

# **Is Money Targeting an Option for the People's Bank of China?**

---

A thesis  
submitted in partial fulfilment  
of the requirements for the Degree of  
Master of Commerce of Management

at  
Lincoln University  
by  
Ke Mo

---

Lincoln University

2009

**Abstract of a thesis submitted in partial fulfilments of  
the requirements for the Degree of M.C.M.**

**Is Money Targeting an Option for the People's Bank of  
China?**

by

Ke Mo

**Abstract**

This study examines which monetary aggregates, namely nominal M0, M1 and M2, can be used by the People's Bank of China to conduct monetary policy. The model includes real M0, M1 and M2 as the dependent variable respectively and their determinants, such as real income, real inflation rate, and real rate of one-year saving deposit. Johansen (1988) and Johansen and Juselius's (1990) procedures are used to estimate the long-run relationship between the monetary aggregates and their variables. Short-run model is applied to M0, M1 and M2 respectively to see whether the error term is negative to validate the significance of the long-run relationship using the Ordinary Least Square estimation.

Keywords: Money targeting; unit root; cointegration; income elasticity

## **Acknowledgement**

First of all, I would like to express my gratitude to Dr. Christopher Gan and Dr. Baiding Hu for being my thesis supervisors. Special thanks also go to Dr. Christopher Gan and Dr. Baiding Hu.

I would like to show my deepest gratitude to Dr. Christopher Gan, a respectable, responsible and resourceful scholar, who has provided me with valuable guidance in every stage of the writing of this thesis. Without his enlightening instruction, impressive kindness and patience, I could not have completed my thesis. His keen and vigorous academic observation enlightens me not only in this thesis but also in my future study. I would like to thank Dr. Baiding Hu for his profound knowledge of statistics.

Last but not least, my special thanks also go to Shuzhang Sun for his insightful comments during my study period and to my family for their unconditional love and support.

# Table of Contents

Abstract	ii
Acknowledgment	iii
Table of Contents	iv
List of Tables	vi
List of Figures	vii
Chapter 1: Introduction	1
1.1 Background	1
1.1.1 The Chinese Banking Sector	1
1.1.2 Main Contours of Monetary Policy Development	2
1.1.3 Inflation Cycle and Inflationary Expectations	4
1.1.4 Theory of Money Targeting	6
1.2 Research Objectives	7
1.3 Structure of the Thesis	8
Chapter 2: Literature Review	9
2.1 The Evolution of the Chinese Monetary Policy	9
2.2 Money Demand in Foreign Countries	14
2.3 Money Demand in China	22
Chapter 3: Data and Methodology	30
3.1 Variable Selection	30
3.2 Model Formulation	32
3.3 Expected Signs of Coefficients	33

3.4 Methodology	33
3.4.1 Unit Root Tests	34
3.4.2 Cointegration	35
3.4.3 Short-run Model	38
Chapter 4: Empirical Results	40
4.1 Introduction	40
4.2 Data Description	40
4.3 Hodrick-Prescott Filter	41
4.4 Unit Root Tests	44
4.4.1 Graphical Descriptions of Quarterly Data	44
4.4.2 Unit Root Tests	49
4.5 Cointegration Tests	50
4.6 Short- run Model	59
4.6.1 Unrestricted Model	59
4.6.2 Restricted Model	64
Chapter 5: Conclusions and Discussion	67
5.1 Introduction	67
5.2 Research Findings	67
5.3 Policy Implications and Limitations	72
5.4 Recommendations for future research	76
References	77

## List of Tables

### Tables

4.1 ADF Unit Root Test Results	43
4.2 Results of Unit Root Tests	49
4.3 Cointegration Test Results	51
4.4 Cointegrating Vectors Normalized on LRM0, LRM1 and LRM2	54
4.5 Diagnostic Tests	58
4.6 Results of Unrestricted Short-run Model: DLRM0	61
4.7 Results of Unrestricted Short-run Model: DLRM1	62
4.8 Results of Unrestricted Short-run Model: DLRM2	62
4.9 Results of Restricted Short-run Model: DLRM1	64
4.10 Results of White's Method	65
4.11 Results of Restricted Short-run Model: DLRM2	66
4.12 Diagnostic Tests	66

## List of Figures

### Figures

1.1	Consumer Price Index	3
1.2	Movements in the Future Price Expectations and the CPI	5
4.1	K0	42
4.2	K1	42
4.3	K2	43
4.4	Level of RM0	45
4.5	Level of RM1	45
4.6	Level of RM2	46
4.7	Level of RINC	46
4.8	Level of INF	46
4.9	Level of DR	46
4.10	Difference of RM0	47
4.11	Difference of RM1	47
4.12	Difference of RM2	48
4.13	Difference of RINC	48
4.14	Difference of INF	48
4.15	Difference of DR	48

# **Chapter 1: Introduction**

## **1.1 Background**

The Chinese economy has been growing dramatically since the economic and financial reforms in the late 1970s. The nominal GDP growth rate is relatively high compared to other developing countries, and the foreign reserve reached over \$1.5 trillion by the end of 2007. In addition, the reforms have brought large changes to the Chinese banking system and its monetary management and policies.

### **1.1.1 The Chinese Banking Sector**

Before the economic reforms in 1978, the People's Bank of China (PBC) acted as both commercial bank and the central bank. It transferred funds from savers to borrowers, and also set the state production plans in each production sectors for the Ministry of Finance. However, it did not generate any profits, implement any asset and liability management nor conduct monetary policy. The economical variables, such as exchange rates, interest rates and price level, were determined by the government (Yu and Xie, 1999). In 1984, the PBC became the central bank of China and four major commercial banks were established: the Agricultural Bank of China, the People's Construction Bank of China, the Industrial and Commercial Bank of China, the Bank of Communications, and the China International Trust and Investment Company Bank (Hafer and Kutan, 1994). Today these banks are known as the Bank of China, the People's Construction Bank of China, the Agricultural Bank of China, and the Industrial and Commercial Bank of China respectively. In the same

year, a reserve system was established to restructure the Chinese banking system. In addition, there are some smaller commercial banks, urban cooperative banks, non-financial institutions, and foreign bank branches in the Chinese financial system (Fang et al., 2000). In December 2006, China has committed to open up its financial system further under World Trade Organization accession agreement and foreign banks should have little barriers to compete with the Chinese banks. Therefore, the Chinese banks face tremendous pressure in attracting local businesses and maintaining profitability and solvency.

