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Is money targeting an option for the People's Bank of China?

Abstract

This study examines which monetary aggregates, namely nominal M0, M1, M2, can be used by the People's Bank of China to conduct monetary policy. We find the three monetary aggregates are cointegrated with their determinants, such as real income, real inflation rate, and real rate of one-year saving deposit using Johansen (1988) and Johansen and Juselius's (1990) procedures. We also find the income elasticity of M0 is less than one, indicating the increase in income would be faster than the increase in narrow measure of money. The income elasticities of M1 and M2 are greater than one respectively, suggesting the evidence of monetization process and rapid financial innovations. Further, short-run model is applied to M0, M1, and M2, respectively, and the results suggest that only M2 has a significant negative error correction term. Finally, we conclude that M2 would be an appropriate target in conducting monetary policy rather than using M0 and M1.

Keywords: money demand, monetary policy, monetary aggregates.
JEL Classification: E41, E42, E52.

Introduction

The Chinese economy has been growing dramatically since the economic and financial reforms in the late 1970s. The reforms have brought large changes to the country's monetary management and policies. For example, in the 1980s, the People's Bank of China (PBC) used direct monetary control, such as credit quotas, difference control and targeting the monetary base to manage inflation. Difference control was introduced in 1980 to improve the flexibility of the credit plan. An estimated difference between credit expenditure and credit receipts was set by the PBC, and the total differences among all commercial banks were examined. If the actual differences do not exceed the estimated target, commercial banks could make more loans. The purpose of adopting this control was to pay more attention to asset management than to liability management. Ping and Xiaopu (2003) argue that there was no monetary policy in China before the 1990s, and only credit quota control and government intervention were used in determining the economic variables. After 1993, the exchange rate, interest rate and tax rate were used to control economic activity in the country. The credit quota control system was abandoned and the PBC implemented reserve requirements, open market operations and discount window lending to influence economic activity in 1998. For the first time the PBC used monetary targeting to control the money supply from 1998. Furthermore, regulations on capital inflows have been gradually removed since the early 2000s.

Dai (2006) argues that money supply targeting was not successful because of the unstable money demand function. Mookerjee and Peebles (1998) found that it was difficult to control the money supply using reserve requirements and direct credit control. At the beginning of 2004, the PBC started to use interest rate targeting in place of money supply targeting as the intermediate goal in conducting monetary policy (Dai, 2006).

In July 2005, the pegged exchange regime was removed. The Chinese Renminbi (RMB) was revalued by 2.1% and a managed float exchange rate system was adopted (Forssbæck and Oxelheim, 2007). In January 2007, the Shanghai inter-bank offer rate was introduced to build a money market benchmark interest rate system. At present, the PBC implements a tight monetary policy to restrain the rapid growth of money and credit, prevent high inflation, and create a sound monetary and financial environment (China Monetary Policy Report Quarter Four, pp. 22, 2007).

In general, most studies estimate the money demand function with different variables, different data time periods, and different testing methods. However, no study has addressed which monetary aggregate is the best target variable comparing M0, M1, and M2 in estimating the Chinese money demand function. This study investigates which monetary aggregates, namely real M0, M1, and M2, are stable in the long run by constructing the money demand functions.

The study is organized as follows: section 1 provides the literature review on money demand estimation. Section 2 discusses the methodology and data. Section 3 discusses the empirical results and findings and the final section concludes the study.

1. Literature review

Feltenstein and Farhadian (1987) constructed two models to measure the changes in money supply and real money balances for the period of 1954-1983. In the first model, they employed the government decit, the wage bill[1] of the government and enter-

[1] Wage bill of the government and enterprises is defined as government and enterprises made payments to households and households purchased goods and transacted among themselves.

prises, and procurement payments to farmers in their money supply function. Their test results showed all coefficients of the variables have the correct signs and they fully explain the changes in broad money. Furthermore, in the second model, they found that the real money balance can be explained by real income and anticipated true rate of inflation.

Hafer and Jansen (1991) employed cointegration tests to find out which monetary aggregate is preferable in the U.S. They used both the short-term interest rate (commercial paper rate) and the long-term interest rate (the corporate bond rate) in addition to real money balances and real income. Their results showed a cointegrating relationship among those variables, but there was no strong evidence of cointegration relationship for M1. Thus, M2 is a preferable measure for conducting monetary policy.

Chow (1987) used the quantity theory of money to explain the price level in China for the period of 1952-1983. By taking the logarithms on $P = \upsilon(M / Y)$ and regressing $\ln P$ on $\ln(M / Y)$, the coefficient of $\ln(M / Y)$ equals 0.2687, which means that changes in $\ln(M / Y)$ will lead to a smaller change in $\ln P$. This is consistent with the quantity theory of money. However, 0.2687 is less than unity, suggesting that the velocity of money is not constant.

Chen (1989) estimated the causal relationship between M0, M2, and M3 and indicators of macroeconomic performance, overall economic development, price stability, balanced budget deficits, and balanced trade deficits using the BVAR model. The author found that the bidirectional causality is from M0 to overall economic development, to the balanced budget deficits, and to the balanced trade deficits, and the unidirectional causality is from the money supply to inflation. The author suggests that M0 is the best indicator in conducting monetary policy.

