Journal of Macroeconomics 33 (2011) 358–371

Contents lists available at ScienceDirect

Journal of Macroeconomics

journal homepage: www.elsevier.com/locate/jmacro

An empirical evaluation of China's monetary policies

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ARTICLE INFO

Article history:
Received 25 February 2009
Accepted 4 November 2010
Available online 19 November 2010

JEL classification::
E52

Keywords:
Monetary policy
Taylor rule
McCallum rule
Output gap
Inflation rate
Real effective exchange rate

ABSTRACT

This paper investigates the responsiveness of the Chinese government's monetary policies in terms of the money supply and interest rates to economic conditions and the effectiveness of these policies in achieving the goals of stimulating economic growth and controlling inflation. We analyze the responsiveness and effectiveness by estimating the Taylor rule, the McCallum rule, and a vector autoregressive model using quarterly data in the period of 1992–2009. The results show that, overall, the monetary policy variables respond to economic growth and the inflation rate, but the magnitudes of the responses are much weaker than those observed in market economies. Money supply responded actively to both the inflation rate and the real output and had certain effects on the future inflation rates and real output. The official interest rates, on the other hand, responded passively to the inflation rate and did not respond to the real output. They do not have any effect on future inflation rates and real output either.

1. Introduction

Once a centrally planned economy, China has now implemented economic reforms to transform itself into a market-oriented economy and it has enjoyed an average annual real growth rate of about 10% for more than 20 years. After a few years of experimenting, the central bank of China announced in 1998 that it abandoned the traditional central-planning system of allocating funding to state-owned enterprises. Following the model in developed market economies, the central bank has been using the money supply and official interest rates as its main tools to implement its monetary policies. What was the role played by the central bank in the recent years of rapid growth? How effective were the monetary policies in promoting growth while maintaining stability? This paper sets out to answer these questions. Just as real economic variables and the inflation rate fluctuated over the last 20 years, so did the monetary variables. Such fluctuations in both economic variables and policy variables make it possible to conduct an empirical evaluation of the responsiveness and effectiveness of the government's monetary policies. The time is ripe for such an evaluation as we now have enough data for a reasonable analysis.

We address issues of how the money supply and official interest rates respond to macroeconomic variables such as the output, the inflation rate, and the real effective exchange rate. We explore which of the two monetary policy tools, money supply or official interest rates, play a more important role. We also examine how effective these monetary policies are in influencing future outputs and inflation rates. Regarding the former question of how responsive the monetary tools are, we adopt the frameworks of the Taylor rule and the MaCallum rule used widely in the literature to estimate the responses of the

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0164-0704/$ - see front matter
doi:10.1016/j.jmacro.2010.11.003

short-term official interest rate and the growth rate of the money supply to the real output and the inflation rate. We use time-varying-coefficient models as well as fixed-coefficient models to estimate the response coefficients in the Taylor rule and the MaCallum rule. For the latter task of analyzing the effectiveness of the policy variables, we adopt the standard vector autoregressive (VAR) model, examine the impulse response functions of the economic variables to the policy variables, and analyze the variance decomposition of the forecasting errors of the VAR model.

Our results indicate that, overall, the monetary policy variables do respond to and have some effect on the economic growth, the inflation rate, and the real effective exchange rate as in Western market economies. However, the relationships among monetary policy variables and macroeconomic activities tend to be weaker than those in Western market economies. More importantly, unlike what's been found in the Western economies, it is the growth rate of money supply that played a more crucial role in fine-tuning the economy, while the official interest rates played a very passive role. In the first 2 years of the sample period of 1992–2009, the money supply was too large and can be blamed for the ensuing high inflation in 1993–1994. The sharp decline in the money supply in 1994 was effective in bringing down inflation. For the remaining years of the sample period, the money supply had clear negative responses to both the inflation rate and the real output, in line with the MaCallum rule. The official interest rates passively responded to the inflation rate with a delay in the first half of the sample period and changed little in the second half of the sample period. Overall, the official interest rates had little effect on both the inflation rate and real output.

The rest of this paper is organized as follows. Section 2 begins with a brief review of the literature on the evaluation of monetary policies. It then provides a brief account of China's macroeconomic background, the government's emphasis on different goals in various periods, and the literature on China's monetary policies. This is followed by summary statistics and graphic illustrations of key macroeconomic variables for the sample period of 1992–2009. Section 3 investigates the responsiveness of the monetary policy variables to the economic conditions by estimating the Taylor rule and the McCallum rule equations. Section 4 presents an econometric analysis of the effectiveness of the monetary policy variables, using impulse response functions and variance decomposition of forecast errors, which characterize the importance of each variable in predicting future values of its own and other variables in the VAR system. Section 5 interprets the econometric results from a historical perspective. The last section concludes the paper.

2. Literature, economic background, and data

2.1. A brief review of related literature

Monetary policy evaluation has been an active research area in economics because of its immense importance. The literature is dominated by research on developed economies, especially the US. We briefly review the most relevant studies below and mention other related work in the following sections as the discussion proceeds.

After a relatively quiet period following Sargent and Wallace (1975) who argue that monetary policy can be ineffective under rational expectations and Lucas (1976) who critiques the naive predictions of non-structural models estimated with historical data, research on policy evaluation resumed in the late 1980s and 1990s. One of the active strands in the literature begins with Taylor (1993) who proposes a rule for central banks to set a nominal target interest rate that is increasing in the expected inflation-rate gap and the output gap. The rule describes how central banks raise (reduce) the target interest rate when the expected inflation is higher (lower) than the desired target inflation rate and when the actual output is greater (smaller) than the natural output. The Taylor rule and its variations have been estimated empirically for the US and other countries by economists around the world. Taylor (1993) first estimates the Taylor rule equation for the US. Clarida et al. (1998) provide international evidence. Taylor (2001) extends the rule to include exchange rate as one of the economic variables the official interest rate responds to. Kuzin (2006) uses the framework to analyze the inflation battling experience of the German central bank. Esanov et al. (2005) evaluate Russia's monetary policy. Kim and Nelson (2006) use a model with time-varying coefficients to estimate forward-looking monetary policy rules. Xie and Luo (2002) is the first study of China's monetary policy that used the Taylor rule.[1]

Similar to the Taylor rule for the official interest rate targeting, the McCallum (1988) rule describes the growth rate of the money supply. The original McCallum rule describes the growth rate of the money supply as a function of the growth rates of GDP and money velocity. More recent studies revise the McCallum rule so that the money supply growth targets the expected inflation-rate gap and the output gap, parallel to the Taylor rule. An example is Esanov et al. (2005). The revised McCallum rule describes how central banks reduce (increase) the money supply when the expected inflation is higher (lower) than the desired target inflation rate and when the actual output is greater (smaller) than the natural output.

There is also a body of literature on monetary policy rules based on vector autoregressive (VAR) models. Important studies include Sims (1992), Bernanke and Blinder (1992), Cristiano et al. (1999). They conclude that the federal funds target rate and the non-borrowed reserves are typical monetary policy variables in the US, while innovations to money supply are not ideal variables to represent monetary policy shocks.

[1] There have been a flurry of studies, mostly in Chinese journals, following Xie and Luo on the Taylor rule in China with extended sample periods. All these papers estimate fixed-coefficient Taylor rule models and conclude that the Taylor rule does not describe China's monetary policy well.

2.2. A brief history of china's recent economic development

China began its economic reforms in the early 1980s. Through its open-door policy, it attracted a large amount of foreign direct investments which propelled its high economic growth. The People's Bank of China became the central bank in 1984 and started to play an important role in fine-tuning economic activities. Between 1984 and 1994, the central bank's main objectives were to stimulate economic growth and to maintain stability in commodity prices. Balancing the two objectives, however, proved to be difficult. The real economy experienced a dramatic, albeit turbulent growth. Up to 2009, the highest growth occurred in 1984 with a real GDP growth rate of 15.2% and the lowest occurred in 1990 with just 3.8%. Overall, the real GDP growth averaged around 10% per year. In the meantime, there were three major high inflation episodes before 2009: one in 1985, one in 1989, and one in 1994. The last one saw an inflation rate of around 25%. These high inflation episodes were all caused by the easy credit provided to state-owned enterprises by government-controlled commercial banks and over-investments in hot industries and regions at the time. In the midst of each high inflation episode, the government scrambled to tighten the money supply and to raise the official interest rates. In 1995, after the highest inflation since the economic reform, the central bank revised its policy goals and set inflation fighting as its priority. Various measures were adopted to cool off the economy. These measures eventually proved to be effective. Both real economic growth rates and inflation rates fell considerably. The 1997 Asian Financial Crisis resulted in a serious decline in demand. The GDP growth rate dropped to below 8%, the inflation rate fell sharply, and the interest rates followed suit. In 1998, the inflation rate became negative for the first time and interest rates reached their lowest level since the start of the economic reform. They remained at low levels until 2006.

