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Contents

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Abstract

This paper evaluates the usefulness of a McCallum monetary policy rule based on money supply for maintaining price stability in mainland China. We examine whether excess money relative to rule-based values provides information that improves the forecasting of price developments. The results suggest that our monetary variable helps in predicting both consumer and corporate goods price inflation, but the results for consumer prices depend on the forecasting period. Nevertheless, growth of the Chinese monetary base has tracked the McCallum rule quite closely. Moreover, results using a structural vector autoregression suggest that our measure of excess money supply could be used to identify monetary policy shocks in the Chinese economy.

Keywords: McCallum rule; monetary policy; China
JEL classification: E52; E31

We are grateful to Li-gang Liu, Wenlang Zhang and Jimmy Shek from the Hong Kong Monetary Authority for providing us with data on China's GDP. The views expressed in the paper are those of the authors alone and do not necessarily reflect those of the Bank of the Bank of Finland

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Tuuli Koivu[a] , Aaron Mehrotra[a, c] and Riikka Nuutilainen[b]

McCallum rule and Chinese monetary policy

Tiivistelmä

Tässä tutkimuksessa tarkastellaan rahan tarjontaan perustuvan McCallumin rahapolitiikkasäännön hyödyllisyyttä Kiinan hintavakauden ylläpitämisessä. Tutkimuksessa arvioidaan, voiko toteutuneen rahamäärän kasvun poikkeamaa säännönmukaisesta kasvusta (ns. ylimääräinen raha) käyttää inflaation ennustamisessa. Tulosten mukaan ylimääräinen raha auttaa ennustamaan kuluttaja- ja tukkuhintainflaatiota, mutta kuluttajahintojen tapauksessa tulokset riippuvat ennusteajankohdasta. Perusrahan kasvu Kiinassa on tarkasteluaikana ollut erittäin lähellä McCallum-rahapolitiikkasäännön mukaista kehitystä. Tulosten mukaan ylimääräistä rahaa voidaan käyttää myös Kiinan rahapolitiikkasokkien identifioimiseen rakenteellisessa vektoriautoregressiivisessä mallissa.

Asiasanat: McCallum-sääntö, rahapolitiikka, Kiina

1 Introduction

The literature on monetary policy rules is related to the formal analysis of rules versus discretion by Kydland and Prescott (1977), and there is now an ample literature on evaluating monetary policy by estimating simple policy rules. One should not assume that all aspects of policy could be summarized by such a rule or that the central bank could mechanically follow a rule. Nevertheless, use of a rule in evaluating monetary policy may render it easier to communicate to the general public, who will in turn be better able to judge the central bank's performance vis-à-vis its objectives. The literature on estimating monetary policy rules has focused predominantly on advanced economies, especially via the estimation of Taylor-type interest-rate feedback rules (see Taylor, 1993). In contrast, little such work has been done on developing or emerging economies.

In this paper, we analyze monetary policy in the biggest emerging economy – China. Clearly, such analysis must take into account the specific features of the country. From the viewpoint of this paper, the dominant characteristic of China's monetary policy is the prominent role of the money supply. According to the People's Bank of China (PBC), an appropriate supply of money would promote "economic growth positively and contribute to preventing both inflation and deflation" (PBC, 2005). Moreover, the monetary authority specifies annual targets for money growth, most prominently for the broad money supply, M2.[1] As interest rates have not yet assumed a key role in the monetary transmission mechanism, the modelling of policy using a Taylor rule emphasizing short-term interest rates would hardly seem appropriate for China. In contrast, a monetary policy rule based on control of money supply, such as the one proposed by McCallum (e.g. McCallum 1988, 2003), would seem a viable alternative.

We examine the usefulness of the McCallum rule for modelling China's conduct of monetary policy. This rule specifies money growth as a function of targeted nominal GDP growth, corrected for changes in the velocity of money. The fit of this rule for China has been recently investigated by Burdekin and Siklos (2008) and Liu and Zhang (2007). In addition to analysing the fit of the rule, the latter authors also include a quantity rule for money in their model, which was developed for analysing monetary policy in China. Our

[1] Monetary targeting was adopted in several advanced economies in the 1970s and it was widely considered successful in controlling inflation in Germany and Switzerland (see e.g. Mishkin, 2001). However, the German Bundesbank missed its money growth targets quite frequently. Bernanke and Mihov (1997) argue that Bundesbank policy was actually better described as inflation targeting rather than money targeting.

emphasis is rather different. We focus here on the issue of whether the McCallum rule provides important information for the central bank in its attempt to maintain price stability in China. In particular, we examine whether excess money supply – actual growth in excess of rule-based values – provides important information on price movements in consumer and corporate goods. Given the discussion about the role of asset prices in formulating monetary policy more generally, we also briefly explore the possibility that excess money supply can be used for forecasting share or land price developments in China. Finally, we investigate, within a structural vector autoregressive framework, whether the McCallum rule could be used to identify monetary policy shocks in China.

We find that the actual Chinese money supply, measured by monetary base, has been very close to the rule-based values during our estimation period. If instead M2 is used to measure money supply - an indicator rather than an operating target - Chinese monetary policy is found to have been contractionary from 1995 to 2002 and broadly neutral as from 2003. Interestingly, the episode of monetary contraction corresponds to the period of mild deflation in the Chinese economy. We find that the deviation of monetary growth from the rule improves consumer and corporate goods price inflation forecasts, compared with simple autoregressive inflation processes. Nevertheless, the results for consumer prices are dependent on the forecasting period. Moreover, we find little evidence that excess money supply would help predict asset price inflation. Finally, expansionary monetary policy shocks in a structural vector autoregressive framework lead to increases in nominal GDP. Our results provide support for the PBC's focus on monetary aggregates in pursuing macroeconomic stabilization.

