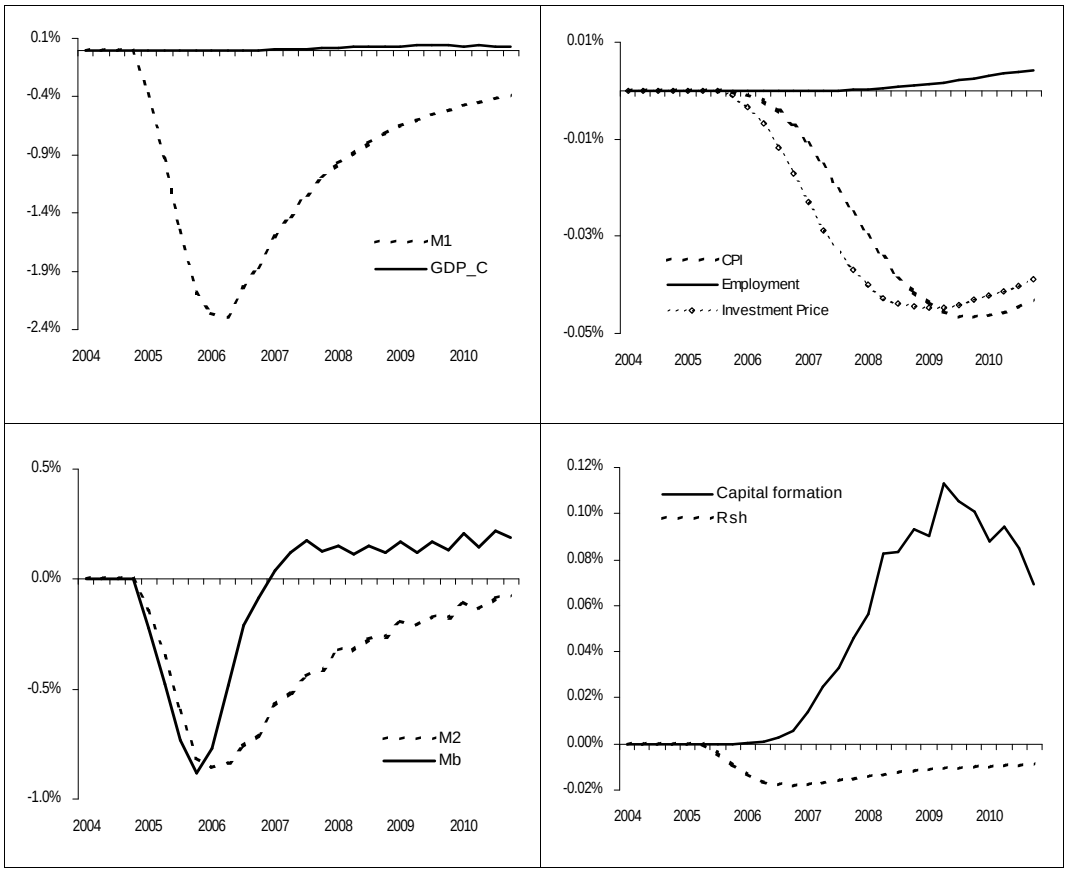
Step increase of required reserve ratio from 7.5% to 8% since 2005Q1



Note: The curves in the first three panels show year-on-year growth rates of the variables net of the base-run growth rates; the curves in the lower right panel simply show the differences of short-run interest rate and *rMbS* from the base run values.

Figure 9. Simulation of quantitative policy instrument effect

Trend reduction in q_t: $q_t = 0.98\ q_{t-1}$ since 2005Q1 (default $q_t = 1$)



Note: The curves in the first three panels show year-on-year growth rates of the variables net of the base-run growth rates; the curves in the lower right panel simply show the differences of short-run interest rate and *rMbS* from the base run values.

Table 1. Diagnostic test of M1 equation

Residual standard error	$s_{\hat{u}}$ =0.02452	
Null hypotheses (H_0)	Test statistics	[p value]
$\hat{u}$ No autocorrelation	F(3,30) = 1.8169	[0.1654]
$\hat{u}$ Normality	$c^2(2)$ = 1.9732	[0.3729]
$\hat{u}$ Homoscedasticity	F(10,22) = 1.4232	[0.2344]
RESET	F(1,32) = 3.0251	[0.0916]

Table 2. Diagnostic test of quasi-money and currency in issue equations

	M2-M1		MC	
Residual standard error	$s_{\hat{u}}$ =0.3342		$s_{\hat{u}}$ =0.0239	
Null hypotheses (H_0)	Test statistics	[p value]	Test statistics	[p value]
$\hat{u}$ No autocorrelation	F(3,33) = 0.1889	[0.9032]	F(3,35) =0.0271	[0.9939]
$\hat{u}$ Normality	$c^2(2)$ = 8.0952	[0.0175]	$c^2(2)$=2.1659	[0.3386]
$\hat{u}$ Homoscedasticity	F(7,28) = 1.3603	[0.2605]	F(5,32) =2.3613	[0.0622]
RESET	F(1,35) = 1.2267	[0.2756]	F(1,37) =2.4644	[0.125]

Table 3. Diagnostic test of excess reserve and base money supply equations

	ERS		*rMbS*	
Residual standard error	$s_{\hat{u}}$ =0.00762		$s_{\hat{u}}$ =0.0266	
Null hypotheses (H_0)	Test statistics	[p value]	Test statistics	[p value]
$\hat{u}$ No autocorrelation	F(3,34) = 2.0969	[0.1189]	F(3,32) =1.2208	[0.3181]
$\hat{u}$ Normality	$c^2(2)$ = 0.0229	[0.9886]	$c^2(2)$=5.7741	[0.0557]
$\hat{u}$ Homoscedasticity	F(9,27) = 0.7331	[0.6755]	F(4,30) =0.8255	[0.5194]
RESET	F(1,36) = 0.0076	[0.9310]	F(1,34) =0.0778	[0.782]