From 1988 to 1994, China ran a complicated dual-track system of exchange rates in which the official exchange rate and a market-determined exchange rate coexist. From 1994 to July 2005, the Chinese currency, known as the Renminbi, was pegged to the US dollar. Under the pressure of China's trading partners, the Renminbi has appreciated more than 20% against the US dollar since July 2005. The global financial crisis in the fall of 2008 caused a sharp downturn in China's export growth and the monetary authority of China repegged the Renminbi to the US dollar until May 2010. While the nominal exchange rate between the Renminbi and the US dollar was invariant for most of the sample period in this study, the exchange rate between the Renminbi and a basket of currencies of China's trading partners varied as those other currencies varied with the US dollar. In addition, since the inflation rates in China and all its trading partners fluctuated and the weights of trading volume with its partners changed over time, China's real effective exchange rate also fluctuated.

From the brief description above and the plots of data below, we see that the economy in China since the reforms is as cyclical as many Western economies in the Pre-Keynesian era. The large fluctuations of various economic variables in the last 20 years provide a good opportunity to study the responsiveness and effectiveness of the monetary policies in China.

2.3. Data

We use quarterly observations of macroeconomic variables in this study. The official interest rate, r_t, is the average of the 1-year deposit rate and the 1-year commercial lending rate where t indicates a quarter. Both rates are set by the central bank as the most important benchmark rates in China and are extremely highly correlated, with a roughly 3% spread between the commercial lending rate and the deposit rate. The inflation rate, π_t, is the quarterly observation of the annual Consumer Price Index (CPI) based inflation rate.[2] The real money growth rate, m_t, is the quarterly observation of the annual growth rate of the money supply (M1), minus the annual inflation rate.[3] In the literature on Western economies, some authors argue that money supply variables are not ideal monetary policy variables because money supply contains demand shocks. In China, however, the central bank claims that its main monetary tool is money supply, while other instruments and methods, such as the official interest rates, open market operations, and issuance of central bank notes, are supplementary tools to prevent the actual growth rate of money supply from deviating from its target too much. Money supply is, therefore, the most important monetary policy variable in China, as we verify in this paper. The real effective exchange rate (REER), compiled by the International Monetary Fund (IMF), is the index value of Renminbi in terms of a trade-weighted average of foreign currencies, adjusted for inflation rates of the involved countries.[4] We use $e_t = 100\log(\mathrm{REER}_t/100)$ in the paper and simply refer to it as the real effective exchange rate. The quarterly observations of the annual growth rate of Gross Domestic Products (GDP) is denoted as Y_t. In the analysis of the Taylor rule and the McCallum rule, the output gap, defined to be the actual log GDP minus its "natural" value, is used. The construction of the output gap is as follows. First, at the end of each quarter, t, we calculate the fourth-order moving average of the log quarterly real GDP, $\overline{\log \mathrm{GDP}}_t = \frac{1}{4}\sum_{j=0}^{3} \log \mathrm{GDP}_{t-j}$. We then follow the literature to construct the output gap using the standard filtering procedure initiated by Hodrick and Prescott (1997).

[2] China reports the *annual* inflation rate on a monthly basis. The exact monthly and quarterly inflation rates are not available.

[3] Real money supply, rather than the nominal one, better reflects the true economic situation, unmasked by inflation. McCallum (2000), Esanov et al. (2005) both use similar measures of real money supply in their analyses.

[4] The REER of China compiled by IMF is based on sixteen foreign currencies and weighted by the total import-export of the sixteen countries. The Bank for International Settlements compiles a similar series of REER for China, which is highly correlated with that of IMF.

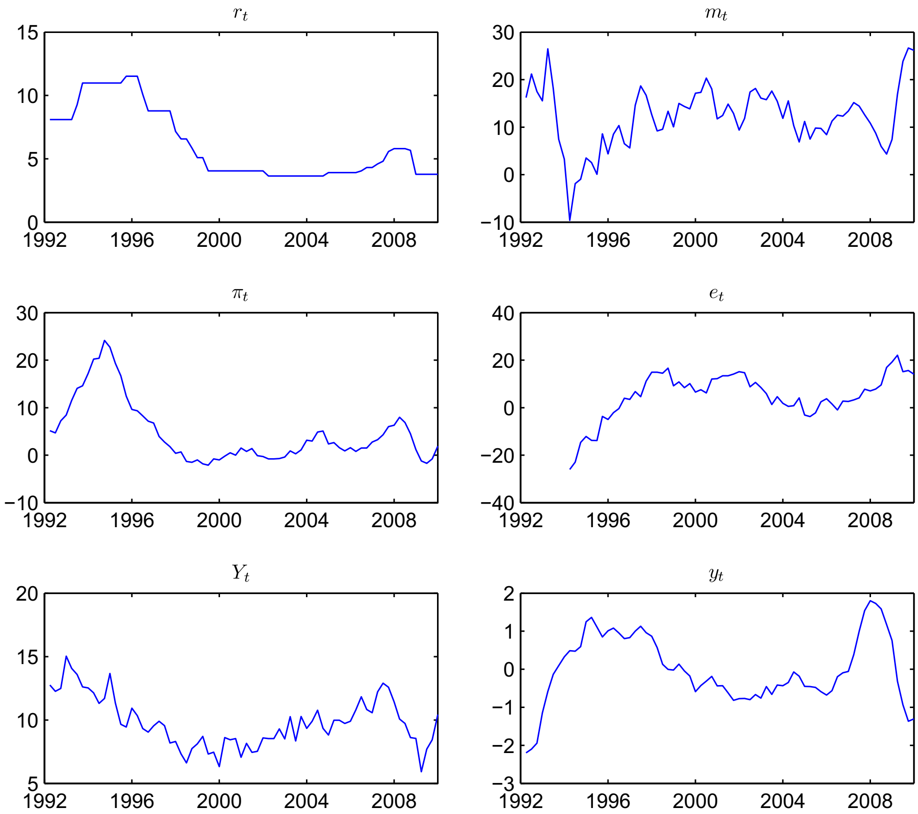

Fig. 1. Time series of macroeconomic variables. The six panels show quarterly observations (in percentage) of the official interest rate, r_t, the annual growth rate of real money supply, m_t, the annual inflation rate, π_t, the real effective exchange rate, e_t, the annual growth rate of GDP, Y_t, and the output gap, y_t, calculated with the Hodrick–Prescott filter.

Fig. 1 shows the time-series plots of these macroeconomic variables in percentages. The macroeconomic conditions in China during the sample period experienced substantial fluctuations as described in the previous subsection. The most notable features are the low output growth during 1998–2000 and high inflation rates centered around 1994. The pattern of the output gap, y_t, shown in the figure confirms the intuition of what the economy experienced during the sample period. The very negative output gap in 1992 follows the low GDP around 1990. Another prolonged period of a negative output gap starting sometime in 1998 corresponds to the low-growth period following the Asian Financial Crisis in 1997. The real effective exchange rate fluctuates over the sample period, despite the fact the nominal exchange rate is pegged to the US dollar before the second quarter of 2005 and after the third quarter of 2008.

The figure provides a first glimpse at how monetary policy variables correspond to macroeconomic variables. The official interest rate roughly follows the real output gap and the inflation rate. It underwent large fluctuations over the entire sample period, though the fluctuation in the second half of the sample period is much smaller. The real money growth rate also appears to be responsive to output and inflation. The period of the lowest real money supply growth in 1994 follows that of high growth in output and high inflation rate.

Panel A of Table 1 presents the descriptive statistics of these macroeconomic variables, including the mean, standard deviation, skewness, kurtosis, and several autocorrelation coefficients. The sample period is from the first quarter of 1992 to the last quarter of 2009 (1992.I–2009.IV), both inclusive, except for the real effective exchange rate which begins in 1994.I. The average of the growth rate of the real money supply is very high. The standard deviations of the inflation rate and the money supply growth rate are both high. The skewness and kurtosis of each variable do not show large violation of the normality. The autocorrelations of the variables are high for lags of one to three quarters because many of these variables are quarterly observations of annual growth rates. The autocorrelations of the four-quarter lag remain high except for the growth rate of the real money supply.