This paper is structured as follows. The following section provides a short description of Chinese monetary policy after 1994. Section 3 presents the McCallum rule for monetary policy. In section 4, we conduct forecasting experiments for prices of consumer and corporate goods, as well as for assets, using our measure of excess money. Section 5 considers use of McCallum rule for identifying monetary policy shocks in China, and Section 6 concludes with policy implications.

2 Short description of China's monetary policy

Because there are several extensive descriptions of China's recent monetary policy in existence (see e.g. Xie, 2004; Geiger, 2006; Laurens and Maino, 2007), we provide here just a brief summary of the main features.

The stated objective of PBC monetary policy is "to maintain stability of the value of the currency and thereby promote economic growth".[2] As summarised by Geiger (2006), the authorities use various instruments to achieve the objective. During our sample period, monetary policy operated within the framework of a fixed or managed exchange rate and strict controls on capital flows. The latter have enabled an independent monetary policy despite the fixed exchange rate regime.

Many studies note the absence of a major role for interest rates in the Chinese economy, as compared to the advanced economies (see e.g. Laurens and Maino, 2007; Mehrotra, 2007; Koivu, 2008). Even though the authorities actually set several interest rates (central bank lending rate, rediscount rate and benchmark rates for different maturities of deposits and loans), the interest rate channel has been ineffective for various reasons. For example, the liberalisation of interest rates has advanced rather slowly, the banking sector has traditionally not been profit-oriented, and companies generally relegate interest costs to a minor role in their investment decisions.[3]

Chinese authorities have generally been reluctant to use interest rates as a policy tool. Instead, they set annual intermediate targets for money supply growth (M1 and M2) and in recent years, the central bank has also announced a target for credit growth. The authorities have then controlled the money supply by setting the reserve requirement ratio and deciding on central bank lending, which used to be a significant part of commercial banks' financing. The PBC has also controlled market liquidity via open-market operations in treasury bonds, and since 2003 by selling central bank bills to commercial banks.

The authorities have also used administrative policy tools to guide financial sector developments in China. Until the start of 1998, credit plans formed the basis of bank lending. Even after the abolishment of credit plans, the authorities have continued to issue lending guidelines for commercial banks (window guidance policy). This policy, which in-

[2] http://www.pbc.gov.cn/english/huobizhengce/objective.asp on February 8, 2008.
[3] In a former command economy, the lack of profit orientation is related to the concept of soft budget constraint, whereby an economic agent's budget does not pose a strict constraint on his spending (see Kornai, 1992).

cludes the issuance of direct guidelines and orders to the commercial banks, was intensified due to rapid credit growth in 2003 and again in 2007.

As suggested by Geiger (2006), the PBC has often missed the exact targets for monetary growth. However, actual monetary developments have closely tracked the major trends in central bank targets, and the ultimate targets of China's monetary policy – low inflation and rapid growth – have been simultaneously achieved since the mid-1990s.

3 The McCallum monetary policy rule for China

The limited role of interest rates in PBC monetary policy suggests that a policy rule for the nominal interest rate may not accurately reflect actual policy. In several contributions, McCallum (1988, 2003) has proposed a rule for determining the monetary base, which can be written as

$$\Delta m_t = \Delta x^* - \Delta v^a{}_t + 0.5(\Delta x^* - \Delta x_{t-1}). \quad (1)$$

In (1), m and x denote the monetary aggregate and nominal GDP, and Δv_t^a is the average rate of money velocity growth over the previous year.[4] The rule includes a prominent role for the target growth rate of nominal GDP, Δx^*, which of course must be predefined. It also corrects for expansionary money demand due to declining velocity - captured by the term Δv. A difference versus the original rule is that, due to our limited data sample, we use the average money velocity growth over the previous year, instead of over four years, as in e.g. McCallum (2003).[5] McCallum (1988) specifies the rule in terms of the monetary base because this variable is controllable by the monetary authority, and this is also our benchmark approach. But we also experiment with M2 as the measure of money supply. This is justified by the prominent role of M2 in the implementation of Chinese monetary policy, not least due to its use as an intermediate annual target. PBC does not announce annual targets for the monetary base. Nevertheless, it should be emphasized that in this case money assumes the role of indicator variable rather than operating target.

[4] We use data on nominal GDP kindly provided by Li-gang Liu, Wenlang Zhang and Jimmy Shek from the Hong Kong Monetary Authority. The data on monetary aggregates and prices are from the CEIC and IFS databases.
[5] We also use the target for the current period instead of previous-period GDP.

Our study is not the first to fit the McCallum rule to Chinese data. Burdekin and Siklos (2008) apply the rule, first using the coefficients specified by McCallum, and then by allowing the data to determine the coefficient estimates. They use simulated values for the target nominal GDP growth, Δx^*. Liu and Zhang (2007) use graphical analysis to compare the fit of the McCallum rule with actual outcomes for money supply.[6] Like Liu and Zhang (2007), we derive the target for nominal GDP from the targets for real GDP and CPI specified in the Chinese government's social and economic development goals[7] (see e.g. China Monetary Policy Report, Quarter Four, 2006, page 74).