Yi (1991) is the first researcher to discuss the monetization process during the Chinese economic reform. The author suggests that the monetization process can explain why the growth rate of money supply was greater than the sum of real GNP growth and inflation rate. There are five channels of the monetization process: household sector, agriculture sector, township and village enterprises, private firms, and free markets.

Hafer and Kutan (1994) applied cointegration tests to determine whether there was a long-run equilibrium relationship between nominal money balances, interest rates, prices, and real national income in China during the period of 1952-1988. Two price measures, the official index of retail prices and the implicit national income deflator, were used in the authors' study. Their test results showed that when the official index of retail prices is used, there is no long-run equilibrium relationship between the money demand function and its determinants. However, a significant relationship was found when the implicit national income deflator is used. They suggest that the broader measure, M2, is preferable one to be implemented in monetary policy.

Qin (1994) estimated the demand for money in China by studying two different time periods. He used quarterly data for 1978Q1-1991Q4 and annual data for 1952-1991. The author argued that since household savings are very sensitive to the change in both inflation and interest rates, inflation can not fully represent money demand. Thus, Qin used real interest rates (the one year bank deposit rate net of inflation) to represent the opportunity cost of holding money.

Chen (1997) applied cointegration tests to estimate the long-run money demand function in China during the period of 1951-1991. By implementing both the augmented Dickey-Fuller (ADF) procedure and Kwiatkowski, Phillips, Schmidt, and Shin's (KPSS) procedure, the author showed that inflation was stationary and the real balance and output were nonstationary. Chen suggests if M0 is used to conduct monetary policy, then M0 should grow between 24% and 25% to control the inflation rate under 10%. If M2 is used, then the increase in M2 should not exceed 28% to 29%.

Austin, Ward, and Dalziel (2007) used Terasvirta's procedure to test the linearity of an error correction model of money demand against a smooth transition regression non-linear alternative in China. The authors found that the money demand function is difficult to estimate when the inflation rate exceeds 5%. Their results show that income only positively impacts real money balance under a high inflation regime, which is consistent with the theoretical model.

In general, the reforms have changed the monetary policies and implementations compared to pre-reform period. It is important to understand how these changes affect the monetary policies during the post-reform period and finally their effects on the Chinese macroeconomic variables. Furthermore, the existing literatures on Chinese money demand functions primarily focus on the pre-reform period. The longest data period of those studies is only up to 1997 and there is no study that focuses on which monetary aggregate is the best target variable comparing M0, M1, and M2 by considering the effects of financial reforms. Therefore, our objective is to test whether the financial reforms have led to changes in money demand function during the post-reform period.

2. Data and methodology

2.1. Data. The period of study is from 1995Q1 through 2008Q1. The reason for choosing 1995Q1 as the beginning period is that the National Bureau of Statistics of China switched to the United Nations system of national accounts, which leads different measurement of macroeconomic variables, such as GDP and monetary aggregates (Holz, 2004). CPI is expressed in quarterly terms with the first value equal to one hundred. We subtracted one hundred from each quarter. Further, we adjusted nominal M0 (Currency in Circulation), M1 (M0+ Institution Demand Deposits), M2 (M1 + Institution Time Deposits + Household Savings Deposits + Other Deposits), and nominal GDP for inflation by deflating them by the CPI. The real rate of one-year saving deposit is computed by one-year saving deposit rate minus the actual inflation rate. Finally, the real money aggregates and GDP are in natural logarithm form. Real rate of one-year saving deposit and real inflation are in levels.

2.2. Research methodology. *2.2.1. Model formulation.* The formulation of the money demand function follows Chen's (1997) study. Our empirical model adds one additional variable, namely one-year saving deposit rate, in estimating the money demand function in China. M3 is replaced by M1 in our money demand functions. The money demand functions are estimated in log-linear form, nominal M0, M1, and M2 and real income are in logarithms; one-year saving deposit rate and the actual inflation rate are in levels. Our money demand functions are given as follows:

$$LRM0 = \alpha_{11} + \alpha_{12} LRINC + \alpha_{13} INF + \alpha_{14} RINTR_{yr} + \varepsilon_{01} , \quad (1)$$

$$LRM1 = \alpha_{21} + \alpha_{22} LRINC + \alpha_{23} INF + \alpha_{24} RINTR_{yr} + \varepsilon_{02} , \quad (2)$$

$$LRM2 = \alpha_{31} + \alpha_{32} LRINC + \alpha_{33} INF + \alpha_{34} RINTR_{yr} + \varepsilon_{03} , \quad (3)$$

where $LRM0$, $LRM1$, and $LRM2$ are $\ln\left(\frac{M0}{CPI}\right)$, $\ln\left(\frac{M1}{CPI}\right)$, and $\ln\left(\frac{M2}{CPI}\right)$; $LRINC$ is $\ln$(real income); INF is the real inflation rate; $RINTR_{yr}$ is the real rate of one-year saving deposit and ε is the error term.