Panel B of Table 1 supplements the descriptive statistics in Panel A by reporting the correlations between pairs of macroeconomic variables with the log GDP replaced by the output gap. The lagged value of these variables are also included because they will be used in the later analyses of the Taylor rule and the McCallum rule. The official interest rate has a high correlation with the inflation rate and a very high correlation with its own lagged value. The growth rate of the real money supply is modestly and negatively correlated with the output gap and the inflation rate. It is negatively correlated with the official interest rate and positively correlated with its own lagged value. The correlation between the real effective exchange rate and the inflation rate is negative and large in magnitude. This reflects the fact that most variation in the real effective exchange rate is driven by the inflation rates, rather than by the exchange rate itself, for most of the sample period.

Table 1
Descriptive statistics of the macroeconomic variables. Panel A of this table presents descriptive statistics of the macroeconomic variables and interest rates. Panel B of the table presents the pairwise correlation coefficients between these variables. The macroeconomic variables are quarterly observations of the official interest rate, r_t, the annual growth rate of real money supply, m_t, the annual CPI inflation rate, π_t, the annual GDP growth rate, Y_t, the output gap, y_t, and the log of the real effective exchange rate, e_t. The official interest rate is the average of the 1-year deposit rate and commercial lending rate. All these rates are given in percentages. Besides the mean and standard deviation (st.dev) in percentage, the table also reports skewness, kurtosis (without subtracting 3), and autocorrelation coefficient, ρ_i, of lag i quarters for i = 1, 2, 3, 4, 6. The sample period is 1992.I–2009.IV, except for quantities involving e_t which begins at 1994.I.

Variable	Mean	St.dev	Skew	Kurt	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6
A. Descriptive statistics										
r_t	6.11	2.78	0.80	2.08	0.97	0.94	0.90	0.86	0.81	0.77
m_t	12.10	6.52	−0.38	4.07	0.74	0.47	0.25	0.05	−0.02	−0.09
π_t	4.63	6.43	1.44	4.27	0.97	0.90	0.81	0.70	0.61	0.51
Y_t	9.83	1.97	0.44	2.66	0.83	0.72	0.62	0.57	0.47	0.37
y_t	0.00	0.89	−0.05	2.72	0.89	0.71	0.51	0.33	0.19	0.08
e_t	5.05	9.62	−1.08	4.39	0.84	0.71	0.60	0.51	0.36	0.23
	r_t	m_t	π_t	y_t	e_t	r_{t-1}	m_{t-1}	π_{t-1}	y_{t-1}	e_{t-1}
B. Correlations between the variables										
r_t	1									
m_t	−0.50	1								
π_t	0.83	−0.62	1							
y_t	0.50	−0.55	0.43	1						
e_t	−0.57	0.59	−0.79	−0.29	1					
r_{t-1}	0.98	−0.51	0.78	0.52	−0.52	1				
m_{t-1}	−0.45	0.77	−0.52	−0.50	0.60	−0.48	1			
π_{t-1}	0.86	−0.66	0.97	0.51	−0.76	0.83	−0.62	1		
y_{t-1}	0.40	−0.54	0.29	0.94	−0.15	0.44	−0.53	0.41	1	
e_{t-1}	−0.66	0.65	−0.85	−0.40	0.93	−0.60	0.66	−0.82	−0.27	1

3. The responsiveness of monetary policies

3.1. The fixed-coefficient models

The original Taylor rule specifies that the target interest rate of the central bank, r_t^*, is determined by

$$r_t^* = a_c^* + a_\pi^*[E(\pi_{t+1}|I_t) - \pi^*] + a_y y_t, \tag{1}$$

where π_t is the realized annual inflation rate at t, π^* is the desired target inflation rate, I_t is the information set at t, and y_t is the output gap. In the absence of the so-called inflation bias and the output bias, the parameter a_c^* is the long-run equilibrium nominal interest rate. The parameters $a_\pi^* > 0$ and $a_y > 0$ are the measures of responsiveness of the target interest rate towards the inflation gap, $E(\pi_{t+1}|I_t) - \pi^*$, and the output gap, y_t. In this equation, an $a_\pi^* > 1$ represents an active interest rate policy and an $a_\pi^* \leqslant 1$ represents a passive interest rate policy. Similarly, a higher value of a_y represents a more active response of the interest rate policy towards output gap. Since the inflation rate is highly persistent, $E(\pi_{t+1}|I_t) = \pi_t$ is adopted by Taylor and many other authors. In general, we assume $E(\pi_{t+1}|I_t) = \gamma\pi_t$ for $\gamma \leqslant 1$. By denoting $a_\pi = \gamma a_\pi^*$, and $a_c = a_c^* - a_\pi^*\pi^*$, (1) can be rewritten as

$$r_t^* = a_c + a_\pi \pi_t + a_y y_t. \tag{2}$$

A more general Taylor rule also considers the response of the official interest rate to the real effective exchange rate, as in Taylor (2001),

$$r_t^* = a_c + a_\pi \pi_t + a_y y_t + a_e e_t. \tag{3}$$

As argued by Taylor (2001), the sign of a_e is supposed to be negative when the exchange rate is the value of the domestic currency in terms of (a weighted average of) foreign currencies.

In practice, central banks tend to maintain smoothness in the actual rate. Alternatively, central banks may sometimes compromise the market forces reflected in the existing interest rate. In the literature, it is commonly assumed that the actual interest rate, r_t, is a weighted average of the target rate, r_t^*, and the existing interest rate, r_{t-1}, plus a noise term, ε_t, due to other random factors at the time. This smoothing behavior is represented by

$$r_t = (1-\rho)r_t^* + \rho r_{t-1} + \varepsilon_t, \tag{4}$$

where $0 \leqslant \rho < 1$. The case of $\rho = 0$ corresponds to the original Taylor rule without smoothing. By combining (3) and (4), we obtain the following fixed-coefficient Taylor rule equation for the actual official interest rate.

$$r_t = (1-\rho)(a_c + a_\pi \pi_t + a_y y_t + a_e e_t) + \rho r_{t-1} + \varepsilon_t. \tag{5}$$

The generalized McCallum rule in this paper for the target growth rate of the real money supply is also a function of the inflation gap, the output gap, and for symmetry consideration, the real effective exchange rate,

$$m_t^* = b_c + b_\pi \pi_t + b_y y_t + b_e e_t. \tag{6}$$

We also consider a model in which the actual growth rate of the real money supply depends on its lagged value as an additional explanatory variable, plus a noise term,

$$m_t = (1-\phi)m_t^* + \phi m_{t-1} + \eta_t, \tag{7}$$

where m_t is the annual growth rate of the real money supply at the end of quarter t and η_t is a random noise term. The model to be estimated is then

$$m_t = (1-\phi)(b_c + b_\pi \pi_t + b_y y_t + b_e e_t) + \phi m_{t-1} + \eta_t. \tag{8}$$

A stabilizing rule for the money supply is supposed to be counter-cyclical. Therefore, the maintained hypothesis is that $b_\pi < 0$ and $b_y < 0$. Unlike the Taylor rule, however, the lagged value of the growth rate of the real money supply can be added for reasons other than the smoothing consideration. While the central bank can set its official interest rates precisely, the realized growth rate of the real money supply is not entirely determined by the central bank. First, there is an unexpected inflation component in the real money supply that is beyond the control of the central bank. More importantly, there are numerous factors on the demand side that can affect the recorded actual money supply. A monetary policy may specify that the current money supply should correct any deviation in the past money supply from its target. As a result, the sign of ϕ cannot be easily determined *a priori*.