Unfortunately, the target for the GDP deflator – needed to calculate the nominal GDP target – is not defined. However, as shown in Figure A1 in the Appendix, the annual growth rates for CPI and GDP deflators are highly correlated (correlation coefficient 0.98 for 1994Q1-2007Q2). Growth of the GDP deflator slightly exceeds the annual changes in the CPI since 2000. Therefore, we add the difference between the GDP deflator and consumer price inflation to the announced CPI target to derive the target rate for nominal GDP. We argue that our approach may be better able to capture the nominal GDP target of the Chinese authorities than is possible with simulated values.

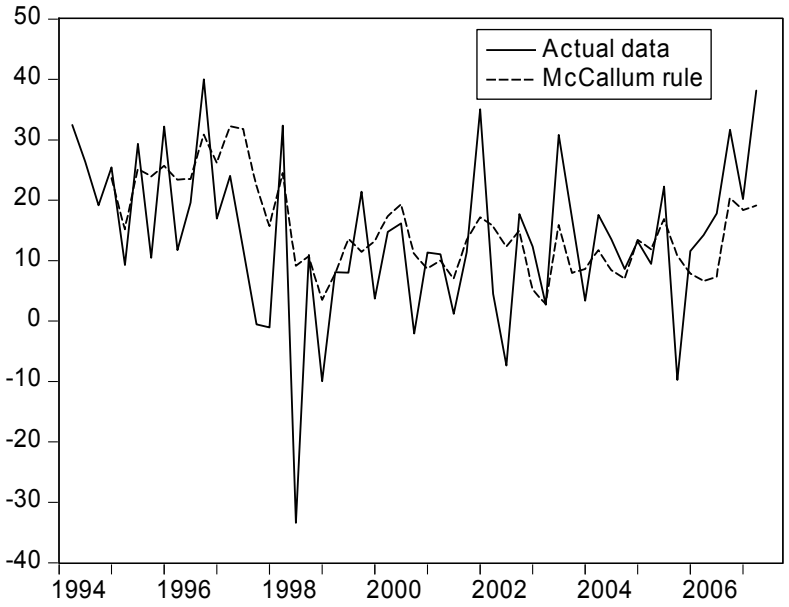
Our analysis starts with 1994 which has been considered the starting year for the so-called third phase of Chinese reforms and was particularly important from the monetary policy perspective. The official and market exchange rates were unified, and current account transactions were liberalised. In addition, banking reform advanced to the establishment of three policy banks, importantly separating policy finance from the more commercially-oriented activities. At the same time, the PBC began to publish target values for monetary aggregates M1 and M2.

Figure 1 displays the estimated McCallum rule for China's monetary base, together with the actual outcomes.[8] Actual movements in the monetary base have quite closely tracked the values implied by the McCallum rule, even though there is some indication of contractionary monetary policy in the first part of the period studied. Since 2003, growth of base money has been very close to the specified McCallum rule. During the last few quar-

[6] Liu and Zhang (2007) also use a quantity-based rule in their New-Keynesian model to analyse China's monetary policy. However, the rule used in the model differs from the exact specification by McCallum.
[7] For 1994-1997, the PBC used to specify targets only for retail price inflation and GDP.
[8] We use the variable "reserve money" reported in the People's Bank of China Quarterly Statistical Bulletin. This aggregate includes currency issue as well as deposits of financial institutions and non-financial corporations held at the central bank.

ters of the period studied, monetary growth increased faster than the McCallum rule prescription, partly due to hikes in reserve requirement ratios that expanded the monetary base. [9] Figure A2 in the Appendix displays developments over time in the growth of base money velocity.

Figure 1 Outcome for monetary base and McCallum rule, %-change y-o-y

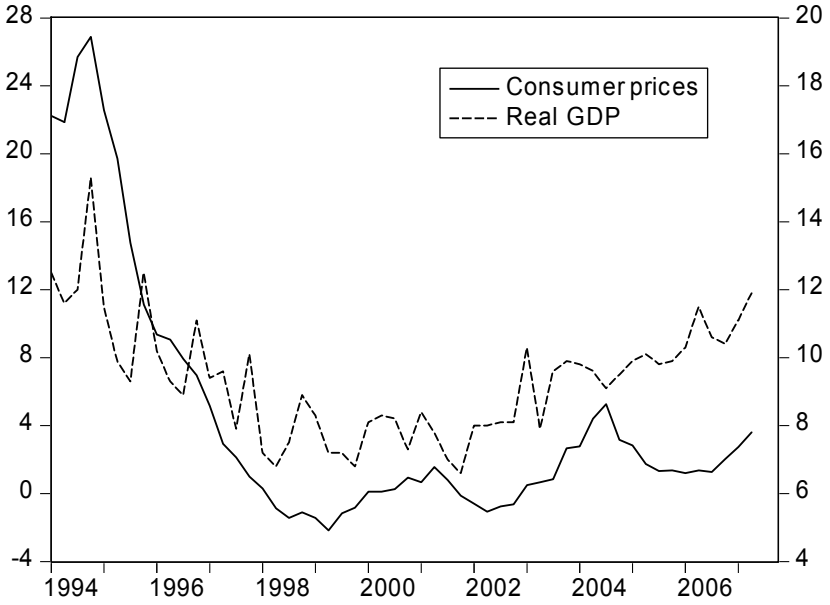


Interestingly, China's monetary policy stance, as defined by the McCallum rule, is reflected in fluctuations of CPI inflation during the period studied. After hitting a record high of over 25% at the beginning of our sample period, year-on-year CPI inflation slowed down quickly and was even followed by two deflationary periods, 1998-2000 and 2001-2002. This decline in inflation, which corresponds closely with the timing of slightly contractionary monetary policy, is shown in Figure 2. Since 2003, inflation has generally remained low, except for the one-time hike, due mainly to increases in grain prices in 2004 and higher inflation after the end of 2006. Meanwhile, GDP growth remained strong throughout our sample period. Nevertheless, the growth rate seems to have reacted to monetary policy stance, as real GDP growth dropped from over 13% in 1994 to 7.6% in 1999, when the effect of contractionary policy was compounded by the Asian crisis. Since 2001, GDP growth has picked up again, to exceed 11% in 2007. Later in this paper, we confirm the