First, our study will use M0, M1, and M2 separately as monetary aggregates because the purpose of our study is to find out which monetary aggregates are stable in the long run. Second, a scale variable is used to represent economic activities. Real income will be used in our study. Real income is expected to be positively related to the money demand functions (Equations 4, 5, and 6) because as real income increases so does the number of transactions in the economy, which increases people's demand for money. Third, the demand for an asset depends on its opportunity cost. Hafer and Kutan (1994) argued that government rates, such as Treasury bill rates and government bond rates, do not exist in China and savings deposit rate is the best interest rate measure. Therefore, the one-year saving deposit rate will be used in our study. Actual inflation is used in our study as an additional variable to represent the opportunity cost of holding money. The one-year saving deposit rate and the actual inflation rate are expected to be negatively related to the money demand functions.

2.2.2. Cointegration analysis. The Hodrick-Prescott (HP) filter is used to examine whether the income velocity is unity. Following this, regression analysis is used to derive the money demand function (Equation 4, 5, and 6). We use unit root tests to determine if all variables are integrated of order one. In order to estimate the long-run relationship between the money demand and its determinants in China, Johansen (1988) and Johansen and Juselius's (1990) procedures are applied to the data. These procedures essentially provide maximum likelihood estimation with two test statistics, *trace* and $\lambda - \max$. Johansen and Juselius (1990) demonstrated that β can be estimated as the eigenvector associated with r largest by solving Equation (7) (Oskooee and Shabsigh, 1996):

$$\left| \lambda S_{kk} - S_{k0} S_{00}^{-1} S_{0k} \right| = 0 , \quad (4)$$

where $S_{ij} = T^{-1} \sum_{t=1}^{T} R_{it} R'_{jt}$ for $i, j = 0, k$.

After obtaining the eigenvalues by solving Equation (7), we can calculate both the *trace* and $\lambda - \max$ statistics as follows:

$$Trace = -T \sum_{i=r+1}^{q} \ln(1 - \hat{\lambda}_i) , \quad (5)$$

And $Max\lambda = -T \ln(1 - \hat{\lambda}_r)$,

where $\lambda_{r+1}, ..., \lambda_N$ are the estimates of N-r smallest eigenvalues (Oskooee and Shabsigh, 1996).

The three sets of hypotheses (r=0 vs r=1, r$\leq$1 vs r=2, and r$\leq$2 vs r=3) are tested individually until one of them cannot be rejected. Our study employs four lags because we used quarterly data in our study.

In order to understand how adjustments are taking place among the variables to achieve long-run equilibrium, it is necessary to use the error correction model (ECM). An ECM includes an EC term which models the existence of a long-run relationship (Granger, 1986). In our study, the unrestricted short-run model is applied to M0, M1, and M2, respectively. If the EC term has a negative sign in our tests, then we conclude that the cointegrating relationship is significant. This is possible because its magnitude indicates the speed of adjustment from short-run disequilibrium towards the long-run equilibrium. Second, the restricted model is applied by gradually eliminating the insignificant variables. If any model has a positive EC term, it will not enter into the restricted model. The EC term can be calculated using Equations (4), (5), and (6). The number of lags in the short run is one less than the number of lags in the cointegration tests, thus, three lags are used.

The short-run models are formulated as follows:

$$\begin{aligned}\Delta LRM0_t = {} & \alpha_0 + \alpha_1 \Delta LRM0_{t-1} + \alpha_2 \Delta LRM0_{t-2} + \alpha_3 \Delta LRM0_{t-3} \\ & + \alpha_4 \Delta LRINC_{t-1} + \alpha_5 \Delta LRINC_{t-2} + \alpha_6 \Delta LRINC_{t-3} \\ & + \alpha_7 \Delta INF_{t-1} + \alpha_8 \Delta INF_{t-2} + \alpha_9 \Delta INF_{t-3} \\ & + \alpha_{10} \Delta RINTR_{t-1} + \alpha_{11} \Delta RINTR_{t-2} + \alpha_{12} \Delta RINTR_{t-3} \\ & + \alpha_{13} EC_{t-1} + e_t\end{aligned}, \quad (6)$$

$$\begin{aligned}\Delta LRM1_t = {} & \beta_0 + \beta_1 \Delta LRM1_{t-1} + \beta_2 \Delta LRM1_{t-2} + \beta_3 \Delta LRM1_{t-3} \\ & + \beta_4 \Delta LRINC_{t-1} + \beta_5 \Delta LRINC_{t-2} + \beta_6 \Delta LRINC_{t-3} \\ & + \beta_7 \Delta INF_{t-1} + \beta_8 \Delta INF_{t-2} + \beta_9 \Delta INF_{t-3} \\ & + \beta_{10} \Delta RINTR_{t-1} + \beta_{11} \Delta RINTR_{t-2} + \beta_{12} \Delta RINTR_{t-3} \\ & + \beta_{13} EC_{t-1} + e_t\end{aligned}, \quad (7)$$

$$\begin{aligned}\Delta LRM2_t = {} & \theta_0 + \theta_1 \Delta LRM2_{t-1} + \theta_2 \Delta LRM2_{t-2} + \theta_3 \Delta LRM2_{t-3} \\ & + \theta_4 \Delta LRINC_{t-1} + \theta_5 \Delta LRINC_{t-2} + \theta_6 \Delta LRINC_{t-3} \\ & + \theta_7 \Delta INF_{t-1} + \theta_8 \Delta INF_{t-2} + \theta_9 \Delta INF_{t-3} \\ & + \theta_{10} \Delta RINTR_{t-1} + \theta_{11} \Delta RINTR_{t-2} + \theta_{12} \Delta RINTR_{t-3} \\ & + \theta_{13} EC_{t-1} + e_t\end{aligned}, \quad (8)$$

where EC stands for error correction term and other variables are defined as previously.