Table 2
The Taylor rule and McCallum rule. This table presents the estimated Taylor rule and McCallum rule with fixed coefficients, $r_t = (1-\rho)[a_c + a_\pi \pi_t + a_y y_t + a_e e_t] + \rho r_{t-1} + D_t\left[(1-\rho')\left(a'_c + a'_\pi \pi_t + a'_y y_t + a'_e e_t\right) + \rho' r_{t-1}\right] + \varepsilon_t$, $m_t = (1-\phi)[b_c + b_\pi \pi_t + b_y y_t + b_e e_t] + \phi m_{t-1} + D_t\left[(1-\phi')\left(b'_c + b'_\pi \pi_t + b'_y y_t + b'_e e_t\right) + \phi' m_{t-1}\right] + \eta_t$, where r_t is the official interest rate, m_t is the annual growth rate of real money supply, π_t is the annual inflation rate, y_t is the output gap, e_t is the real effective exchange rate, and $D_t \equiv 0$ in Panel A and is the dummy variable for 2000.I–2009.IV in Panel B. The Newey-West t-ratios in parentheses are adjusted for a 4-quarter lag. The sample period is 1992.I–2009.IV, except for the equations involving e_t which begins at 1994.I.

a_c	a_π	a_y	a_e	ρ	R^2
A. $D_t \equiv 0$					
3.24	0.53	−0.53		0.88	0.98
(5.53)	(4.93)	(−0.89)		(29.07)	
4.65	0.24	0.52	−0.12	0.87	0.98
(6.91)	(2.36)	(0.76)	(−1.56)	(25.37)	
b_c	b_π	b_y	b_e	ϕ	R^2
15.14	−0.61	−2.90		0.57	0.67
(11.70)	(−3.03)	(−1.99)		(7.83)	
13.58	−0.30	−2.79	0.10	0.56	0.72
(5.40)	(−0.71)	(−1.09)	(0.40)	(6.53)	
a_c	a_π	a_y	a_e	ρ	R^2
B. D_t equals the dummy for 2000.I–2009.IV					
4.14	0.46	−0.57		0.86	0.98
(2.50)	(3.37)	(−0.80)		(11.15)	
5.50	0.06	2.53	−0.16	0.80	0.98
(4.18)	(0.45)	(3.48)	(−1.46)	(5.67)	
a'_c	a'_π	a'_y	a'_e	ρ'	
1.20	−0.01	0.27		−0.42	
(2.39)	(−0.28)	(2.48)		(−1.86)	
0.92	0.03	−0.13	0.03	−0.39	
(1.16)	(0.56)	(−0.38)	(1.49)	(−1.25)	
b_c	b_π	b_y	b_e	ϕ	R^2
15.80	−0.58	−3.25		0.45	0.70
(8.49)	(−2.93)	(−2.16)		(5.48)	
13.34	−0.70	1.76	−0.06	0.20	0.78
(3.67)	(−1.42)	(0.65)	(−0.17)	(1.12)	
b'_c	b'_π	b'_y	b'_e	ϕ'	
−4.85	−1.09	4.08		0.32	
(−1.30)	(−2.23)	(2.39)		(2.30)	
−12.12	−1.15	−0.97	0.11	0.57	
(−1.17)	(−0.99)	(−0.18)	(0.17)	(2.66)	

Table 3
The Taylor rule and McCallum rule: lagged dependent variables. This table presents the estimated Taylor rule and McCallum rule with fixed coefficients, $r_t = (1-\rho)[a_c + a_\pi \pi_{t-1} + a_y y_{t-1} + a_e e_{t-1}] + \rho r_{t-1} + D_t\left[(1-\rho')\left(a'_c + a'_\pi \pi_{t-1} + a'_y y_{t-1} + a'_e e_{t-1}\right) + \rho' r_{t-1}\right] + \varepsilon_t$, $m_t = (1-\phi)[b_c + b_\pi \pi_{t-1} + b_y y_{t-1} + b_e e_{t-1}] + \phi m_{t-1} + D_t[(1-\phi')\left(b'_c + b'_\pi \pi_{t-1} + b'_y y_{t-1} + b'_e e_{t-1}\right) + \phi' m_{t-1}] + \eta_t$, where r_t is the official interest rate, m_t is the annual growth rate of real money supply, π_t is the annual inflation rate, y_t is the annual output gap, e_t is the real effective exchange rate, and $D_t \equiv 0$ in Panel A and is the dummy variable for 2000.I–2009.IV in Panel B. The Newey-West t-ratios in parentheses are adjusted for a 4-quarter lag. The sample period is 1992.I–2009.IV, except for the equations involving e_t which begins at 1994.I.

a_c	a_π	a_y	a_e	ρ	R^2
A. $D_t \equiv 0$					
3.12	0.54	−1.23		0.88	0.98
(5.00)	(4.59)	(−1.64)		(21.63)	
4.78	0.21	0.09	−0.14	0.87	0.98
(5.83)	(1.90)	(0.12)	(−1.57)	(23.15)	
b_c	b_π	b_y	b_e	ϕ	R^2
15.05	−0.60	−2.35		0.53	0.66
(12.09)	(−2.78)	(−1.86)		(6.27)	
11.52	0.03	−3.12	0.30	0.55	0.72
(4.80)	(0.06)	(−1.60)	(1.09)	(6.22)	
a_c	a_π	a_y	a_e	ρ	R^2
B. D_t equals the dummy for 2000.I–2009.IV					
4.44	0.44	−0.91		0.83	0.98
(3.81)	(5.11)	(−1.53)		(10.59)	
5.18	0.13	1.92	−0.12	0.76	0.98
(8.11)	(1.74)	(3.43)	(−1.73)	(7.12)	
a'_c	a'_π	a'_y	a'_e	ρ'	
0.69	−0.04	0.26		−0.22	
(1.15)	(−0.85)	(1.96)		(−1.12)	
0.34	−0.05	−0.17	0.01	−0.09	
(0.40)	(−1.49)	(−0.51)	(0.50)	(−0.47)	
b_c	b_π	b_y	b_e	ϕ	R^2
15.63	−0.57	−2.87		0.41	0.69
(9.63)	(−3.10)	(−2.46)		(5.91)	
15.31	−0.76	0.90	−0.18	0.37	0.77
(4.63)	(−1.74)	(0.37)	(−0.56)	(2.12)	
b'_c	b'_π	b'_y	b'_e	ϕ'	
−1.33	−1.06	3.90		0.18	
(−0.42)	(−1.58)	(1.91)		(1.28)	
−5.17	−0.30	−0.44	0.37	0.23	
(−1.07)	(−0.42)	(−0.16)	(1.22)	(1.16)	

Table 2 reports the regression results of the Taylor rule Eq. (5) and the McCallum rule Eq. (8) for the sample period 1992.I–2009.IV using the nonlinear least squares (NLS) estimation. Panel A is for the entire sample period, while Panel B shows the results that allow parameters to be different across the subperiod 1992.I–2000.IV and the subperiod 2000.I–2009.IV. The parameters $\left(a'_c, a'_\pi, a'_y, a'_e\right)$ and $\left(b'_c, b'_\pi, b'_y, b'_e\right)$ are the changes in the second subperiod. Since the data are quarterly observations of annual growth rates, the error terms of the two equations are likely autocorrelated. The numbers in parentheses under the coefficient estimates in the table are Newey-West t-ratios, adjusted for a four-quarter lag.

During the entire sample period, the official interest rate responds positively to the inflation rate. The response, however, appears to be passive: $a_\pi < 1$.[5] In addition, the official interest rate exhibits an insignificant response to the output gap. The sign of a_e is negative, as the theory predicts, but its significance is low, both economically and statistically. As the McCallum rule describes, the growth rate of the real money supply is significantly negatively related to the output gap and significantly negatively related to the inflation rate. Its response to the real effective exchange rate is small and insignificant. The inclusion of the real effective exchange rate weakens the role of the inflation rate, as they are highly negatively correlated.

The results in Panel B reveal a substantial difference between the two subperiods, as some of the parameters of $\left(a'_c, a'_\pi, a'_y, a'_e\right)$ and $\left(b'_c, b'_\pi, b'_y, b'_e\right)$ are significantly different from zero. The most meaningful result is that the real money supply in the second subperiod is more responsive to the inflation rate and is insensitive to the output gap (as $b_y + b'_y$ is slightly positive).

[5] The time-series model of the inflation rate gives $E(\pi_{t+1}|\pi_t) = 0.10 + 0.97\pi_t$, so $a^*_\pi < 1$ remains true.

Since the actual data on the inflation rate and output are reported with a delay, at the time of policy making, the required information may not be entirely available. As a result, the model may be mis-specified. To accommodate such a possibility, we re-estimate the model with the lagged variables, π_{t-1}, y_{t-1}, and e_{t-1} for both the Taylor rule and the MaCallum rule. The results are reported in Table 3.

The results in Table 3 are consistent with those in Table 2. The signs and the magnitudes of the parameter estimates are roughly the same as the corresponding ones in Table 2. The *t*-ratios of the estimates are also similar in general. As such, the basic conclusions using contemporaneous variables remain the same. Overall, the official interest rate responds passively to the inflation gap, but it does not respond to the output gap, while the real money supply responds negatively to both the inflation gap and the output gap.