[9] In this case fast monetary growth may reflect tighter instead of looser monetary policy. As this time period is mainly outside our estimation sample, it does not pose a major problem for our analysis.

link between policy (defined by the McCallum rule) and GDP growth and inflation within a more formal framework.

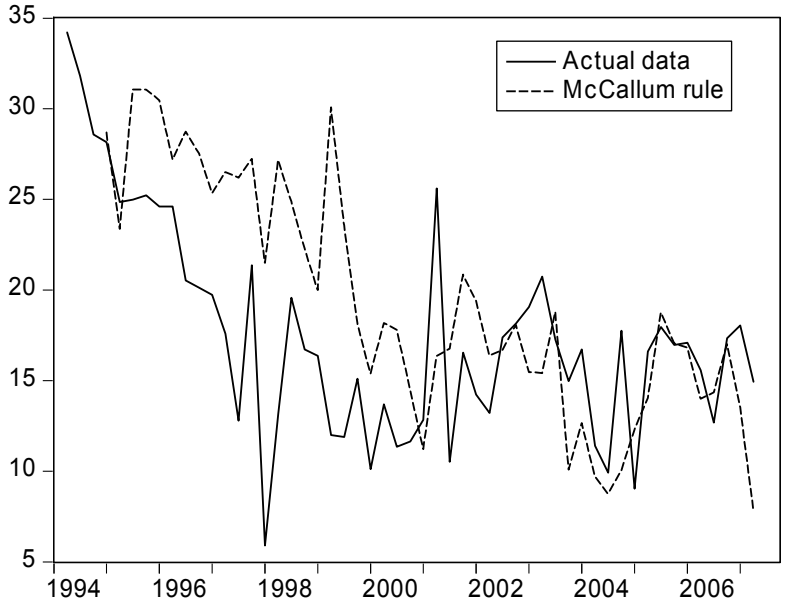
Figure 2 Consumer good prices and real GDP, %-change y-o-y



We also evaluate China's monetary policy using the broader monetary aggregate M2. While its use is justified by its role as a major intermediate target for China's monetary policy, it does not serve as an operating target for the monetary authority. Even in China, where practically all banks are majority state-owned, the authorities do not have complete control over commercial banks' activities nor thus over M2.

Developments in M2 vis-à-vis the McCallum rule are quite similar to what we saw in regard to base money. In the first half of the sample period, monetary policy was contractionary in that the actual money supply (M2) increased at a lower rate than that specified by the McCallum rule, as shown in Figure 3. Since 2001, actual developments have been more in line with the policy rule, and in the recent years monetary policy has been fairly neutral vis-à-vis the rule.

Figure 3 Outcome for M2 and McCallum rule, %-change y-o-y



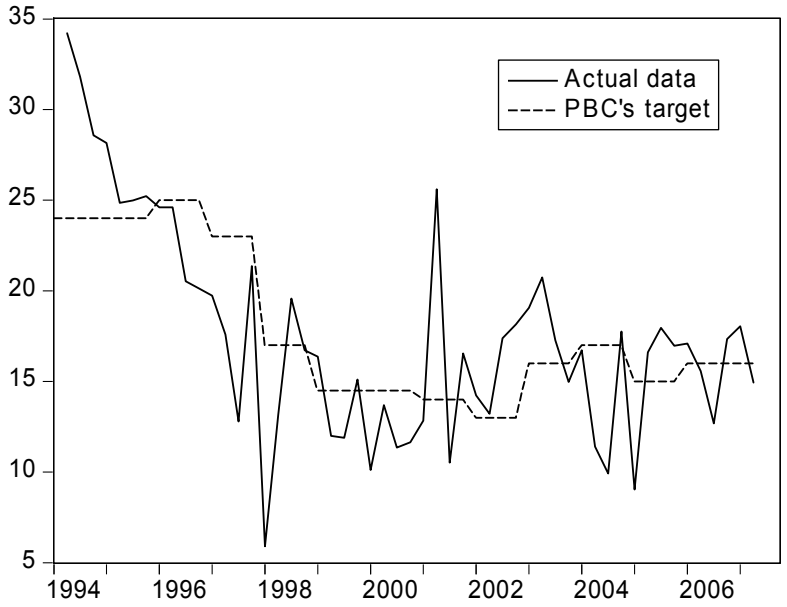
The status of M2 as an intermediate target further enables a comparison of PBC announced targets and values generated by the McCallum rule. As displayed in Table 1, values implied by the rule exceeded the central bank's target growth rate for M2 every year up to 2003. In the last few years, the McCallum rule and the PBC target have followed growth rates very close to each other. Furthermore and keeping in mind the caveat that M2 cannot be used as an operating target, China's realised monetary policy was previously even more contractionary than what the target would have suggested (Figure 4). After inflation was brought down by 1996, the M2 growth rate remained below the central bank's target most of the time until 2001. Since then, actual monetary growth has been quite close to the target.