3. Empirical results

3.1. Hodrick-Prescott filter. The quantity theory of money states that

$$MV = PT, \quad (9)$$

where M is the total amount of money in circulation, V is the velocity of money, P is the price level and T is the level of transactions. It is difficult to measure or record total transactions but the GDP can measure both aggregate income and expenditure in an economy. Thus, we replaced the total transactions by GDP (y). Equation (12) can be rewritten as follows:

$$MV = Py, \quad (10)$$

Rearranging Equation (10) yields the following:

$$V = Py / M, \quad (11)$$

If V is stable, it yields a unity coefficient by regressing $ln\,P$ on ln(M/y) $ln(N / y)$.

Thus, we use the Hodrick-Prescott (HP)[1] filter to test the constancy of K. K is inverse income velocity which equals $k = M / Py$[2].

[1] The smoothing parameter of HP filter is 1600 for quarterly data.

[2] $k_0 = M_0 / Py,\ k_1 = M_1 / Py$ and $k_2 = M_2 / Py$.

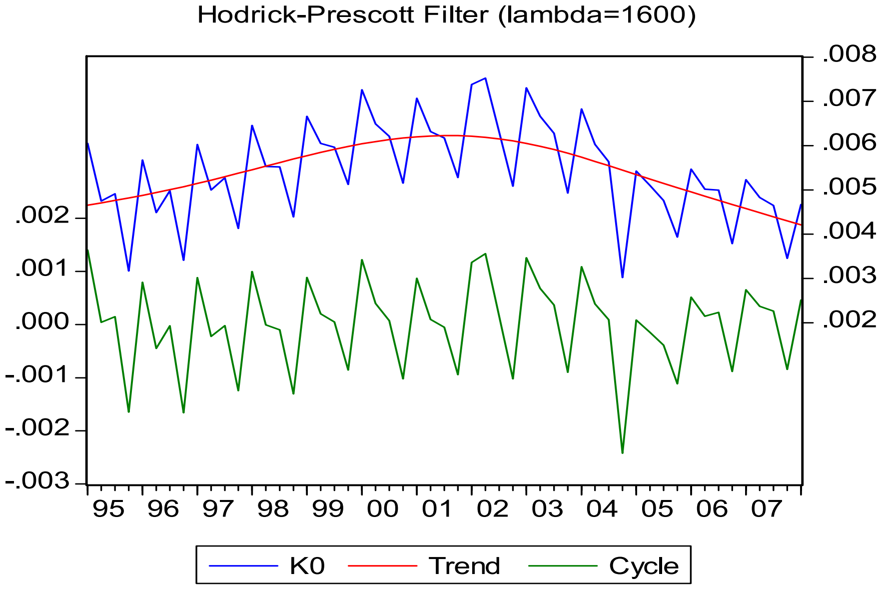

Fig. 1. K0

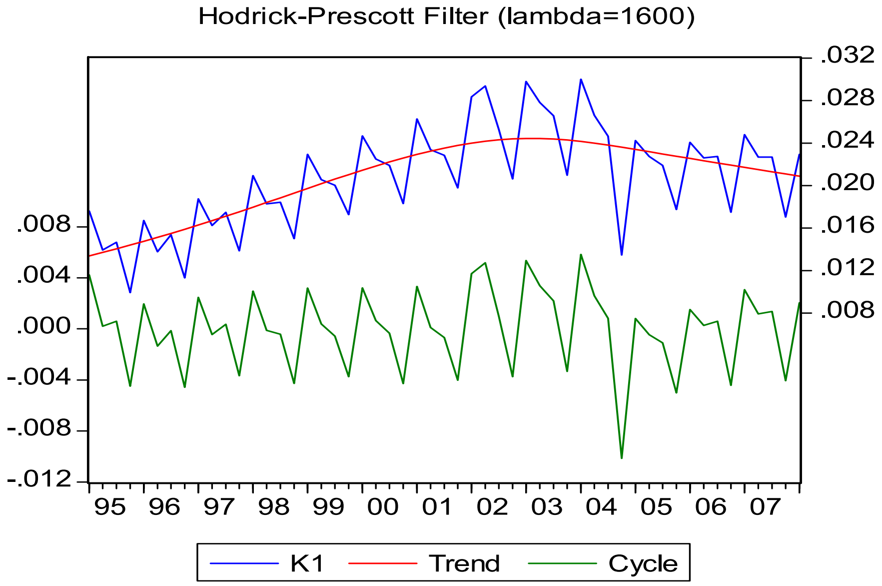

Fig. 2. K1

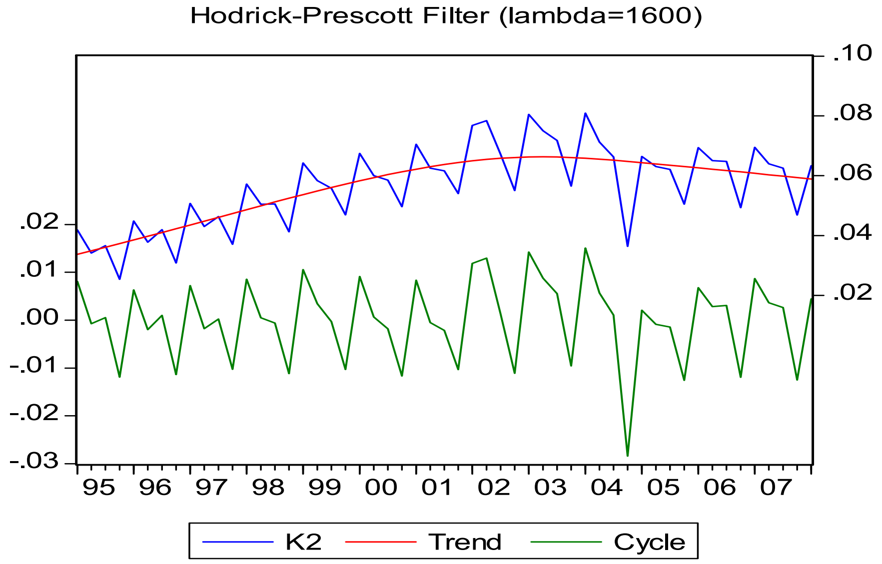

Fig. 3. K2

According to the graphs in Figures 1, 2, and 3, the trends of k increase first and start to decrease. Therefore, k is not constant over time. Further, we employ ADF unit root test for k_0, k_1 and k_2 respectively, to confirm that income velocities are not constant statistically.

Table 1. ADF unit root test results

Variable	Test statistics[1]
k_0	-1.21
k_1	-2.13
k_2	-2.20

The test statistics are all greater than the critical value at the 5% level of significance from Table 1, we reject the null hypothesis of k has unit root. Thus, the three income velocities are not constant over time. A possible explanation for the non-constant income velocity is that it decreases first with the deepening monetization process and increases with the deepening financial innovations and economic stability (China Monetary Policy Report, 2005, p. 5). Specifically, the monetization process increases the demand for money and financial assets to facilitate transactions and the demand for money increases at a rate faster than income. It makes the chain of currency in circulation longer and complicated, and creates new cash flow channels among individuals. Therefore, it leads to a decreasing income velocity (Yi, 1991). The increasing complexity of financial innovation and economic growth makes the chain of currency in circulation shorter and accelerates the growth of income. As a result, income grows at a faster rate than the demand for money, which leads to the increasing income velocity (China Monetary Policy Report, 2005).