3.2. The time-varying-coefficient models

While the Taylor rule and the McCallum rule with fixed coefficients have shown to be useful in describing the monetary policies adopted by the central banks of various countries, the literature has also documented evidence that central banks tend to maintain a great deal of discretion rather than mechanically follow any given rule. For example, Clarida et al., 2000 find that the estimated Taylor rule for the US Federal Reserve changes remarkably after the Volcker disinflation period. Demers and Rodriguez (2001) investigate the stability of the Taylor rule for the Canadian central bank in the period 1963–1999 and show that the monetary rule cannot be evaluated over this period without taking into account parameter instability and structural changes. One reason for time-varying coefficients is the persistency of the inflation rate. There are periods of high inflation rates and periods of low inflation rates. The target inflation rate, π^*, may change from time to time as a result. Extensions to the original Taylor rule that accommodate structural flexibility of model parameters abound in the literature. Kim and Nelson (2006) analyze a model with time-varying coefficients in the Taylor rule, while Sims and Zha (2006) argue for the importance of time-varying variance of shocks in modeling monetary policy rules.

The subperiod results presented in the last subsection indicate that it is worthwhile to consider models of the Taylor rule and the McCallum rule with time-varying coefficients. While there can be various specifications of the models of this nature, one criterion we have is to maintain simplicity and avoid over-parametrization. For that reason, we begin with the models with all the parameters varying over time, similar to those used by Kim and Nelson (2006). We then examine the variability of each estimated time-varying parameters and set the parameters that do not show significant variation as constants. The final models are

$$r_t = (1-\rho)(a_{ct} + a_{\pi t}\pi_t + a_y y_t + a_e e_t) + \rho r_{t-1} + \varepsilon_t, \tag{9}$$

$$m_t = (1-\phi)(b_{ct} + b_{\pi t}\pi_t + b_y y_t + b_e e_t) + \phi m_{t-1} + \eta_t. \tag{10}$$

We assume $a_{it} = a_{i,t-1} + u_{it}$, $u_{it} \sim N(0, \sigma^2_{ui})$ for $i = c, \pi$ and $\varepsilon_t \sim N(0, \sigma^2_{\varepsilon})$. Similarly, we assume $b_{it} = b_{i,t-1} + \upsilon_{it}$, $\upsilon_{it} \sim N(0, \sigma^2_{\upsilon i})$ for $i = c, \pi$ and $\eta_t \sim N\left(0, \sigma^2_{\eta}\right)$, All the shocks, ε_t, η_t, u_{at}, $u_{\pi t}$, υ_{at}, and $\upsilon_{\pi t}$ are assumed to be independent. The time-varying coefficients are treated as unobserved state variables. The models are estimated with the Markov Chain Monte Carlo (MCMC) method using the Kalman filter as the initial estimate. The estimated parameters, a_y, a_e, σ_{ε}, σ_{ua}, $\sigma_{u\pi}$, ρ, b_y, b_e, σ_{η}, σ_{va}, $\sigma_{v\pi}$, and ϕ are reported in Table 5. The sign and significance of a_y and b_y are consistent with those in Tables 2 and 3. So are the sign and significance of a_e and b_e. The standard deviations of the error terms of the time-varying coefficients reported in Table 4 are all significant. The significance of σ_{ua}, $\sigma_{u\pi}$, σ_{va}, and $\sigma_{v\pi}$ justifies the use of models with time-varying coefficients.

The time-series of the estimated time-varying coefficients, a_{ct}, $a_{\pi t}$, b_{ct}, and $b_{\pi t}$ are plotted in Fig. 2. It confirms that there are considerable variations in these coefficients if they are allowed to vary. For some parameters, estimates from the models with fixed coefficients reflect the average values of the time-varying ones. Exceptions, however, do exist. The estimated a_{ct} gradually increases over time, which is not seen from Tables 2 and 3. The reason for an increased a_{ct} is that the inflation rate was very high in the first few years of the sample period and low afterwards. It is possible that the target inflation rate of the

Table 4
Estimates of the time-varying-coefficient Taylor rule and McCallum rule. This table presents the estimated parameters of the Taylor rule and the McCallum rule with time-varying coefficients, $r_t = (1-\rho)(a_{ct} + a_{\pi t}\pi_t + a_y y_t + a_e e_t) + \rho r_{t-1} + \varepsilon_t$, $m_t = (1-\phi)(b_{ct} + b_{\pi t}\pi_t + b_y y_t + b_e e_t) + \phi m_{t-1} + \eta_t$, with $a_{it} = a_{i,t-1} + u_{it}$, $u_{it} \sim N(0, \sigma^2_{ui})$ for $i = c, \pi$, $\varepsilon_t \sim N(0, \sigma^2_{\varepsilon})$, $b_{it} = b_{i,t-1} + \upsilon_{it}$, $\upsilon_{it} \sim N(0, \sigma^2_{\upsilon i})$ for $i = c, \pi$. All the shocks ε_t, u_{at}, $u_{\pi t}$ η_t, υ_{at}, and $\upsilon_{\pi t}$ are independent. The model is estimated with the Markov Chain Monte Carlo (MCMC) method. The numbers below the parameter estimates are the *t*-ratios. The sample period is 1994.I–2009.IV.

a_y	a_e	ρ	σ_{ε}	σ_{uc}	$\sigma_{u\pi}$
0.32 (1.33)	−0.13 (−0.17)	0.91 (26.21)	0.33 (21.26)	0.32 (19.97)	0.22 (28.35)
b_y	b_e	ϕ	σ_{η}	σ_{vc}	$\sigma_{v\pi}$
−2.43 (−7.49)	−0.01 (−0.20)	0.49 (10.21)	1.22 (18.08)	0.27 (23.84)	0.23 (26.47)

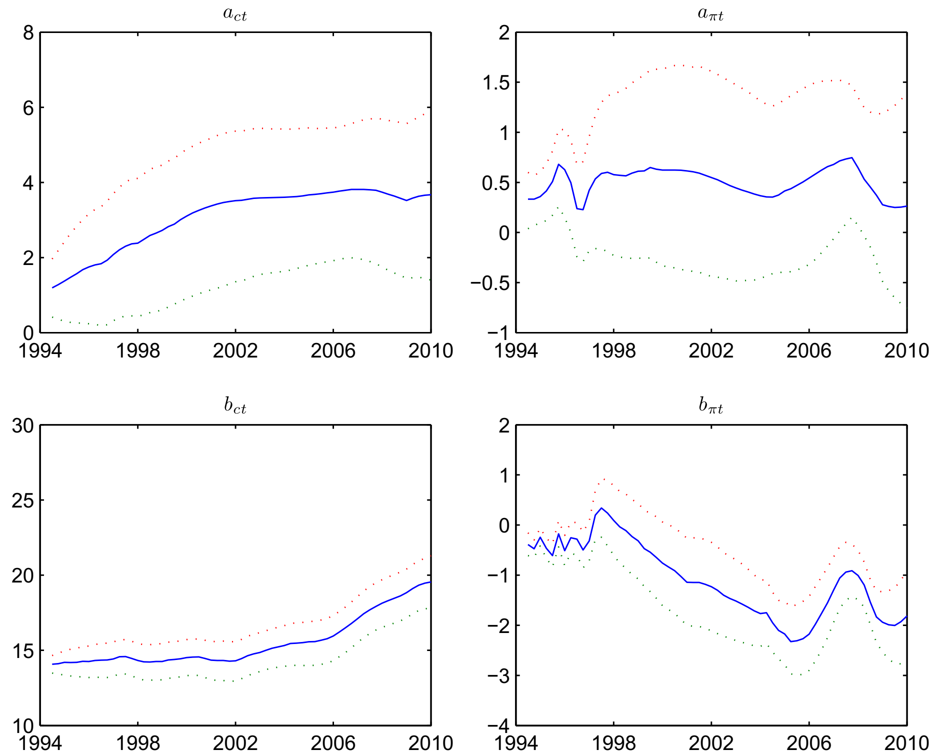

Fig. 2. Time-varying coefficients of the Taylor and McCallum rules. This figure plots the estimated time-varying coefficients of the Taylor rule, a_{ct} and $a_{\pi t}$, and of the McCallum rule, b_{ct} and $b_{\pi t}$. The dashed lines indicate the 90% confidence interval.