Table 1 Outcome from McCallum rule and PBC annual target for M2

	McCallum rule, %	PBC target*, %
1995	28.5	23-25
1996	28.5	25
1997	26.3	23
1998	24.0	16-18
1999	23.0	14-15
2000	16.5	14-15
2001	16.3	14
2002	17.6	13
2003	15.0	16
2004	10.3	17
2005	15.5	15
2006	15.5	16

*Source: PBC Annual Reports and China Monetary Policy Reports, various issues.

Figure 4 Outcome for M2 and PBC target, %-change y-o-y



4 McCallum rule and inflation forecasting

In this section, we use our measure of excess money supply – deviation of actual money supply growth from the value specified by the McCallum rule – for inflation forecasting. For this purpose, we estimate a reduced form bivariate vector autoregressive model, employing lags of an inflation measure and excess money supply. The model is estimated for 1995Q1-2006Q2, and *h*-step-ahead out-of-sample forecasts are generated for 2006Q3-2007Q2.[10] Omitting the deterministic terms, a reduced form model can be expressed as

$$x_t = A_1 x_{t-1} + ... + A_p x_{t-p} + u_t . \quad (2)$$

Here, x_t is a ($K \times 1$) vector of endogenous variables. The A_i are fixed ($K \times K$) coefficient matrices and the u_t is assumed to follow a K-dimensional white noise process with $E(u_t) = 0$. Regarding model specification, we follow the Akaike information criterion for optimal lag length, with a maximum of 6 lags. In the case where misspecification tests provide evidence against this lag length, we generally include three lags, which is appropriate for a first-differenced series of quarterly data. All the estimated bivariate models pass the Portmanteau (at 16 lags) and LM tests (at 5, 4, and 1 lags) for autocorrelation, and the ARCH-LM test (at 16 lags) for model residuals. The Schmidt-Phillips test for unit roots suggests that both excess money supply and the different measures of inflation are stationary, as the null hypothesis of a unit root is rejected at the 5% level. These results are available from the authors upon request.

In order to evaluate the forecasting performance of these models, we need a benchmark for comparing with the forecasts. As is common in the literature, we compare the root mean squared forecast errors (RMSE) to those provided by a simple autoregressive (AR) process. The satisfactory forecasting performance of an AR process has been well documented in the literature for both the euro area and US economies (e.g. Marcellino et al, 2003; Banerjee and Marcellino, 2006). For China, Mehrotra and Sánchez-Fung (2008) compare inflation forecasts obtained from 15 different models and find that only those incorporating many predictors via a principal component outperform the AR process. In addition to using consumer price index as a measure of prices, we also use the corporate

[10] For land prices, the sample starts in 1998 due to data availability.

goods price index (CGPI) published by the PBC (see Figure A3 in the Appendix). This measure covers prices of goods in inter-enterprise transactions, and it includes agricultural, mining, and processed products, together with coal, oil and electricity. The results from this exercise are provided in Table 2. A figure of less than 1 indicates that including a monetary variable improves the forecast, as compared with a univariate AR-process.

Table 2 Inflation forecasts, *h*-step-ahead

Predictor	Monetary base, deviation from McCallum rule			M2, deviation from McCallum rule			M2, deviation from PBC target		
	h-step-ahead forecast			*h-step-ahead forecast*			*h-step-ahead forecast*		
	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$
Consumer prices	0.26	0.91	0.92	0.91	0.91	0.91	0.65	0.93	0.94
Corporate goods prices	0.14	0.68	0.42	0.52	0.41	0.83	0.59	0.49	0.89

Note: RMSE relative to AR-process.

It is clear that our measure of excess money supply (for both monetary base and M2) improves the forecasts of consumer and corporate goods prices, for all forecast horizons considered, as compared with an AR-process. It is also noteworthy that inclusion of the deviation from the PBC monetary growth target outperforms the univariate process. Therefore, all these measures have information value for future price pressures.

The role of asset prices in the formulation of monetary policy has been debated for years, and the discussion has often intensified at times of boom and slowdown in the stock and housing markets in the 1990s and 2000s. Theory generally suggests that monetary policy should stabilize infrequently adjusted prices but not the highly flexible asset prices (see e.g. Woodford 2003). Concern has also been raised about the ability of the monetary authority to identify asset price bubbles. According to Svensson (2004), the monetary authority should react to asset prices only to the extent that they have an impact on output gap

and inflation. Goodhart and Hofmann (2002), on the other hand, claim that ignoring asset price movements leads to suboptimal outcomes for the economy in terms of inflation and output gap variability. Without taking a stand on the exact role of asset prices in policy formulation, we focus on whether our measures of liquidity provide any information on asset price developments. In this regard, we repeat the exercise of Table 2 by including as price indicators a land price index as well as Shanghai and Shenzhen share prices.

Our results in Table 3 do not provide firm evidence in support of the forecasting ability of our measures of excess money supply for asset prices. In general, only for the very short run (1 quarter) does the inclusion of excess liquidity measures produce better results than the AR-process. This could be due to the rapid movements in asset prices, or to the fact that in China asset prices are driven by their own shocks rather than the stance of monetary policy.