### **1.1.2 Main Contours of Monetary Policy Development**

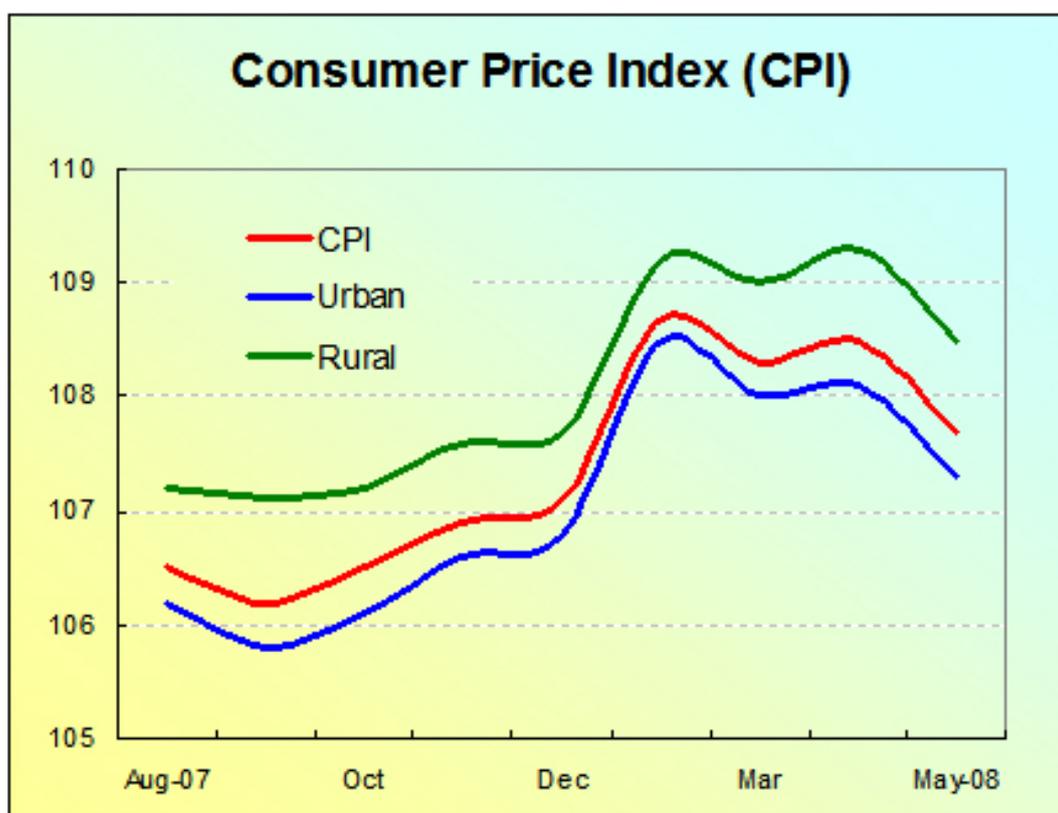
The evolution of monetary policy<sup>1</sup> in China can be summarized as follows. In the 1980s, the PBC used direct monetary control, such as credit quota control, difference control and monetary base control. In addition, China introduced a dual exchange rate system in 1981 and in the middle of 1990s, the dual exchange rate system was abandoned and a fixed exchange rate system (the PBC pegged the Chinese RMB against the US dollar) was introduced (Forssbäck and Oxelheim, 2007). Ping and Xiaopu (2003) argued 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 mainly to control economic activities in the country. The credit quota control system was abandoned and the PBC implemented the reserve requirement, open market

---

<sup>1</sup> The evolution of monetary policy will be discussed in much greater depth in Chapter 2.

operation and discount window to influence the economic activities in 1998. For the first time the PBC used monetary targeting to control the money supply from 1998. Furthermore, the regulations of capital inflows have been gradually removed since the early 2000s. Residents and nonresidents have been allowed to invest in B-shares, which are denominated and transacted in foreign currency but listed in China, since February 19, 2001. At the beginning of 2004, the PBC started to use interest rate instead of money targeting as the intermediate goal in conducting monetary policy (Dai, 2006). However, the consumer price index is still high as shown in Figure 1.1. The question remains whether monetary targeting should be reused to stabilize inflation.

**Figure 1.1 Consumer Price Index**



Source: National Bureau of Statistics of China.

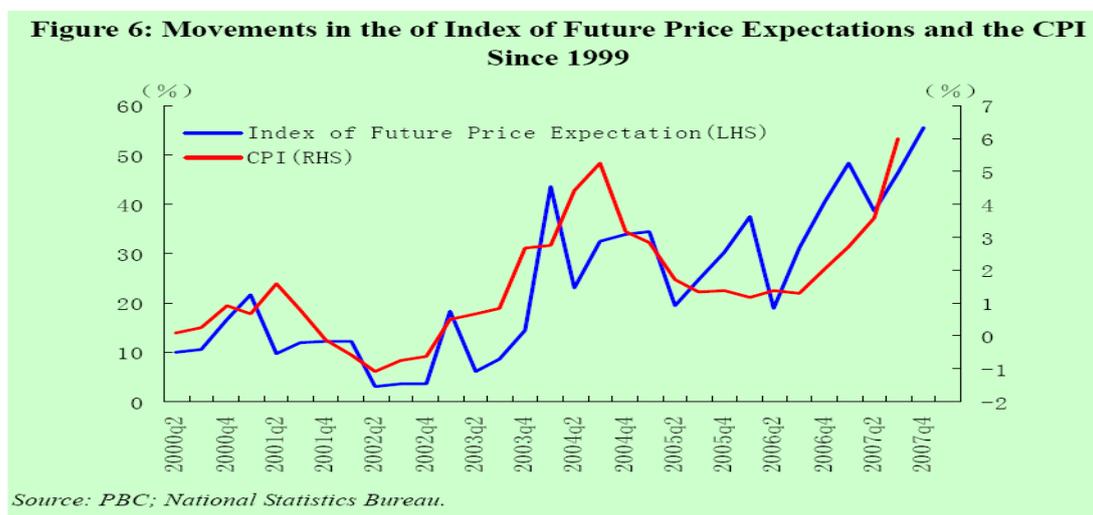
In July 2005, the pegged exchange regime was removed. The RMB was revalued by 2.1% and a managed float exchange rate system was adopted (Forssbäck and Oxelheim, 2007). In January 2007, the Shanghai inter-bank offer rate was introduced to build a money market benchmark interest rate system. At present, the PBC implements a tight monetary policy to restrain the rapid growth of money and credit, prevent high inflation and create sound monetary and financial environment (China Monetary Policy Report Quarter Four, p22, 2007).