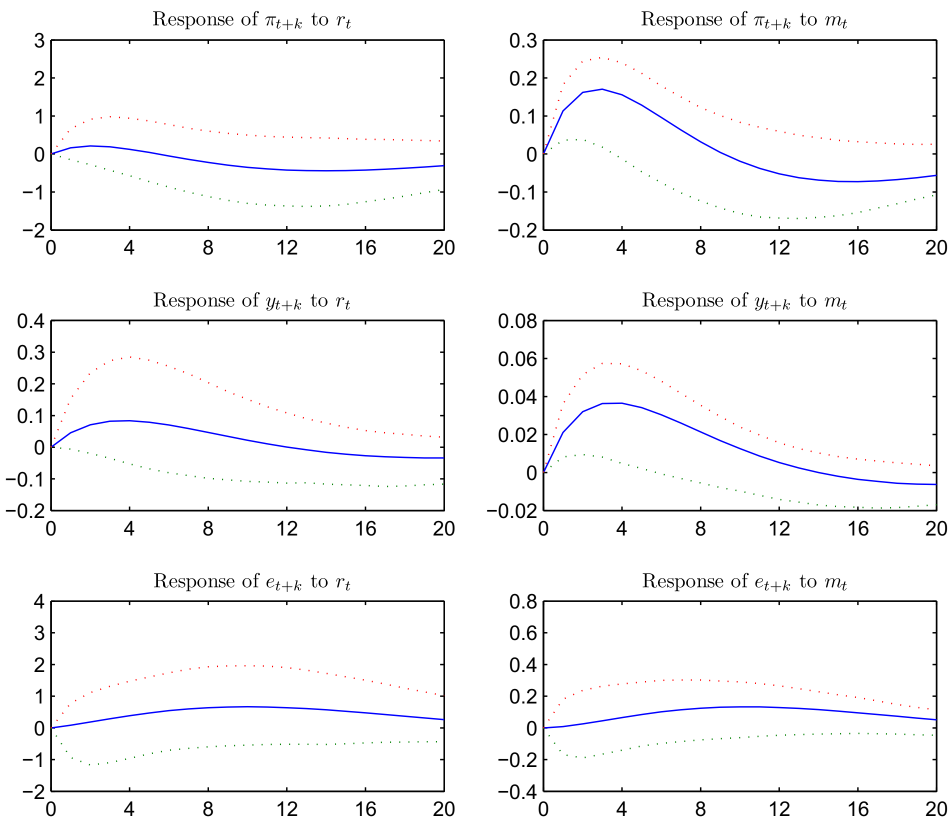

Fig. 3. The orthogonalized impulse response functions: $x_t = (\pi_t, y_t, e_t, r_t, m_t)'$. This figure plots the impulse response functions of the economic variables, π_{t+k}, y_{t+k}, and e_{t+k} to the shock of monetary policy variables, r_t and m_t, where $k = 1, \ldots, 20$ quarters. The order of the variables in the VAR is $x_t = (\pi_t, y_t, e_t, r_t, m_t)'$. The dashed lines indicate the 90% confidence interval.

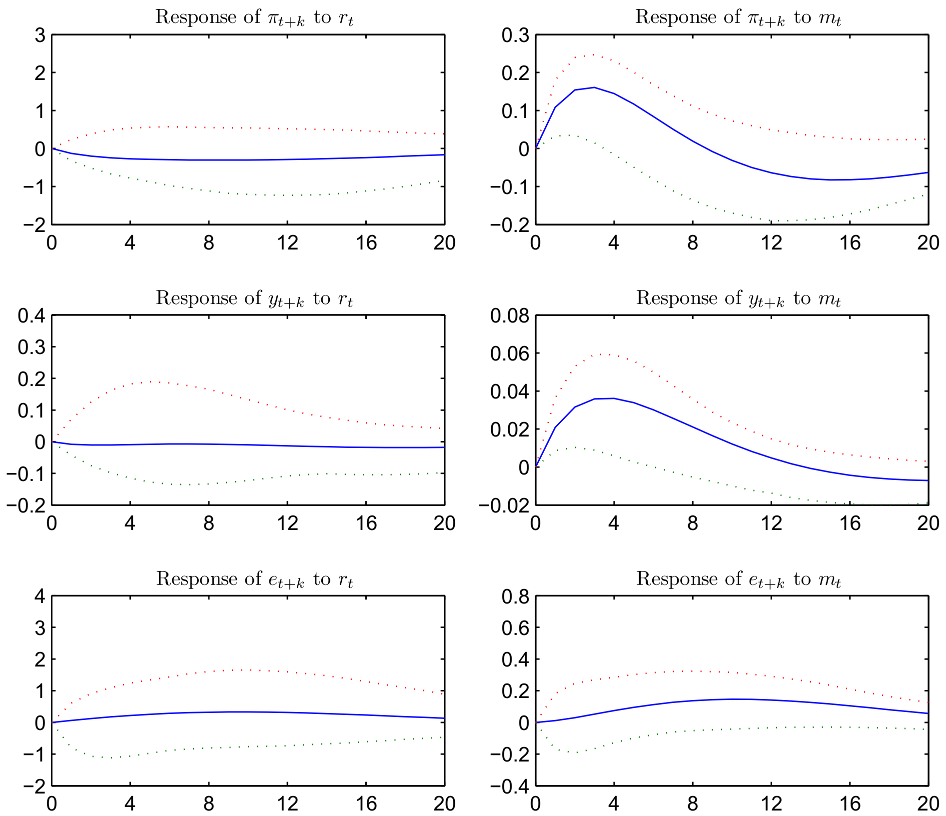

Fig. 4. The orthogonalized impulse response functions: $x_t = (\pi_t, y_t, e_t, m_t, r_t)'$. This figure plots the impulse response functions of the economic variables, π_{t+k}, y_{t+k}, and e_{t+k} to the shock of monetary policy variables, r_t and m_t, where $k = 1, \ldots, 20$ quarters. The order of the variables in the VAR is $x_t = (\pi_t, y_t, e_t, m_t, r_t)'$. The dashed lines indicate the 90% confidence interval.

central bank, π^*, follows the same pattern. As a result, $a_{ct} = a_0^* - a_{\pi t}^* \pi_t^*$ increased over time, as π_t^* decreased over time, while $a_{\pi t}$ fluctuated around 0.5. For the time-varying features of the McCallum rule, the responsiveness of the growth rate of the real money supply to the inflation rate, $b_{\pi t}$, is initially near zero, and is briefly positive in 1997, which is undetected in the fixed-coefficient models. After that, it basically stays in the negative region just as the results in Tables 2 and 3 indicate. Some of the interesting phenomena are not obvious from the models with fixed coefficients.

4. The effectiveness of monetary policies

4.1. The impulse response functions from VAR model

Following the recent literature, we use a vector autoregressive (VAR) model to analyze the relationships among the official interest rate, the growth rate of the real money supply, the inflation rate, and the output gap. We denote x_t as a vector with components y_t, π_t, e_t, r_t, and m_t. The VAR equation for x_t takes the form

$$x_t = a_0 + \sum_{i=1}^{p} A_i x_{t-i} + \varepsilon_t, \tag{11}$$

where a_0 is a constant 4-vector, A_i's are constant 5×5 matrices, and ε_t is the error term. While the VAR model can be used to analyze the interactions among all the components of x_t, our purpose in this section is to analyze the effectiveness of the monetary policy variables (r_t, m_t) on current and future economic variables (y_t, π_t, e_t). For that purpose, a constant coefficient model appears appropriate because what we are trying to capture here is the aggregate reaction of the economy as a whole to the policy variables, unlike the Taylor rule and the McCallum rule which describe central bankers' discretion. We use quasi-maximum likelihood to estimate the parameters. The VAR order, $p = 1$, is determined by the likelihood ratio test.

In Figs. 3 and 4, we plot the orthogonalized impulse response functions of the inflation rate, the output gap, and the real effective exchange rate with respect to the official interest rate and the growth rate of the real money supply. The impulse response functions are the expected increases in one component of x_{t+k} in percentage for a one-percent increase in another component of x_t. Let's take for example, the expected increase in the inflation rate at $t + 4$ for a one-percent increase in the real money supply at t. Fig. 3 is based on $x_t = (\pi_t, y_t, e_t, r_t, m_t)'$ while Fig. 4 is based on $x_t = (\pi_t, y_t, e_t, m_t, r_t)'$. We present the results for two different orders of x_t to show the robustness of the results because the order may matter. The solid line is the estimated impulse response function. The dashed line above the solid line is the 95th-percentile of the distribution of the

Table 5
Variance decompositions of prediction errors: $x_t = (\pi_t, y_t, e_t, r_t, m_t)'$. This table presents the variance decompositions of the prediction errors of the inflation rate, π_t, the output gap, y_t, the real effective exchange rate, e_t, the official interest rate, r_t, and the growth rate of the money supply, m_t. The prediction horizons are zero quarters, four quarters, and 20 quarters. The numbers (in percentage) indicate the variation over a future date of a variable indicated on the left attributed to the variable indicated at the top of the column. The numbers in parentheses are t-ratios. The sample period is 1994.I–2009.IV.