3.2. Unit root tests. The ADF tests are used to confirm the integration properties of the data. Before implementing the ADF tests, we determine the maximum number of lags in the estimated ADF test regression equations. First, we use $p_{\max} = 12(T/100)^{1/4}$, where $p_{\max}$ denotes the maximum number of lags and T is the sample size, to determine the maximum number of lags to be used in the unit root tests as suggested by Schwert (1989). In our study, we substitute T = 53 into $p_{\max} = 12(T/100)^{1/4}$, which results in $p_{\max} = 12(53/100)^{1/4}$ =10.24. Thus, the number of lags is 10 for the quarterly data. Second, we estimate the ADF regression with $p_{\max}$. If the absolute value of the t-statistic for testing the last lagged difference is greater than 1.6, then we perform the ADF test with $p_{\max}$. Otherwise, we reduce the lag length by one and repeat the process.

Table 2. Results of unit root tests[a]

Variable[b]	Calculated ADF statistic	
	Level	First differences
LRM0	-3.26[1][c]	-3.30[3] (***)
LRM1	-3.51[0]	-6.69[0] (*)
LRM2	-3.33[2]	-3.77[1] (**)
LRINC	-1.84[9]	-3.27[6] (***)
INF	-3.48[8]	-4.35[0] (*)
RINTR	-4.00[8]	-4.53[0] (*)

Notes: [a] critical values for the test statistics are -4.25 at 1%, -3.55 at 5% and -3.21 at 10%. (*), (**) and (***) indicate the rejection of unit roots at the 1%, 5%, and 10% levels of significance, respectively. These are taken from Mackinnon (1991); [b] logarithms of M0, M1, M2 and real income are used. Real inflation and real rate of one-year saving deposit are in levels; [c] the numbers in parentheses are the number of lags used in the ADF test.

3.3. Cointegration. The results obtained from the unit root tests indicate our variables are integrated of order one, which means the long-run money demand function estimations in our study involve the presence of stationary cointegrating relationships among variables (LRM0, LRM1, LRM2, LRINC, INF, and RINTR).

Table 3. Cointegration test results[a]

Variables in cointegrating vectors	H0	H1	λ-Max	Critical value		Trace	Critical value	
				95%	99%		95%	99%
LRM0, LRINC,	r=0	r=1	44.31*	31.46	36.65	91.12*	62.99	70.05
INF& RINTR	r≤1	r=2	26.17**	25.54	30.34	46.81**	42.44	48.45
	r≤2	r=3	12.04	18.96	23.65	20.64	25.32	30.45
LRM1, LRINC,	r=0	r=1	29.57**	27.07	32.24	57.65*	47.21	54.46
INF& RINTR	r≤1	r=2	21.44**	20.97	25.52	28.08	29.68	35.65
	r≤2	r=3	6.64	14.07	18.63	6.64	15.41	20.04
LRM2, LRINC,	r=0	r=1	35.78*	27.07	32.24	67.75*	47.21	54.46
INF& RINTR	r≤1	r=2	17.21	20.97	25.52	31.97**	29.68	35.65
	r≤2	r=3	12.14	14.01	18.63	14.76	15.41	20.04

Notes: [a] the cointegration tests include four lags for each variable. The estimation period is 1996:Q2-2008:Q1; [b] r stands for number of cointegrating vectors; [c] (*) and (**) indicate the rejection of null hypothesis at the 1% and 5% levels of significance, respectively; [d] linear deterministic trend is employed.