Table 3. Asset price forecasts, *h*-step-ahead

Predictor	Monetary base, deviation from McCallum rule			M2, deviation from McCallum rule			M2, deviation from PBC target		
	h-step-ahead fore-cast			*h-step-ahead fore-cast*			*h-step-ahead fore-cast*		
	h = 1	*h* = 2	*h* = 4	*h* = 1	*h* = 2	*h* = 4	*h* = 1	*h* = 2	*h* = 4
Land prices	0.34	0.58	0.87	0.53	0.96	1.07	1.16	1.10	1.05
Shanghai share prices	0.45	1.10	1.09	1.86	1.11	1.14	0.81	0.98	0.99
Shenzhen share prices	0.40	1.53	1.41	0.90	0.98	1.11	0.30	1.37	1.28

Note: RMSE relative to AR-process.

A final remark on the forecasting exercises concerns robustness of the results with respect to estimation period. We have repeated the forecasting exercise of Table 2 using an estimation period of 1995M1-2004M2 and a corresponding forecasting period of 2004M3-

2005M2. For corporate goods price inflation, the results generally remain robust, as the AR-process is beaten in 7 of 9 tested observations. Nonetheless, for consumer price inflation the results are less encouraging, as the AR process is outperformed in just 2 of 9 observations. This suggests that the results for consumer price inflation in this section are dependent on the sample period, and information over and above monetary pressures should be considered carefully in evaluating price pressures in the Chinese economy.

5 Identifying policy shocks with the McCallum rule

In the final section of the paper, we utilize the McCallum rule to capture monetary policy shocks in the Chinese economy in a structural vector autoregressive framework. In particular, we are interested in the effects on China's nominal output of a deviation of monetary base from the value specified by the McCallum rule. While the previous analysis established the possibility of using the monetary policy rule for inflation forecasting, little was said about the dynamic impacts of monetary expansions/contractions over time. More generally, because thus far no consensus has been reached in the literature as regards the identification of Chinese monetary policy shocks, our approach provides a possible alternative.[11]

In order to identify monetary policy shocks using the McCallum rule, we proceed as follows. After estimation of a reduced form model Eq. (2) and having obtained a congruent representation of the data, we proceed to specification of the structural form, which can be written as

$$\mathrm{A}x_t = A_1^* x_{t-1} + \ldots + A_p^* x_{t-p} + \mathrm{B}\varepsilon_t \,. \qquad (3)$$

In (3), the structural shocks, ε_t, are related to model residuals via linear relations. They are assumed to be uncorrelated and therefore orthogonal. The A_i^*'s (i = 1, ..., p) are again ($K \times K$) coefficient matrices, and B is a structural form parameter matrix. The reduced form model can be linked to the structural form simply via $u_t = \mathrm{A}^{-1}\mathrm{B}\ \varepsilon_t$. We specify the McCallum rule in the matrices A and B, and estimate the so-called AB-model by Amisano

[11] Dickinson and Liu (2007) identify monetary policy shocks in China by using the central bank lending rate and the quantity of credit. Mehrotra (2007) uses the central bank repo rate, while Chow and Shen (2004) capture Chinese monetary policy shocks by narrow money M1.

and Giannini (1997). The structural model is estimated by maximum likelihood, subject to the structural-form restrictions, and using the covariance-variance matrix of the reduced form VAR.

We commence our analysis by re-writing the McCallum rule (1) as

$$\Delta m_t = 1.5\Delta x^* - \Delta v^a{}_t - 0.5\Delta x_{t-1} \quad (4)$$

To simplify matters, we specify the nominal GDP target, Δx_t^*, to be constant over time. Hence $1.5\Delta x_t^* - \Delta v^a{}_t$ reduces to a variable that is time-varying only to the extent that velocity changes over time. In the VAR estimation that follows, this variable is labelled the (adjusted) change in velocity. In order to calculate the constant nominal GDP target, we focus on the estimation period 1997Q1-2007Q2 and take the average of nominal GDP targets over that time. This yields a nominal GDP target of 12.3%.[12]

We estimate the reduced form VAR model with the following three variables: change in monetary base (Δm_t), change in nominal GDP lagged by one period (Δx_{t-1}) and the adjusted change in velocity ($1.5\Delta x_t^* - \Delta v^a{}_t$). Utilizing 4 lags and including a constant as a deterministic term, we estimate this model for the period 1997Q1-2007Q2. Then, in order to remove the most statistically insignificant coefficients, we sequentially eliminate those with the lowest *t*-values until all remaining coefficients have *t*-values of at least 1.00. The resulting model appears to be a valid representation of the data. In particular, the adjusted Portmanteau test (at 16 lags, *p*-value 0.47), the LM-test (4 lags, *p*-value 0.34) and the multivariate VARCH-LM test (5 lags, *p*-value 0.38) do not provide evidence against the model specification.