### **1.1.3 Inflation Cycle and Inflationary Expectations**

The credit decentralization and market reforms also accelerated inflation. Private firms were allowed to enter into the market and since government subsidies are only transferred to state firms, private firms started to seek high yield investments to decrease operational expenses. In return, they enjoyed high productivity growth. State firms, on the other hand, are subsidized by the government and any losses are covered by subsidies. Therefore, the state firms did not have incentives to invest in high yield investments, which led to low productivity growth. The difference between high and low productivity growth is called the productivity gap and the government tried to minimize the gap by allocating more credit to state firms. However, the government could not control the credit allocation adequately because banks allocated most of the credit to private firms to maximize their own profits whereas state firms only had small credits to invest. The government was forced to use money creation to supply more credits to state firms and finally, the output growth rate and the productivity gap

increased, which led to the increase in inflation. This process is circulatory (Brandt and Zhu, 2000). In addition, inflationary expectations in China changed the real interest rate expectations, which affected public savings and investment decisions including both money supply and money demand. Inflationary expectations affect people's decision-making. If people expect high inflation, then they will try to spend more in the earlier stage. With spending on the rise, price levels will also start to increase. If there are low inflationary expectations, then people will save more.

**Figure 1.2 Movements in the Future Price Expectations and the CPI**



Source: China Monetary Policy Report Quarter Three, 2007.

The graph in Figure 1.2 shows the trend of the Index of Future Price Expectations moving in the same direction as the CPI's and is highly correlated. The increase in the Index of Future Price Expectations drives up the CPI and vice versa. In the fourth quarter of 2007, the CPI reached about 6.5%, which was the highest since 2000. The high inflation rate reinforces inflationary expectations and keeps increasing because the CPI has been increasing since the third quarter of 2006.

Thus, the main task of the PBC is to decrease and stabilize the inflation rate. One way to achieve the task is to manage and monitor the growth rate of money supply in the country using money targeting. This thesis will attempt to test whether money targeting can be used by the PBC to conduct monetary policy.

#### **1.1.4 Theory of Money Targeting**

Money supply is defined as the total supply of money in circulation in a given country's economy at a given point of time. M0, M1, and M2 are commonly used to measure the total money supply in a country. The money supply is considered to be an important mechanism in controlling inflation.

The quantity theory of money states that

$$MV=PT \tag{1}$$

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 (1) can be rewritten as follows:

$$MV=Py \tag{2}$$

Rearranging Equation (2) yields the following:

$$M/P=y/V \tag{3}$$

Since  $V$  is quite stable and changes slowly and  $y$  is fixed in a certain period, the increase of money supply will lead to increase of price level. Therefore, inflation is a result of growth money supply. The central bank sets an inflation target each year and if the actual inflation rate exceeds the target rate, the central bank will reduce the money supply in order to decrease the actual inflation rate and vice versa. Furthermore, Equation (3) also implies a necessary condition for using monetary targeting to control inflation, which is the stable demand function. In order to control the money supply, monetary authorities should decide which particular measure of money supply to target. The broader the measured target, the more difficult it will be to control that particular target. However, targeting an unsuitable money supply reduction measure may lead to a situation where the total money supply in the country is not adequately controlled. This research also investigates which monetary aggregates, namely real  $M_0$ ,  $M_1$ , and  $M_2$ , are stable in the long-run by constructing the money demand functions.

## **1.2 Research Objectives**

The research objectives of this study include the following:

- I. the research will test whether there is a positive or negative relationship between real income, real inflation, and one-year saving deposit rate and monetary aggregates, namely real  $M_0$ ,  $M_1$ , and  $M_2$ , in the long-run
- II. the research will test which determinants are cointegrated with real  $M_0$ ,  $M_1$  and  $M_2$  respectively in the long-run
- III. an error correction model will be used to examine the short-run dynamics and

IV. the study findings will provide some policy implications to policy-makers to make better decisions on how to stabilize macroeconomic sustainability

The research strategy for achieving these objectives is as follows. The first step is to construct the money demand functions for China with the real money demand as dependent variable and the determinants, such as real income, real inflation rate, and one-year saving deposit rate as independent variables for real M0, M1, and M2 respectively. The second step is to use the Augmented Dickey-Fuller (ADF) test to determine the degree of integration of each series. Following this, Johansen (1988) and Johansen and Juselius's (1990) procedures will be applied to the data to estimate the long-run relationship between the money demand and its determinants in China. The last step is to determine how the adjustments are taking place among the variables to achieve the long-run equilibrium using the error correction model (ECM).

### **1.3 Structure of the Thesis**

Chapter One provides an overview of the research problem statement and objectives. Chapter Two discusses the evolution of the Chinese monetary policy and will reviews some pioneer literatures, which estimate the demand for money in foreign countries and China respectively. Chapter Three explains the variable selection, model formulation, and the methodology used in the study. Following this, Chapter Four presents a discussion of the empirical results and findings and Chapter Five provides

the conclusions of the research findings, policy implications, limitations and recommendations for future research.

## **Chapter 2 Literature Review**

### **2.1 The Evolution of the Chinese Monetary Policy**

The Chinese monetary policy has undergone different stages of development in terms of objectives, intermediate goals, and monetary tools. In addition, China switched from the centrally planned economy to market economy since the financial reforms in the late 1970s and replaced the direct monetary management by indirect monetary management in 1993 (Yu and Xie, 1999). Furthermore, its exchange rate regime experienced different development stages, such as an administrative exchange system, a dual exchange rate system, a managed float system with a narrow band and a managed float system with a very narrow band (Huang and Wang, 2004). The old and new trading systems, along with different exchange rate regimes, were abolished and introduced respectively. Significant progress has been made in controlling monetary base. Money market and capital market were gradually developed. The evolution of the Chinese monetary policy is discussed as follows in chronological order.