[1] Critical value for the test statistics is -2.92 at 5%.

The first cointegrating vector in Table 3 includes LRM0, LRINC, INF, and RINTR. The null hypothesis of no cointegrating relationship is rejected by both λ-Max and trace statistics at the 1% level of significance. The null hypothesis of r ≤1 is also rejected at the 5% level of significance. Therefore, we have two cointegrating vectors among those variables. However, the cointegrating vector includes LRM1, LRINC, INF and RINTR. The null hypotheses of no cointegrating vector and at most one cointegrating vector are rejected by λ-Max statistics at the 5% level of significance. However, the trace statistic only rejects the null hypothesis of no cointegrating vector at the 1% level of significance. Since we should choose the vector which provides correct signs of coefficients and the λ-Max statistic, in general, has a greater power than the trace statistic when the number of cointegrating vector is either too large or small (Gu, 2004), the two eigenvectors are selected for the same reason. In the third cointegrating vector, the null hypotheses of no cointegrating vector and at most one cointegrating vector are rejected by trace statistic at the 1% and 5% levels, of significance. The λ-Max statistic only rejects the null hypothesis of no cointegrating vector. We conclude that there is one cointegrating vector among LRM2, LRINC, INF, and RINTR.

The cointegrating relationships among variables are summarized by the non-normalized coefficients in the cointegration tests. In order to have long-run money demand functions, we normalize the coefficients in each cointegrating vectors on LRM0, LRM1, and LRM2, respectively. For example, the coefficients variables are divided by 102.6684 (LRM0) for the money demand function of LRM0. The following figures represent the normalized coefficients of variables to form the long-run money demand function of LRM0:

102.6684/102.6684=1,
-9.271142/102.6684=-0.0903,
0.979699/102.6684=0.0095,
0.397364/102.6684=0.0039.

Table 4. Cointegrating vectors normalized on LRM0, LRM1 and LRM2

Vector	LRM0	LRM1	LRM2	LRINC	INF	RINTR
LRM0, LRINC, INF& RINTR	1			0.0903	-0.0095	-0.0039
LRM1, LRINC, INF& RINTR		1		1.0506	-0.1865	-0.1666
LRM2, LRINC, INF& RINTR			1	2.7481	-0.6918	-0.4221

Thus, we have the following money demand functions:

$$LRM0 = 0.0903 LRINC - 0.0095 INF - 0.0039 RINTR, \quad (12)$$

$$LRM1 = 1.0506 LRINC - 0.1865 INF - 0.1666 RINTR, \quad (13)$$

$$LRM2 = 2.7481 LRINC - 0.6918 INF - 0.4221 RINTR. \quad (14)$$

Table 4 shows the income elasticity of M0 is less than one, which is not consistent with the quantity theory of money and pervious studies (Feltenstein and Farhadian, 1987; Chow, 1987; Hafer and Kutan, 1994; Huang, 1994; and Chen, 1997). The lower than unity income elasticity is a result of people having access to more financial instruments included in the broader measure of money as a result of the growth of financial services and innovations. It creates more choices for people to use various financial instruments, such as buying stock and mutual funds. Thus, the increase in income would be faster than the increase in a narrow measure of money, which leads to lower than unity income elasticity (Austin, Ward, and Dalziel, 2007). The real income is positively related to the money demand functions indicating the increase in the real income increases people's demand for money. Inflation and real rate of one-year saving deposit negatively impact the money demand functions. People tend to hold more physical assets rather than money with a higher inflation rate, and an increase in domestic interest rates increases the opportunity cost of holding domestic money. Therefore, people will hold less RMB when the one-year saving deposit rate increases.

Table 4 reveals the long-run income elasticities of M1 and M2 are greater than one: 1.0506 and 2.7481, respectively. There are two reasons for the greater than unity long-run income elasticity in China. First, it is caused by the monetization process because the increase in money aggregates is faster than the increase in income. Yi (1991) summarized five factors of the monetization process that explain the acceleration of the demand for money including households, private firms, farmers, the development of free markets, and government. Second, financial innovation may impact the demand for money and the long-run income elasticity. Financial innovations in China basically changed the economic structure and the financial system. Consequently, these changes caused more than proportional increase in demand for money and financial assets and the long-run income elasticity is greater than one.

Results from previous studies (Luke Chan, Cheng and Deaves, 1991; Hafer and Kutan, 1994) showed that the interest rate coefficient is positively related to the demand for money in China. However, in our study, the signs of the interest rate coefficients are consistent with the economic theory, where an increase in the domestic interest rates raises the opportunity cost of holding money and lowers the holding of money. A possible explanation for the negative signs in our study, as summarized by Gu (2004), is that the Chinese government adjusted the interest rates frequently to account for people's expectation of inflation. The interest rate coefficients of M1 and M2 are 0.1666 and 0.4221, respectively, which are much greater than M0 (0.0039). Thus, interest rates have greater impact on M1 and M2. This also implies that if M1 and M2 are used as monetary targets, they will take a smaller change in interest rates to induce a desired change in the money demand.