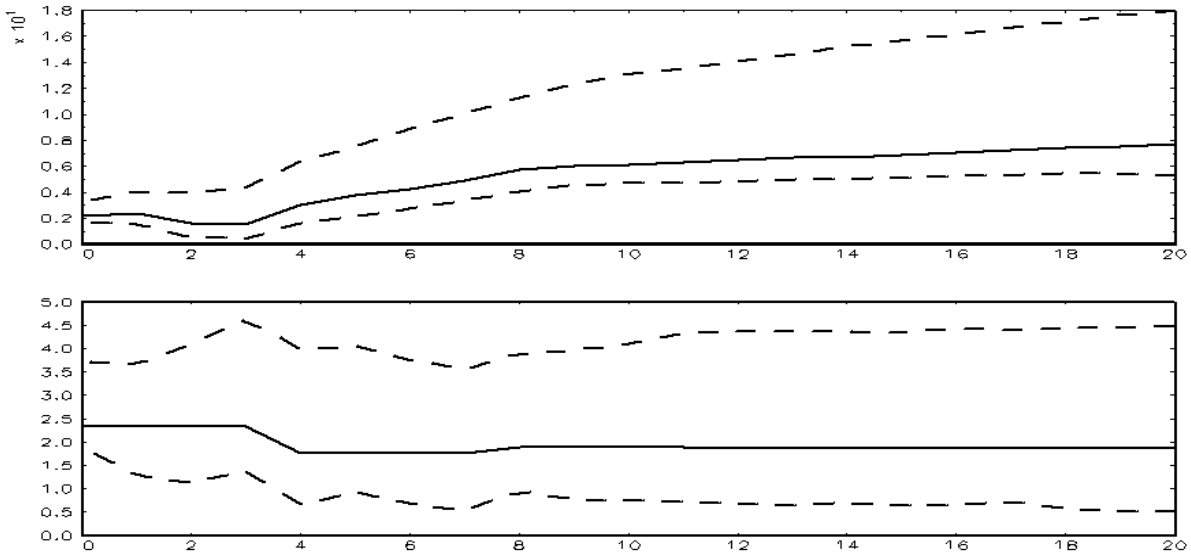
Proceeding to the structural-form specification, the AB-model is written as:

$$\begin{bmatrix} 1 & 0 & a_{13} \\ 0.5 & 1 & -1 \\ a_{31} & a_{32} & 1 \end{bmatrix} u_t = \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \varepsilon_t . \quad (5)$$

[12] Such a nominal target for GDP growth appears reasonable, given that since 1997 the government's real GDP growth targets have remained at 7-8%, consumer price inflation targets between 1-5% and the rise in the GDP deflator has exceeded consumer price inflation after 1999.

The McCallum rule is specified in the second row of (5), so that monetary policy shocks are captured as the row's structural shocks. Regarding the other rows, our identification scheme is close to a recursive system where adjusted velocity reacts immediately to any shock hitting the system and nominal GDP responds sluggishly to shocks. The sluggishness of GDP obtains despite the fact that we allow it to react immediately to a shock to (adjusted) velocity in order to attain a just-identified model. We then examine the dynamics of the monetary policy shock over time via impulse response analysis over 20 quarters, as

Figure 5 Impact of a monetary policy shock on nominal GDP (top) and monetary base (below)



shown in Figure 5. Parameter uncertainty is taken into account through the use of 90% Hall percentile confidence intervals, obtained by bootstrapping with 1,000 replications. The impacts on nominal GDP and monetary base are accumulated over time in order to focus on the levels of these variables.

According to the impulse responses, an expansionary monetary policy shock – relative to the McCallum rule – leads to an immediate increase in the level of base money. The impact on money is permanent, and the increase in the level of nominal GDP is long lasting and statistically significant. It stabilizes only after the fifth year following the shock. While it is generally assumed that money is neutral in the long run (in that there is no impact on *real* output) a permanent impact on prices and hence on the level of *nominal* GDP

is in line with theory.[13] These results provide support for the PBC's focus on the money stock in order to maintain price stability. Together with the finding that realized base money growth has closely tracked the McCallum rule, they suggest that the rule might well be used to capture monetary policy shocks in the Chinese economy.

6 Conclusions

In this paper, we have examined the usefulness of the McCallum rule for modelling the implementation of monetary policy for Mainland China. While earlier studies have emphasized the modest role of interest rates in the Chinese economy, monetary policy can plausibly be analysed in the framework of a quantity-based McCallum rule. Moreover, the quantitative targets set by the People's Bank of China for money supply growth support the argument that monetary policy can be modelled by using money-based rules.

According to our analysis, the simulated McCallum rule accords quite well with actual growth of the base money since 1994. During the early years of the period studied (the mid-1990s) the realised monetary policy seems to have been slightly contractionary, as money supply has grown at a lower rate than that prescribed by the McCallum rule. It appears that in the 2000s the stance of monetary policy has been neutral. These major trends in monetary policy are reflected well in the simultaneous developments in inflation and GDP growth. While the second half of the 1990s was characterized by a somewhat lower growth rate and declining inflation, the more recent years have witnessed faster growth, coupled with relatively stable and low inflation.

We tested whether our measure of the monetary policy stance (deviation of actual money supply growth from that of the McCallum rule) helps to forecast consumer price and corporate goods price inflation. According to the results, using the deviation of monetary growth from the rule indeed improves inflation forecasts, as compared with simple autoregressive processes for inflation. However, the results for consumer prices depend on the forecasting sample. Finally, expansionary monetary policy shocks in a structural vector

[13] An alternative approach would be to include real GDP and its deflator as separate variables in the estimated system, but this would require assumptions as to their weights in the policy rule – something not specified by the McCallum rule. Preliminary estimations using the same coefficient (-0.5) for both variables yield persistent positive effects of an expansionary monetary policy shock, on both the level of real GDP and its deflator.

autoregressive framework, incorporating the McCallum rule, lead to increases in nominal GDP.