Before the financial reforms, the PBC was a mono-bank transferring funds from savers to borrowers, and used direct monetary management to conduct monetary policy. Direct monetary management, also called credit quota control, was used to set

the state production plans in each production sectors for the Ministry of Finance and it comprises the credit and the cash plans. The credit plan has two forms: enterprise and financial credit. The former was extended to finance transitory phenomena and the latter was extended to finance budget deficits. The cash plan sets the target for currency in circulation and commercial banks implemented the target (Feltenstein and Farhadian, 1987). However, the system was inefficient and ineffective. For example, credit allocation did not allocate credit resources efficiently, which led to a bank's liabilities exceeding its assets. Firms could also obtain more credits from other channels, such as foreign sources, capital markets, and informal channels and therefore banks no longer monopolize credit plans. Banks did not follow the credit constraint because the PBC could not effectively enforce credit disciplines. In the late 1970s, China had an administrative exchange system, which was used to support the centrally planned economy. The official exchange rate was linked to a basket of currencies. Foreigners were allowed to exchange currencies using Foreign Exchange Certificates (Huang and Wang, 2004).

In 1980, a new monetary tool called "Difference Control" was introduced 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. However, the targeted difference was based on the actual differences of all commercial banks, and commercial banks started to increase their differences as much as possible by making more loans. Thus, the money supply was not controlled efficiently. China introduced a dual exchange rate system in 1981, and was defined as “an official rate for non-trade-related transactions and an internal settlement rate for authorized current account transactions.” (Huang and Wang, 2004). In a dual exchange rate system, there are both fixed and floating exchange rates in the market. The fixed exchange rate is applied to current account transactions, while the floating rate is determined by the movements of the currencies in the basket.

In 1985, the internal settlement rate was abolished and all transactions were applied to the official rate (Huang and Wang, 2004). In the same year, the PBC introduced “Monetary Base Control”. Monetary base is the central bank’s liabilities equal to bank reserves plus currency in circulation. The PBC controlled the monetary base through three ways, the PBC loans to state banks, the PBC budgeting lending to the government, and the foreign exchange reserves. The lack of international accounting standards and auditing systems causing performances of bank branches were not monitored closely by headquarters, asymmetric information between the PBC, branches, and headquarters was prevalent. Therefore, the bank management of both assets and liabilities got worse. The PBC had to extend liquidity because banks’ loan portfolio and capital positions were deteriorating. Currently, the PBC has abandoned the budget lending to the government because the government has generated more

taxes based on a better tax collection system. Thus, this change has relieved the PBC's financial burden and it reinforced both fiscal and monetary policy (Yu and Xie, 1999).

In 1986, China reintroduced the dual exchange rate system after establishing the special economic zones. Domestic and foreign firms in the zones were allowed to trade foreign currencies at negotiated exchange rate in Foreign Exchange Adjustment Centers (the swap center). However, under this mechanism, China had one official exchange rate and many market exchange rates. The gap between the two rates and the volatility of market rates increased (Huang and Wang, 2004).

In 1994, the dual exchange rate system was abandoned and a managed float exchange rate system with a narrow band (the pegged system of the Chinese RMB with the US dollar) was introduced (Forssbäck and Oxelheim, 2007). All foreign transactions were traded at RMB 8.7 per US dollar. This rate was allowed to fluctuate by  $\pm 2.5\%$  of the previous day's reference rate. In the same year, a new trading system along with the new exchange rate regime, called the China Foreign Exchange Trade System, was introduced to replace the Foreign Exchange Certificates. The narrow band,  $\pm 2.5\%$ , was further decreased during the Asian financial crisis (Huang & Wang, 2004). Owing to the changes of exchange rate regime and policy, foreign reserve increased from 1.5% to 25% of the PBC's total assets between 1985 and 1994. In order to absorb the huge increase in foreign reserves, the PBC used those foreign

exchanges to make loans. If firms export or import goods and services in foreign currencies, they must sell foreign currencies to or buy from commercial banks, then commercial banks trade those currencies with the PBC for domestic currency. Currently, the PBC allows firms to keep part of foreign currencies because using foreign exchanges to make loans becomes difficult (Yu and Xie, 1999). According to Ping and Xiaopu (2003), that there was no monetary policy in China before the 1990s and only credit quota control and government intervention were used in determining the economical variables. After 1993, exchange rate, interest rate and tax rate were mainly used to control economic activities. From 1998, monetary targeting was used in conducting monetary policy.

Credit quota control was abandoned and the PBC started implementing reserve requirement, open market operation and discount window to influence economic activities (Yu and Xie, 1999). Further, the regulations of capital inflows have been gradually removed since the early 2000s. Residents and nonresidents have been allowed to invest in B-shares, which are denominated and transacted in foreign exchange but listed in China, since February 19, 2001. Dai (2006) argues that money targeting was not successful because of the unstable money demand function. Mookerjee and Peebles (1998) found that it was difficult to control money supply using reserve requirements and direct credit control. At the beginning of 2004, the PBC started using interest rate instead of money targeting as the intermediate goal in conducting monetary policy.

The pegged system was removed in July 2005. The RMB was revalued by 2.1% and a managed float exchange rate system was adopted (Forssbäck and Oxelheim, 2007). At present, the PBC is using reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending, open market operation and other policy instruments specified by the State Council to absorb excess liquidity in the banking sector, to maintain the value of the currency and to promote economic growth (China Monetary Policy Report Quarter Four, p50, 2007).

## **2.2 Money Demand in Foreign Countries**

Sriram (2002) applied monthly data from August 1973 to December 1995 in Malaysia and found that real M2 was quite stable in both the long and short-run using the Error Correction Models (ECMs). The opportunity cost of holding money includes 3-month time deposits with the commercial banks (own rate on money), discount rate on 3-month government securities (alternative rate on money) and expected inflation. A dummy variable (DINTS) was introduced to reflect administrative control and market determination of interest rates. Another dummy variable capturing government control over excess liquidity in the banking system in January 1994 was also included in the Sriram's model. The long-run income elasticity is close to one which suggests the financial system is well-developed. Sriram also identified that economic fluctuations and massive capital inflows during 1985-1987 and 1993-1995 did not impact on the stability of real M2 in Malaysia. Furthermore, Sriram addresses four

points in formulating a suitable money demand function. First, one must identify any alternative assets available to hold money. Then, it is necessary to know the liquidity of the money market and the capital market. Third, are interest rates adjusted by market forces or the government? Finally, how fast is financial innovation taking place?