	π_t	y_t	e_t	r_t	m_t
π_t					
0 quarter	100	0.0	0.0	**0.0**	**0.0**
	(–)	(–)	(–)	(–)	(–)
4 quarters	74.8	4.4	9.6	**0.3**	**11.0**
	(6.3)	(0.6)	(1.0)	(**0.1**)	(**1.7**)
20 quarters	38.8	42.6	10.2	**1.5**	**6.9**
	(2.6)	(2.8)	(1.2)	(**0.3**)	(**1.3**)
y_t					
0 quarter	5.5	94.5	0.0	**0.0**	**0.0**
	(1.1)	(19.4)	(–)	(–)	(–)
4 quarters	3.7	69.6	14.9	**1.0**	**10.8**
	(0.5)	(6.2)	(1.6)	(**0.2**)	(**1.4**)
20 quarters	6.9	56.1	22.7	**1.3**	**13.0**
	(0.8)	(5.0)	(2.0)	(**0.2**)	(**1.6**)
e_t					
0 quarter	0.2	1.1	98.8	**0.0**	**0.0**
	(0.0)	(0.4)	(21.3)	(–)	(–)
4 quarters	2.8	10.4	86.4	**0.2**	**0.2**
	(0.4)	(1.0)	(7.3)	(**0.1**)	(**0.1**)
20 quarters	4.0	36.1	54.5	**1.7**	**3.7**
	(0.6)	(2.7)	(3.8)	(**0.4**)	(**0.7**)
r_t					
0 quarter	*0.0*	*1.2*	*0.0*	98.7	0.0
	(0.0)	*(0.4)*	*(0.0)*	(23.6)	(–)
4 quarters	*5.5*	*0.9*	*8.9*	79.3	5.4
	(0.7)	*(0.2)*	*(1.0)*	(7.0)	(1.2)
20 quarters	*15.8*	*40.8*	*8.6*	30.5	4.4
	(1.3)	*(2.8)*	*(0.8)*	(2.3)	(0.9)
m_t					
0 quarter	*3.8*	*0.2*	*0.0*	8.7	87.3
	(1.0)	*(0.1)*	*(0.0)*	(1.7)	(13.3)
4 quarters	*6.7*	*7.3*	*10.4*	8.6	66.9
	(1.0)	*(1.1)*	*(1.5)*	(1.9)	(6.6)
20 quarters	*8.7*	*12.9*	*17.3*	7.6	53.6
	(1.2)	*(1.8)*	*(2.3)*	(1.8)	(5.3)

estimator and the dashed line below the solid line is the fifth-percentile of the distribution. We use bootstrapping with 5000 replications to calculate the distributions of the estimated parameters, without relying on the normality assumption about the error term. As a result, the parameter estimate may not be at the center of the 90% confidence interval due to potential asymmetry of the distribution.

The top-left panel in Fig. 3 shows that the impulse response of the inflation rate to the official interest rate is near zero for all the horizons. In the middle-left panel, the impulse response of the output gap to the official interest rate is also flat around zero for all the horizons, meaning that the changes in the official interest rate have no effects on the future output gap either.[6] The bottom-left panel shows that the real effective exchange rate does not respond to the official interest rate either. In sum, the graph basically indicates that the official interest rate has no effect on the future economic activities.

The top-right panel shows that the response of the inflation rate to the growth rate of real money supply is positive for about 20 quarters. The curve is also humped and the maximum of about 0.18 is reached somewhere near three quarters. The response is significant only for short horizons. The middle-right panel shows that the response of the output gap to the real money supply is positive and marginally significant. The magnitude of the response is quite small. A one-percent decrease in the real money supply causes the output gap to reduce by less than 0.02 in the next quarter. The impact reaches its maximum in less than four quarters and then decays over time. In the bottom-right panel, the impulse response of the real effective exchange rate to the real money supply is insignificant.

In Fig. 4 where the order of the two monetary policy variables is swapped, all the impulse response functions resemble those in Fig. 3. The similarity between Figs. 3 and 4 goes to show that the results are quite robust to the order of the VAR vector.

[6] It should be noted that the conclusion is made for the effects of the official interest rate on the output gap, y_t, rather than on the growth rate of output, Y_t. Our results (not reported here) show that the responses of output itself to the official interest rate are slightly negative.

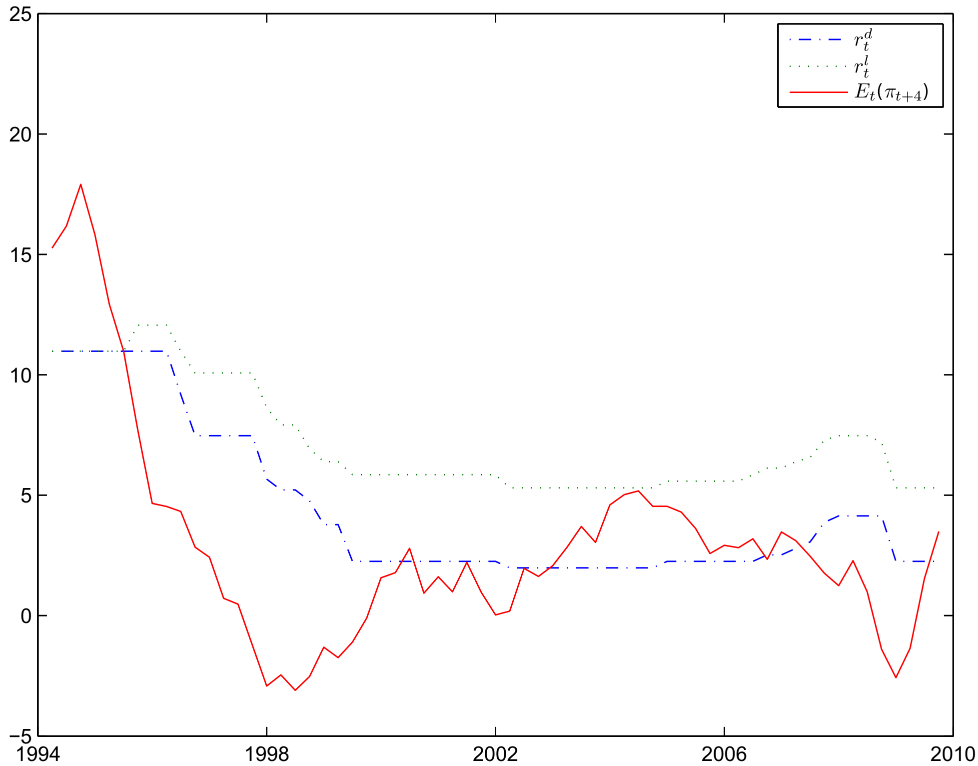

Fig. 5. The deposit rate, the lending rate, and the expected inflation rate. This figure plots the 1-year deposit rate, r_t^d, the 1-year commercial lending rate, r_t^l, and the expected annual inflation rate, $E_t(\pi_{t+1})$.

The results of the impulse response functions are consistent with the earlier results on how the monetary policy variables respond to the economic variables. The official interest rate is passive to the variation in the inflation rate. In addition, the official interest rate does not respond to the output gap. As a result, future inflation rates and output gap are not influenced by the current official interest rate either. On the other hand, the growth rate of the real money supply does respond to both the inflation rate and the output gap. The current money supply also has some effect on the inflation rate and the output gap in the near future.