3.4. Short-run model. The error correction (EC) term is calculated as LRM0, LRM1, and LRM2 minus the estimated LRM0, LRM1, and LRM2, respectively, in time t-1. Thus, we have the following EC terms:

- EC0=LRM0-0.093LRINC+0.0095INF +0.0039RINTR;
- EC1=LRM1-1.0506LRINC+0.1865INF +0.1666RINTR;
- EC2=LRM2-2.7481LRINC+0.6198INF +0.4221RINTR.

Table 5. Results of unrestricted short-run model: DLRM0

Unrestricted model: DLRM0 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
Constant	0.004237	0.004061	1.043262	0.3040
DLRM01	-0.020151	0.066165	-0.304556	0.7625
DLRM02	0.006287	0.060871	0.103285	0.9183
DLRM03	0.028315	0.057841	0.489538	0.6275
DLRINC1	0.024722	0.005325	4.642856	0.0000
DLRINC2	0.021317	0.005409	3.941299	0.0004
DLRINC3	0.02047	0.004994	4.098965	0.0002
DINF1	-0.00269	0.00275	-0.978212	0.3347
DINF2	-0.002323	0.002791	-0.832322	0.4109
DINF3	-0.00276	0.003316	-0.83223	0.4109
DRINTR1	-0.00109	0.002118	-0.514572	0.6101
DRINTR2	-0.001341	0.002151	-0.623424	0.5370
DRINTR3	-0.002106	0.002496	-0.84388	0.4045
ECTERM0	1.018335	0.160213	6.356122	0.0000

Notes: 1. Three lags of first difference in LRM0 are denoted as DLRM01, DLRM02, and DLRM03. 2. Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3. 3. Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3. 4. Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3. 5. The EC term in time t-1 is denoted as ECTERM0.

Table 6. Results of unrestricted short-run model: DLRM1

Unrestricted model: DLRM1 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
C	0.037153	0.001550	23.97629	0.0000
DLRM11	0.266113	0.105686	2.517947	0.0165
DLRM12	0.212978	0.105283	2.02291	0.0508
DLRM13	0.276004	0.099138	2.784031	0.0086
DLRINC1	-0.016191	0.007643	-2.11851	0.0413
DLRINC2	-0.018684	0.007578	-2.465518	0.0187
DLRINC3	-0.018484	0.007369	-2.508412	0.0169
DINF1	0.001201	0.003800	0.316001	0.7539
DINF2	0.003884	0.003745	1.036994	0.3069
DINF3	0.008689	0.003827	2.270399	0.0294
DRINTR1	0.001518	0.002759	0.550179	0.5857
DRINTR2	0.002556	0.002806	0.911	0.3685

Table 6 (cont.). Results of unrestricted short-run model: DLRM1

Unrestricted model: DLRM1 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
DRINTR3	0.006337	0.002975	2.12975	0.0403
ECTERM1	-0.066468	0.022902	-2.902239	0.0064

Notes: 1. Three lags of first difference in LRM1 are denoted as DLRM11, DLRM12, and DLRM13. 2. Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3. 3. Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3. 4. Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3. 5. The EC term in time t-1 is denoted as ECTERM1.

Table 7. Results of unrestricted short-run model: DLRM2

Unrestricted model: DLRM2 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
C	0.035129	0.001013	34.66803	0.0000
DLRM21	0.317001	0.149019	2.127253	0.0405
DLRM22	0.091336	0.156732	0.582753	0.5638
DLRM23	0.354519	0.14197	2.497146	0.0174
DLRINC1	-0.02291	0.003703	-6.186976	0.0000
DLRINC2	-0.024897	0.003561	-6.990552	0.0000
DLRINC3	-0.022581	0.003187	-7.084508	0.0000
DINF1	0.00653	0.002788	2.342243	0.0250
DINF2	0.006546	0.002814	2.326112	0.0259
DINF3	0.007776	0.003376	2.303271	0.0273
DRINTR1	0.003326	0.001759	1.891142	0.0669
DRINTR2	0.0045	0.001776	2.533305	0.0159
DRINTR3	0.00268	0.001966	1.362612	0.1817
ECTERM2	-0.033169	0.002789	-11.89192	0.0000

Notes: 1. Three lags of first difference in LRM2 are denoted as DLRM21, DLRM22, and DLRM23. 2. Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3. 3. Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3. 4. Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3. 5. The EC term in time t-1 is denoted as ECTERM2.

The EC term is positive as shown in Table 5, which did not validate the significance of the long-run cointegrating relationship for M0. Therefore, DLRM0 does not enter into the restricted model. The constant term, DLRM13, and ECTERM1 are significant at the 1% level of significance (see Table 6). In addition, DLRM11, DLRINC1, DLRINC2, DLRINC3, DINF3, and DRINTR3 are significant at the 5% level of significance. All other variables are found to be irrelevant. The negative sign of EC term confirms the cointegrating relationship for M1. The data in Table 7 show the constant term, DLRINC1, DLRINC2, DLRINC3, and ECTERM2 are significant at the 1% level of significance and DLRM21, DLRM23, DINF1, DINF2, DINF3, and DRINTR2 are significant at the 5% level of significance. The EC term also carries a negative sign. The negative signs of EC terms as shown in Tables 6 and 7 suggest that the increases in excess money demand in the previous period decrease the growth in demand for money in present period (Sriram, 2002).