Dahalan, Sharma and Sylwester (2005) compared divisia M1 and M2 (DM1 and DM2) with simple sum M1 and M2 (SM1 and SM2) in Malaysia using quarterly data from 1976 to 2001. The authors used the Error Correction Model and money demand determinants, such as inflation, income, domestic and foreign interest rates and financial wealth to formulate long and short-run relationships. The test statistics ( $\chi^2$ ) suggest that foreign interest rates for SM1, financial wealth and foreign interest rates for SM2 and inflation, domestic and foreign interest rates and financial wealth for DM1 and the foreign interest rates for DM2 do not have long-run relationship with the money demand functions for SM1, SM2, DM1 and DM2 because of the statistical insignificance. On the other hand, the statistical insignificance of the foreign interest rates does not indicate that the foreign influences are not important. Since Malaysia is a small open economy, the foreign influences on the money demand function may be caused by other channels, such as the exchange rates. Furthermore, the authors suggest that SM2 and DM2 could provide more information than SM1 and DM1 because the test results are more plausible. DM2 does not exclude any domestic variables compared to SM2. Taken together, these results suggest that for Malaysia

divisia M2 is the best indicator to conduct monetary policy.

In contrast to conventional money demand specifications, Hueng (1998) used the cash-in-advance model (CIA), which includes the foreign interest rate and the exchange rate in money demand function to test the demand for money in Canada using quarterly data for the period 1973:2-1991:1. There are three advantages in using CIA. First, it explicitly models liquidity services provided by money under the agent's budget constraint instead of the utility function. Second, the CIA model considers the foreign interest rate and the exchange rate. Third, by applying the CIA, we can identify the effects of the interest rates on the money demand function. Hueng found that the real income is positively related to the money demand function, which suggests that an increase in income leads to an increase in money holding. Compared to the real income, domestic interest rate negatively impacts the holding of money because the opportunity cost of holding domestic currency increases if the domestic interest rate rises. Hueng also found that divisia M2 is related to the interest rates and the exchange rate. However, without considering these two variables, there will be misspecification in the money demand function. The author further suggested that the effectiveness of the monetary policy does not depend on the exchange rate system (fixed or floating), but people's decisions to hold money plays an important role in the effectiveness of the monetary policy. Foreign monetary development affects people's money demand. There are three main reasons that affect people's money demand:

- i. an increase in the foreign interest rate raises the opportunity cost of holding foreign currency. Thus, people prefer to hold more domestic currency and to withdraw foreign currency.
- ii. the absolute value of the foreign interest rate elasticity is larger than the domestic interest rate. This indicates that the movement of the foreign interest rate impacts the long-run money demand function of divisia M2 in Canada much greater than the domestic interest rate.
- iii. an appreciation of domestic currency increases the holding of domestic currency and vice versa. Therefore, the real exchange rate has a negative relationship with the money demand function.

Narayan (2007) used the CIA to estimate the money demand function in Indonesia for the period 1970-2005. The author found that real M1 was negatively related to the domestic interest rate and the real exchange rate in the long-run. Real income and foreign interest rate are positively related to real M1; however, real M2 is only impacted positively by real income and negatively by the real exchange rate. There is no significant statistical relationship between real M2 and foreign interest rate. The negative relationships between real M1 and M2 and the real exchange rate suggest the evidence of currency substitution. In the short-run, there was only one causal relationship between the real exchange rate and real M1 and M2. Moreover, money targeting is not an option for Indonesia because of the unstable money demand functions.

Different variables, data length and methodologies can lead to different outcomes following Narayan's (2007) framework, Dekle and Pradhan (1999) approximated long-run money demand functions for the ASEAN-4 countries, Indonesia, Malaysia, Singapore, and Thailand and evaluated the cointegration functions from 1980 to 1995. The index of financial innovation was included in the demand functions to represent the changes in the velocity of money. The authors found the demand functions were stable, which means monetary targets can be used to conduct monetary policies. Furthermore, they pointed out that real money, income, interest rates and domestic and foreign prices with the nominal exchange rate are necessary conditions for a stable long-run money demand function in their findings.

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. In addition, to capture a wide variety of economic experiences, the authors used the data between 1915 and 1988, which includes two world wars, the Great Depression, and two stock market collapses. Further, in order to compare to other researches, another data period (1953-1988) was used in estimating the money demand function because those researches' results focus on the post-war period. The estimation of the money demand function incorporates two different interest rates, namely the commercial paper rate (short-term interest rate)

and the corporate bond rate (long-term interest rate). Results using two interest rates are given as follows:

- i. the commercial paper rate: the trace test results suggest that the null hypothesis of at most one and two cointegrating vector(s) cannot be rejected for M1 and M2 over two periods. The null hypothesis of no cointegrating relationship for M2 is rejected in either period and it is only rejected for M1 at the 10% level of significance in 1915-1988. The maximum eigenvalue test results suggest that the null hypothesis of no cointegrating relationship can be rejected in both sample periods for M2 but not for M1. Therefore, the two test statistics show that there is a long-run relationship between M2 and its determinants, whereas this relationship is plausible for M1.
- ii. the corporate bond rate: for M1, the trace test and the maximum eigenvalue test results suggest that there is no cointegrating relationship in 1953-1988. However, the maximum eigenvalue test results indicate that the null hypothesis of no cointegrating relationship cannot be rejected in 1915-1988. For M2, the null hypothesis of no cointegrating relationship cannot be rejected for the 1915-1988 results, whereas it can be rejected for the 1953-1988 results; however, the maximum eigenvalue test results show that no cointegrating relationship is rejected in both sample period, which is consistent with the results from the commercial paper rate.

Their results showed there was a cointegrating relationship among those variables but there was no strong evidence of cointegration relationship for M1. Thus, M2 is a

preferable measure to conduct monetary policy.

Compared to Hafer and Jansen's (1991) study, McNown and Wallace (1992) incorporated the effective exchange rate in formulating a broader demand for money (M2). In addition, the real GNP and nominal treasury bill rates are also included in formulating both M1 and M2. The quarterly data for the time period 1973:2 to 1988:4 is used in the estimation. Tests of cointegration can be classified into three categories:

- i. the first category includes real M1 and M2 as dependent variable respectively and real GNP as independent variable. The null hypothesis of no cointegrating vector cannot be rejected for M1 using both 6 lags and 4 lags respectively. For M2, the null hypothesis of no cointegrating vector can only be rejected when 6 lags is used. The evidence of cointegrating relationship does not exist when 4 lags is used.
- ii. the second category includes real M1 and M2 as dependent variable respectively, and real GNP and the interest rate as independent variables. For M1, the null hypothesis of no cointegrating vector can be rejected when 6 lags and 4 lags are applied. Thus, there is a long-run relationship among M1, real GNP and the interest rate. For M2, there is no strong evidence to suggest that there is any cointegrating relationship among M2, real GNP and the interest rate.
- iii. the final category only includes M2 as dependent variable. Real GNP, interest rate, and effective exchange rate are independent variables. For trace

$\lambda$  – results, the null hypotheses of no cointegrating vector and at most one cointegrating vector can only be rejected using 6 lags.