4.2. Variance decompositions

Tables 5 and 6 report the variance decompositions of the VAR analysis for three prediction horizons: zero quarter (i.e., the immediate effects), four quarters and 20 quarters. Table 5 is the result for $x_t = (\pi_t, y_t, e_t, r_t, m_t)'$ and Table 6 is the result for $x_t = (\pi_t, y_t, e_t, m_t, r_t)'$. Each table contains variance ratios in five panels and their *t*-ratios in parentheses. A variance ratio number in column *j* of panel *i* indicates the proportion of the variation over certain quarters in the future of $x_{i,t+k}$ contributed by $x_{j,t+s}$ for $s = 0, 1, \ldots, k-1$. For example, the last variance ratio number in the first column, 8.7, means that 8.7% of the variation in m_{t+20} is attributed to π_{t+s} for *s* between 0 and 19. The numbers of greatest interest are the variations of π_t, y_t, and e_t attributed to r_t and m_t. These numbers (in boldface) measure the effects of the monetary policy variables on future economic variables. We also look at the variations of r_t and m_t attributed to π_t, y_t, and e_t for comparison. These numbers (in italics) measure the responses of the monetary policy variables to the past economic variables.

The boldfaced numbers in Table 5 indicate that the much of variation in the future inflation rate and output gap can be attributed to the real money supply, but not to the official interest rate. As much as 11.0% of the variation in the inflation rate four quarters later and 6.9% of the variation in the inflation rate 20 quarters later are attributed to the real money supply. As much as 10.8% of the variation in the output gap four quarters later and 13.0% of the variation in the output gap 20 quarters later are attributed to the real money supply. The associated *t*-ratios, however, indicate that they are not significant. In contrast, less than 2% of the variation in either future inflation or output gap can be attributed to the official interest rate. The variation in the future real exchange rate can neither be explained by the official interest rate, nor by the real money supply.

The proportions of future variations in the official interest rate and money supply attributed to the current inflation rate and the output gap, reported in italics in Table 5, tend to be much greater and more significant. There is an obvious asymmetry between the impacts of the economic variables on the policy variables and the impacts of the policy variables on the economic variables. This asymmetry is a reflection of the passiveness of the policy variables in response to the economic variables.

In Table 6, the order of the variables is changed to $x_t = (\pi_t, y_t, e_t, m_t, r_t)$. The numbers are somewhat different from those in Table 5. The patterns, however, remain the same.

Table 6
Variance decompositions of prediction errors: $x_t = (\pi_t, y_t, e_t, m_t, r_t)'$. This table presents the variance decompositions of the prediction errors of the inflation rate, π_t, the output gap, y_t, the real effective exchange rate, e_t, the official interest rate, r_t, and the growth rate of the money supply, m_t. The prediction horizons are zero quarters, four quarters, and 20 quarters. The numbers (in percentage) indicate the variation over a future date of a variable indicated on the left attributed to the variable indicated at the top of the column. The numbers in parentheses are t-ratios. The sample period is 1994.I–2009.IV.

	π_t	y_t	e_t	m_t	r_t
π_t					
0 quarter	100	0.0	0.0	**0.0**	**0.0**
	(–)	(–)	(–)	(**–**)	(**–**)
4 quarters	74.8	4.4	9.6	**10.9**	**0.4**
	(6.2)	(0.6)	(1.0)	(**1.5**)	(**0.3**)
20 quarters	38.8	42.6	10.2	**7.5**	**0.9**
	(2.5)	(2.8)	(1.2)	(**1.2**)	(**0.2**)
y_t					
0 quarter	5.5	94.5	0.0	**0.0**	**0.0**
	(1.2)	(19.6)	(–)	(**–**)	(**–**)
4 quarters	3.7	69.6	14.9	**11.8**	**0.0**
	(0.5)	(6.2)	(1.6)	(**1.3**)	(**0.0**)
20 quarters	6.9	56.1	22.7	**14.2**	**0.1**
	(0.8)	(5.0)	(2.1)	(**1.5**)	(**0.0**)
e_t					
0 quarter	0.2	1.1	98.8	**0.0**	**0.0**
	(0.0)	(0.4)	(21.4)	(**–**)	(**–**)
4 quarters	2.8	10.4	86.4	**0.4**	**0.1**
	(0.4)	(1.0)	(7.2)	(**0.1**)	(**0.0**)
20 quarters	4.0	36.1	54.5	**5.0**	**0.4**
	(0.5)	(2.7)	(3.8)	(**0.8**)	(**0.1**)
m_t					
0 quarter	*4.2*	*0.2*	*0.0*	95.6	0.0
	(1.0)	*(0.1)*	*(0.0)*	(18.2)	(–)
4 quarters	*7.1*	*7.7*	*10.9*	73.7	0.5
	(1.0)	*(1.2)*	*(1.5)*	(7.0)	(0.5)
20 quarters	*9.0*	*13.4*	*18.0*	58.3	1.3
	(1.2)	*(1.9)*	*(2.3)*	(5.3)	(0.6)
r_t					
0 quarter	*0.0*	*1.1*	*0.0*	9.5	89.3
	(0.0)	*(0.4)*	*(0.0)*	(1.6)	(14.9)
4 quarters	*5.3*	*0.9*	*8.7*	22.3	62.8
	(0.7)	*(0.2)*	*(1.0)*	(2.2)	(5.3)
20 quarters	*15.7*	*40.5*	*8.5*	12.4	23.0
	(1.3)	*(2.8)*	*(0.9)*	(1.6)	(2.0)

5. Historical perspectives

The results of the econometric analyses conducted in the last two sections can be interpreted from historical perspectives. We summarize the main features of the monetary policy variables below by referring to the major events that occurred during the sample period.

One important feature in the behavior of the monetary policy variables is their passiveness. This is more evident in the official interest rates. Before the economic reforms, the official interest rates barely moved. After the inception of the economic reforms, the behavior of the official interest rates changed dramatically. The government learned to use the official interest rates, in conjunction with the money supply, to fine-tune the economy. The sharp decline in the official interest rates in the 1996–1999 period, as seen from Fig. 1, is the reaction of the government to the declining inflation rate and the negative demand shock in the wake of the Asian Financial Crisis. However, the changes in the official interest rates lagged significantly behind those of the inflation rate and other real variables. From Fig. 1, we see that the annual inflation rate went down to zero in early 1998. In fact, the monthly inflation rate was already negative in most months of 1997. The official deposit rate and the lending rate, however, stayed high at 7.47% and 10.08%, respectively, at the beginning of 1997, fell only gradually for the next 2 years, and remained at 4.77% and 6.93%, respectively, until December 1998. The slow adjustments of the interest rates during that period may have contributed to the slow recovery of the real economy. It took a long time before the economic activities got back on track. The actual output growth was the lowest during the 1998–2001 period in the whole sample period and the output gap was below zero during the 1998–2003 period, as seen in Fig. 1. Fig. 5 plots the official 1-year deposit rate, the official 1-year commercial lending rate, and the expected 1-year inflation rate according to the VAR model. The inertness of the official interest rates during the 1996–1999 period is evident. The magnitude of their changes over time is far smaller than that of the expected inflation in the whole sample period. After 1999, the inflation rate fluctuated from time to time, but the official interest rates did not budge much until the end of the sample period. The inflation rate moved up to more than 5% in mid-2007, while the 1-year deposit rate was only slightly above 3%, causing a negative real deposit rate, even though the central bank had raised the official rates four times in one year. The consequence of the negative real interest rates is yet to be seen.

6. Conclusion

In this paper, we address issues regarding the responsiveness and effectiveness of monetary policies in China in recent years. The large fluctuations in both economic variables and monetary policy variables provide an opportunity for this task. The empirical evidence we present in this paper shows that the two monetary policy variables, the growth rate of the real money supply and the official interest rates, do respond to the inflation rate and the output gap. The way these two policy variables respond to economic variables is better described by the models of the Taylor rule and the McCallum rule with time-varying coefficients than by the original models with fixed coefficients. The emphasis on stimulating growth in 1992–1993, the early years of the sample period, led to the high inflation rate later around 1994. The increase in the official interest rate and the sharp cut in the money supply in 1993–1995 were belated, but eventually worked to bring the inflation rate down. The delayed cut in the official interest rate after the Asian Financial Crisis in 1997–1998 partially caused sluggish recovery afterwards. Overall, we find that money supply was a more effective instrument used in China, responding to both the inflation rate and the real economy more actively, while the official interest rate responded to the inflation rate only passively.

Acknowledgements

We would like to thank Jianglin Lu, the participants of the 2007 China International Conference in Finance in Chengdu, and especially the two anonymous referees for their helpful comments and suggestions. Longzhen Fan acknowledges financial support from the National Science Foundation of China Grant NSFC-70971025. Chu Zhang acknowledges financial support from the Direct Allocation Grant DAG S08/09.BM18 of HKUST. All remaining errors are ours.

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