The restricted models of M1 and M2 are constructed by eliminating the insignificant variables shown in Tables 6 and 7. For example, DLRM12, DINF1, DINF2, DRINTR1, and DRINTR2 are insignificant (see Table 6) since their p-values are greater than 1% and 5% levels of significance, respectively. DLRM22, DRINTR1, and DRINTR3 are insignificant (see Table 7) since their p-values are also greater than 1% and 5% levels of significance, respectively. After determining the insignificant variables, the ordinary least square estimation is applied to M1 and M2, respectively. The final results are shown in Tables 8 and 9.

Table 8. Results of short-run model: DLRM1

Restricted model: DLRM1 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
C	0.038207	0.001479	25.83341	0.0000
DLRM11	0.354455	0.081163	4.367183	0.0001
DLRM13	0.327938	0.084082	3.900223	0.0003
DLRINC3	-0.010689	0.005987	-1.785391	0.0814
DINF3	0.007862	0.003119	2.520206	0.0156
DRINTR3	0.004732	0.002482	1.906683	0.0634
ECTERM1	-0.017036	0.010093	-1.68786	0.0989

The constant term, DLRM11 and DLRM13 are significant at the 1% level of significance (see Table 8). DINF3 is significant at the 5% level of significance. DLRINC3, DRINTR3 and ECTERM1 are significant at the 10% level of significance. Our results reveal the presence of heteroscedasticity and we re-estimate the model using the White's method (see Table 9).

Table 9. Results of White's method

Restricted model: DLRM1 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std. error	t-statistic	p-value
C	0.038207	0.001446	26.42325	0.0000
DLRM11	0.354455	0.096158	3.68618	0.0006
DLRM13	0.327938	0.063318	5.179182	0.0000
DLRINC3	-0.010689	0.006352	-1.682891	0.0998
DINF3	0.007862	0.004204	1.870028	0.0685
DRINTR3	0.004732	0.003715	1.273629	0.2098
ECTERM1	-0.017036	0.010624	-1.603512	0.1163

Interestingly, DRINTR3 and ECTERM1 are insignificant at the 10% level of significance. Thus, the insignificance of the EC term does not validate the long-run cointegrating relationship.

The data in Table 10 shows all variables are significant at the 5% level of significance. The results are consistent with the unrestricted model for DLRM2. The EC term has a negative sign.

Table 10. Results of Short-run Model: DLRM2

Restricted Model: DLRM2 Estimated by OLS: Sample is 1996Q1 to 2008Q1				
Variable	Coefficient	Std.Error	t-Statistic	p-value
C	0.035522	0.001057	33.61215	0.0000
DLRM21	0.357945	0.145938	2.452725	0.0189
DLRM23	0.360702	0.125635	2.871029	0.0067
DLRINC1	-0.020759	0.003828	-5.422111	0.0000
DLRINC2	-0.022903	0.003562	-6.429081	0.0000
DLRINC3	-0.022001	0.003397	-6.47675	0.0000
DINF1	0.003943	0.001668	2.363939	0.0233
DINF2	0.007775	0.002038	3.815224	0.0005
DINF3	0.004735	0.001706	2.774949	0.0085
DRINTR2	0.006754	0.001664	4.057853	0.0002
ECTERM2	-0.030707	0.00282	-10.88988	0.0000

Conclusions and discussion

Our study suggests that there is a long-run relationship between the broad measure of money (M2) and its determinants. However, the long-run relationships for M0 and M1 are plausible. Thus, M2 would be an appropriate target in conducting monetary policy rather than using M0 and M1. Further, in the presence of the fast development of financial markets, such as money market, bond and stock markets, the narrow money aggregate (M0) is no longer an appropriate target to determine the money supply because those markets impact the demand for money much more than before in China. Our results also suggest that the monetization process and the financial innovations also impact the demand for money in China. In order to have stable growth in monetary aggregates, the monetization process and financial innovations should be carried out step by step. As discussed in our research findings, a smaller change in interest rates influences the demand for money in China. In order to influence the demand for money, the PBC should know to what extent households, private firms and stated-owned enterprises are sensitive to interest rate changes.

Three important factors should be addressed when considering the Chinese money demand. First, the large capital inflows into China require a large demand for money, otherwise these inflows may cause an increase in inflation. On the other hand, the demand for money may decrease suddenly if large capital outflows take place. Thus, in order to have a stable increase or decrease in monetary aggregate, the PBC should monitor the sudden increase or decrease in capital movements. Second, substantial increase in exports and imports may impact the demand for money in China since China became a member of WTO. Third, the movements of exchange rates may impact firms' demand for RMB because they convert foreign exchange earnings to RMB based on the expectations of future appreciation of RMB. Further, since the restrictions on domestic holdings of foreign currency have been gradually loosened, the demand for RMB may also be impacted based on the future appreciation or depreciation of the RMB.

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