The coefficient of effective exchange rate is positive, which indicates the evidence of currency substitution. In order to achieve a stable M2 money demand function, the authors suggest that it is necessary to include the effective exchange rate in formulating the money demand function of M2. However, it is not the case for M1.

Bahmani-Oskooee and Shabsigh (1996) used Johansen and Juselius's procedure to estimate the long-run relationship between the real M1 and M2 and the real income and interest rate in Japan using quarterly data from the first quarter of 1973 to the fourth quarter of 1990. For M1, the null hypothesis of no cointegration is rejected because the trace statistic is greater than its critical value at both 95% and 90% level and the  $\lambda$  – max statistic is also greater than its critical value but only at 90% level. However, the null hypothesis of at most one cointegrating vector is not rejected. Thus, M1 has a long-run relationship with real income and interest rate. In contrast to M1, M2 does not have any long-run relationship with real income and interest rate because both test statistics are smaller than the critical values. Interestingly, in order to achieve the stability of M2, the effective exchange rate of the Yen should be included in the estimation. By adding the effective exchange rate, the null hypotheses

of no cointegrating and at most one cointegrating vector are rejected. Thus, there are two cointegrating vectors among M2, real income, interest rate and the effective exchange rate. Furthermore, the coefficient of the effective exchange rate is positive, which suggests an evidence of currency substitution.

### **2.3 Money Demand in China**

Felstenstein and Farhadian (1987) constructed two models to measure the changes in money supply and real money balances for the period 1954-1983. In the first model, they employed the government deficit, wage bill of the government and enterprises, 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 could fully explain the changes in broad money. Further, in the second model, they found that the real money balance can be explained by real income and anticipated true rate of inflation. The income elasticity of real money balances is 1.373, which is greater than unity. This result implies that the velocity of money is not constant and the evidence of monetization process. In addition, the true rate of inflation is 2.5 times higher than the official rate.

Chow (1987) used the quantity theory of money to explain the price level in China for the period 1952-1983. By taking the logarithms on  $P = v(M/Y)$  and regress  $\ln P$  on  $\ln(M/Y)$ , the coefficient of  $\ln(M/Y)$  is 0.2687, which means the change in  $\ln(M/Y)$  will lead to a less change in  $\ln P$ . This is consistent with the quantity

theory of money. However, 0.2687 is less than unity, and therefore, the velocity of money is not constant. The author also found the income elasticity is greater than unity, 1.162, which is not consistent with the quantity theory of money.

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:

- i. the increase in transaction demands of firms and households require more money in the economy.
- ii. the introduction of the responsibility system in the agriculture sector led more farmers enter into marketplace. The government purchases goods from farmers using cash, which increases the demand for money.
- iii. the growth of township and village enterprises accelerates the demand for

- iv. the rapid growth of private firms increases the demand for money.
- v. the development of free markets causes cash flow from urban areas to rural areas because farmers' sales form a large percentage in free markets.

During the period 1979-1984, the inflation rate was moderate because the monetization process absorbed the excess money in the economy. Further, the monetization process is the explanation for the non-constant velocity of money. The excess money could not be absorbed because the monetization process started to slow down in 1985 which resulted in higher inflation rate (Yi, 1991).

Luke Chan, Cheng and Deaves (1991) used currency stock, real income, reported price level and interest rate to construct the Chinese money demand function. By using the ordinary least-squares estimation, the authors conclude that both interest rate and anticipated inflation were not significant in explaining the money demand function. Interestingly, the income elasticity is unity, which is not consistent with Feltenstein and Farhadian and Chows' results.

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. The economy of China was centrally planned during that period. Hafer and Kutan's study

also showed which monetary aggregate was a better indicator in conducting monetary policy. Two price measures, the official index of retail prices and the implicit national income deflator were used in Hafer and Kutan's research. The real income was adjusted to: (1) nominal income deflated by the retail price index, and (2) the national income deflator. 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 relationship between them exists when the implicit national income deflator is used. For M0, the results do not reject the unitary income elasticity hypothesis. Also, the results show that the long-run interest elasticity is zero. However, the results reject the price homogeneity (the long-run coefficient of price level is 2.48), which suggest that the changes in money demand and price level are not proportional and one percent increase in price leads a 2.48 percent increase in the money demand for nominal M0. The income elasticity of M2 is not unity (1.42), which indicates the evidence of monetization. Interestingly, the results of M2 do not reject the price homogeneity, which indicates that the demand for nominal M2 changes with the price level proportionally. Therefore, they suggest the broader measure, M2, is a preferable measure for implementing monetary policy.

Huang (1994) employed M2, GNP, consumer retail sales price, and real interest rate on one-year term saving deposits for the period 1979-1990 and applied the Johansen and Juselius (1990) and Engel and Granger's (1987) procedure to test whether there was any cointegration relationship among those variables. The results suggest there is

a long-run relationship and the income elasticity is 2.12. Further, the author used a recursive regression model to test the stability of all parameters. In addition, Huang tested the weak exogeneity of the independent variables by inverting the ECM model to test the significance of the error correction term. The insignificance of the model means the independent variables are exogenous. By doing so, the weak exogeneity of income and price was confirmed. Huang concluded that monetary targeting can be used in conducting monetary policy because of the stable long-run demand for money in China and to control the inflation rate under 10%, M2 should be growing no more than 37%.

Qin (1994) estimated the demand for money in China by applying two different time period using 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 cannot fully represent money demand. Thus, Qin used real interest rates (one year bank deposit rate net of inflation) to represent the opportunity cost of holding money. Qin also argued that under the financial reforms, the large increase in income levels of both individuals and firms and state economic planning should be considered as part of transaction demands. Since national income and GDP ignore sales, the transfers of intermediate goods, and the effect of changes in income distribution, Qin constructed a monetization index (MI) by employing the price ratio of agricultural to industrial output deflators and the output ratio of the non-state-owned industry to the whole industry to overcome this problem. Further,

Qin used the annual rate of saving and loan ratio to capture the effects of the government investment plan. Since the sample size of 1978Q1-1991Q4 is small and unit root tests may not have much power to determine the degree of integration of each variable, Hendry's general to simple reduction approach was employed to construct an error correction model. Then the Johansen's (1988) procedure was used to check for weak exogeneity of the single equation obtained from the Hendry's general to simple reduction approach. The author found that the annual saving rate and loan ratio was only significant in the short-run but not in the long-run. The interest rate is significant in both short and long-run, which means it should be considered when estimating the demand for money in China. In addition, MI is significant in the long-run because the long-run relationship embedded in the error correction term is identical when using two data sets.