Our results suggest that the McCallum rule could be a useful tool for analysing the monetary policy stance and for providing information about inflationary pressures in the Chinese economy. The results could also be seen to lend support for the PBC's focus on monetary aggregates as intermediate policy targets. Both major targets of China's monetary policy – stability of the value of the currency and fast economic growth – have been simultaneously achieved since the mid-1990s. In the coming years, however, China will face new challenges as economic reforms are pushed forward. Partial privatization of the financial sector, a more flexible exchange rate and gradual liberalization of capital flows may reduce the effectiveness of quantitative monetary policy tools in the economy. Interest rates are likely to assume a bigger role as major operating targets for the implementation of policy - as is the case in advanced economies.

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Appendix

Figure A1 Annual GDP deflator and 12-month change in CPI, %

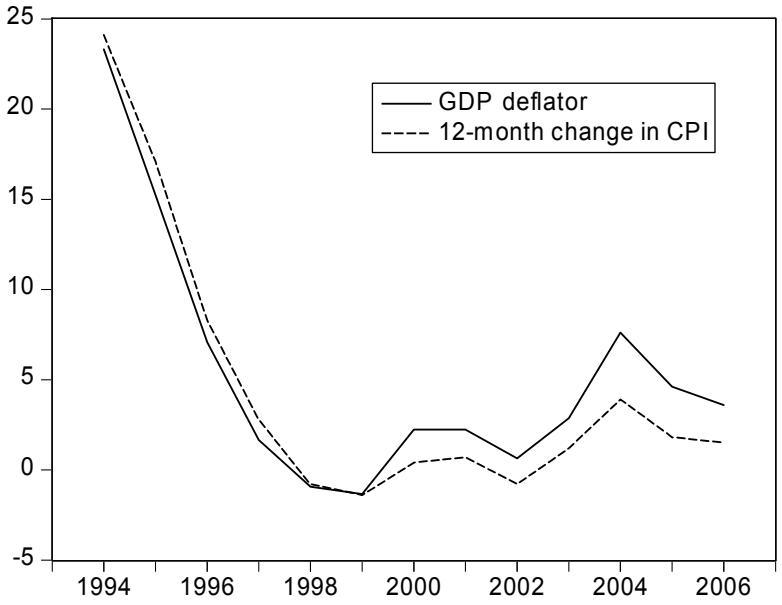


Figure A2 Monetary base velocity, %-change y-o-y

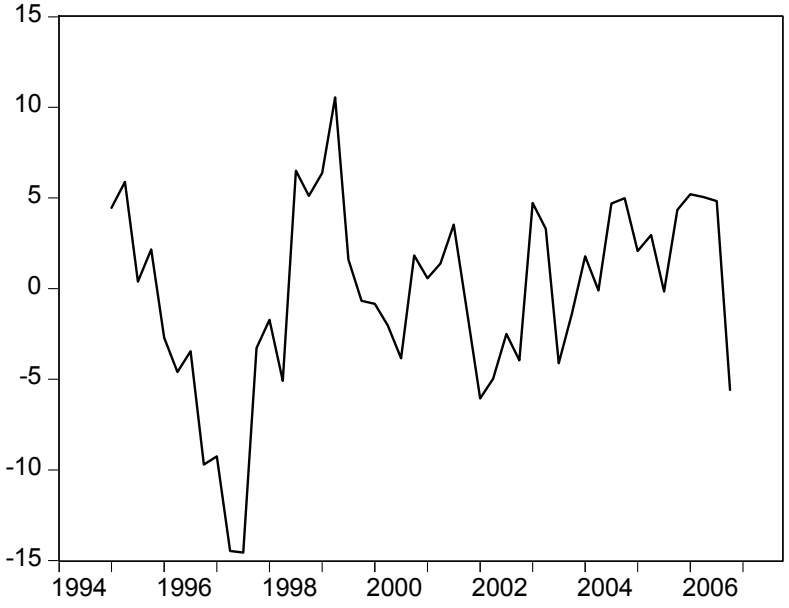
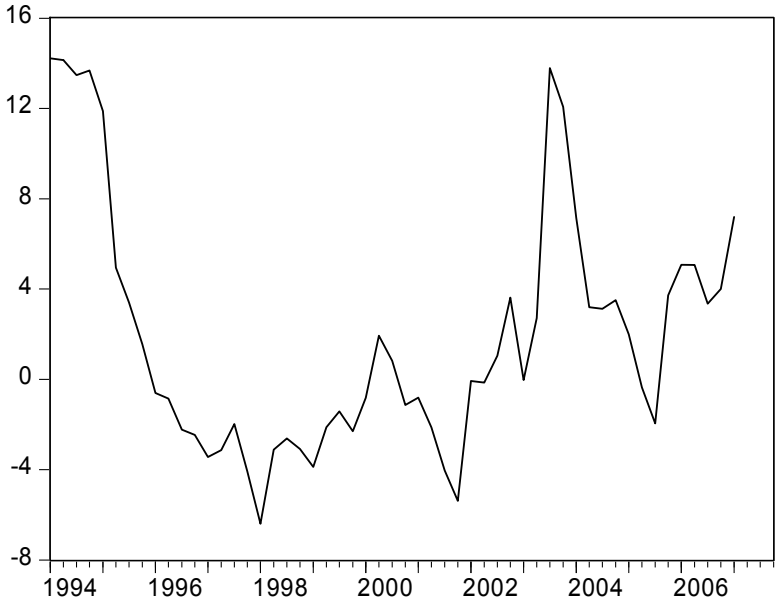


Figure A3 Corporate goods prices, %-change y-o-y



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