Chen (1997) applied cointegration tests to estimate the long-run money demand function in China during the period 1951-1991. By implementing both the augmented Dickey-Fuller procedure (ADF) and Kwiatkowski, Phillips, Schmidt, and Shin's procedure (KPSS), the author showed that inflation was stationary and the real balance and output were non-stationary. The cointegration test suggests the real balance and output are cointegrated with the expected inflation by using M0 and M2 respectively. The income elasticity of M0 is 1.4 to 1.5 and 1.8 to 1.9 for M2, which means the velocity of money is not constant, and the increase in income leads to a decrease in the velocity of money. 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%.

Yu and Tsui (2000) compared simple-sum aggregates to the monetary services index (MSI) by using monthly data for the period 1984-1997. The purpose of this comparison was to find out whether MSI can also be used as a target variable when conducting monetary policy. They suggested MSI can fully represent the function of money, such as the medium of exchange or store of value. It also captures the effect of financial innovations. Furthermore, they found that MSI is better than simple-sum aggregates in estimating the long-run demand for money in China.

In the 1980s, Feltenstein and Farhadian (1987) and Chow (1987) examined the Chinese economy by focusing on how the changes in price levels affect the money supply under a centrally planned economy regime. Both studies showed that the velocity of money is not constant but with different income elasticity (1.373 and 1.162). Unfortunately, they did not explicitly estimate whether there exists any long-run relationship between money aggregates and the explanatory variables. In the 1990s, researchers such as Hafer and Kutan (1994) and Huang (1994), focused on the estimation of the long-run money demand function in China using the Johansen and Juselius's (1990) test. Both studies showed that M0 and M2 are recommended for implementing monetary policy. Qin (1994) introduced MI in estimating the money demand function in China and showed that money demand determinants can fully explain the money demand function. Yu and Tsui (2000) suggested that MSI is better

than simple-sum aggregates in setting monetary policy in China.

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%. In the theoretical model, productive private firms cannot obtain funds easily, which leads to a decrease in output. Their results show that income only positively impacts on real money balance under a high inflation regime, which is consistent with the theoretical model.

In general, most studies estimated the money demand function with different variables, different data time period, and different testing methods, such as the unit root test, the cointegration test and the error correction model. Some of them tested the stability of parameters using the Hansen test and the recursive regression method. The results showed a positive relationship between money demand and income, and a negative relationship between money demand and interest rates. However, there is no study that focuses on which monetary aggregate is the best target variable comparing M0, M1, and M2 in estimating the Chinese money demand function. Furthermore, the longest data period of those studies is only up to 1997.

## Chapter 3 Data and Methodology

### 3.1 Variable Selection

The general specification for the long-term demand for money begins with the following functional relationship:

$$\frac{M}{P} = f(S, OC) \quad (4)$$

Where M is the monetary aggregate in the nominal term, P is price, thus,  $\frac{M}{P}$  is the demand for real balances. S is scale variable. OC is the opportunity cost of holding money.

Equation (4) states that the demand for real balances is a function of a scale variable representing economic activities and the opportunity cost of holding money. Therefore, it is important to select the appropriate and relevant variables in our empirical model to explain the demand for money. First, to model a money demand function, we need to decide which money aggregates should be used. Previous studies such as Chen (1989), Hafer and Kutan (1994), Huang (1994), and Chen (1997) have shown that the monetary policy can be conducted by using M0, M2, or both in China, but 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. Further, Dahalan, Sharma, and Sylwester (2005) suggested that divisional monetary aggregates work better than simple-sum aggregates. However, owing to data limitations, simple-sum M0, M1 and M2 will be used in our study. The consumer price index (CPI) will be used to represent P in Equation (4).

Second, a scale variable is used to represent economic activities. There are many variables which can be used as scale variables, such as real income, disposable income, consumption, and domestic absorption. However, many researchers use real income as a scale variable (see Hafer and Kutan 1994; Huang 1994; Qin 1994; and Chen 1997). GDP is a common proxy for income. Thus, real income will be used in our study.

Third, the demand for an asset depends on its opportunity cost. Luke Chan, Cheng and Deaves (1991), Hafer and Kutan (1994), Huang (1994), and Qin (1994) argued that interest rates can be used as the opportunity cost of holding money. However, 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. For example, if a one-year saving deposit rate is used in estimating money demand function, it is an own-rate on money M2, but it is an alternative rate on money M0. Some studies such as Chen (1997), Sriram (2002), and Austin, Ward, and Dalziel (2007) suggested that expected inflation can be used as opportunity cost of holding money. In addition, Honohan (1994) suggested that the expected inflation is highly correlated with the actual inflation. Therefore, actual inflation is used in our study as an additional variable to represent the opportunity cost of holding money.

Fourth, Hueng (1998) argued that traditional money demand studies have ignored the

influence of foreign monetary developments which may influence the domestic demand for real money balances. Khalid's (1999) study revealed that money demand in an open economy can be estimated by domestic income, foreign income, domestic interest rate, foreign interest rate, and some measure of exchange rate depreciation. However, the RMB was pegged to the US dollar until 2005, thus, the appreciation and depreciation of the RMB were quite small. Although the pegged system was removed in July 2005, the RMB is still under a managed exchange rate system, and it is not allowed to freely float. Chinese residents were not allowed to exchange the RMB into large amount of foreign currencies until recently. Thus, using the exchange rate in estimating the demand for money in China is not appropriate in our study.

### **3.2 Model Formulation**

The formulation of the money demand function follows Chen's (1997) study. Chen used M0, M2, and M3, national income, expected inflation, and retail price in his empirical model. Thus, our study uses Chen's study using real income and actual inflation rate. Further, 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:

$$LRM0 = \alpha_{11} + \alpha_{12}LRINC + \alpha_{13}INF + \alpha_{14}RINTR_{yr} + \varepsilon_{01} \quad (5)$$

$$LRM1 = \alpha_{21} + \alpha_{22}LRINC + \alpha_{23}INF + \alpha_{24}RINTR_{yr} + \varepsilon_{02} \quad (6)$$

$$LRM2 = \alpha_{31} + \alpha_{32}LRINC + \alpha_{33}INF + \alpha_{34}RINTR_{yr} + \varepsilon_{03} \quad (7)$$

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  $\varepsilon$  is the error term.

### 3.3 Expected Signs of Coefficients

- I. Real income is expected to be positively related to the money demand functions (Equation 5, 6, and 7) because as more real incomes increase the number of transactions in an economy and this increases people's demand for money.
- II. The actual inflation rate is expected to be negatively related to the money demand functions because people tend to hold more physical assets rather than money with a higher inflation rate.
- III. The one-year saving deposit rate is expected to be negatively related to the money demand functions because an increase in domestic interest rate increases the opportunity cost of holding domestic money (Hueng, 1998). Therefore, people tend to hold less RMB when one-year saving deposit rate increases.

### 3.4 Methodology

Regression analysis is used to derive the money demand function (Equation 5, 6, and 7). Unit root tests, cointegration analysis and error-correction model will also be conducted in regression analysis. The use of unit root tests is to ensure that all

variables are integrated of order one. Cointegration analysis and error-correction model are used to estimate the long-run money demand function (Equation 5, 6, and 7) and to derive short-run money demand functions (Equation 13, 14, and 15) respectively. Our study will follow this procedure to estimate the demand for money in China.

### 3.4.1 Unit Root Tests

It is common for time series to have increasing conditional means and variances over time. In other words, the series are not stationary and the estimations of the coefficients of the independent variables are biased. Therefore, before using cointegration tests, we need to find out whether the time series are stationary or not. If the time series are stationary in their levels but not in the first differences, then we cannot carry out the cointegration tests and vice versa because the cointegration tests require that all variables should be integrated of order one. Since many economic time series have complicated dynamic structure than other types of time series, the Augmented Dickey-Fuller (ADF) test will be used to determine the degree of integration of each series (Oskooee and Shabsigh, 1996).

To implement the ADF test, we estimate the following regression:

$$\Delta Z_t = a + bT + cZ_{t-1} + \sum_{i=1}^k d_i \Delta Z_{t-1} + W_t \quad (8)$$

Where  $\Delta$  is the first difference operator; T is the time trend and w is a white noise error term. We test whether b is zero. Then ADF test statistic is calculated by dividing

the estimate of  $c$  to its standard error.

Each of the variables used in our study will be tested for a unit root. The ADF tests the null hypothesis of a unit root against the alternative hypothesis of no unit root. The null hypothesis of a unit root is rejected if the calculated  $t$  statistic is less than the critical value. If the calculated  $t$  statistic is greater than the critical value, the null hypothesis is not rejected (Hafer and Jansen, 1991). For example, if we do not reject the null hypothesis in the log-level of each variable, then we will look at the first-difference of each variable; if the null hypothesis is rejected in each variable, we can conclude that all variables are integrated of order one.

### **3.4.2 Cointegration**

Cointegration implies that the cointegrating variables are non-stationary but the linear-relationship between them is stationary and provides a statistical framework for developing the long-run relationship between the money demand and its non-stationary variables (Hafer and Jansen, 1991).

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, and include the short-run dynamics in estimating the long-run money demand function. Further, we

can test for multiple cointegrating vectors and the restricted version of the cointegrating vectors.

Johansen (1988) defined a distributed lag model of a vector of variables as follows:

$$X_t = \Pi_1 X_{t-1} + \dots + \Pi_k X_{t-k} + \varepsilon_t, \quad t = 1, 2, \dots, \quad (9)$$

Where  $X$  is a vector of  $N$  stationary variables,  $\Pi$  is a matrix of parameter, and  $\varepsilon_t$  is an independently and identically distributed  $N$ -dimensional vector with zero mean and  $\Omega$  variance matrix.

If vector  $X$  is non-stationary, then we need to differentiate it to first difference form, which is given as follows:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \varepsilon_t \quad (10)$$

Where  $\Gamma_i = -I + \Pi_1 + \Pi_2 + \dots + \Pi_i$  for  $i = 1, 2, k-1$

And  $\Pi = -I + \Pi_1 + \Pi_2 + \dots + \Pi_k$

$\Pi$  is an  $N \times N$  matrix and includes the number of  $r$  cointegrating vectors between the variables in  $X$ , which provides information about the long-run equilibrium relationships among the variables. The rank of  $\Pi$  shows the number of cointegrating relationships.  $\Gamma$  matrix for the first-differenced variables in  $\Delta X_{t-1}$  contains the contemporaneous short-run adjustment parameters.

Since cointegration requires that all variables are integrated of order one, the maximum rank of  $\Pi$  should be one.  $\Pi$  can be decomposed into the product of two  $q$  by  $r$  matrices  $\alpha$  and  $\beta$  respectively such that  $\Pi = \alpha\beta'$ . The  $\beta$  matrix contains

the  $r$  cointegrating vectors. Then Johansen and Juselius (1990) demonstrated that  $\beta$  can be estimated as the eigenvector associated with  $r$  largest by solving Equation (11) (Oskooee and Shabsigh, 1996):

$$|\lambda S_{kk} - S_{k0} S_{00}^{-1} S_{0k}| = 0 \quad (11)$$

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

Each of the variables in the  $\Delta X_t$  vector is regressed on  $\Delta X_{t-1}, \dots, \Delta X_{t-k-1}$ , then the set of residuals,  $R_{0t}$ , is obtained. Each  $X_{t-k}$  variables is regressed on  $\Delta X_{t-1}, \dots, \Delta X_{t-k-1}$  to obtain  $R_{kt}$ .

After obtaining the eigenvalues by solving Equation (11), we can calculate both the *trace* and  $\lambda$  – max statistics as follows:

$$Trace = -T \sum_{i=r+1}^q \ln(1 - \hat{\lambda}_i) \quad (12)$$

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

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

The hypothesis is given as follows:

$r$  is the number of cointegrating vectors. For example,  $r=0$  indicates that there is no cointegration.

Our study tests the following three hypotheses:

- $r=0$  vs  $r=1$

In this case, if both *trace* and  $\lambda$  – max statistics are greater than the critical values, we reject the null hypothesis and conclude that there is a cointegration relationship. If

both *trace* and  $\lambda$ -max statistics are less than the critical values, we do not reject the null hypothesis and conclude that there is no cointegration.

- $r \leq 1$  vs  $r=2$

In this case, if both *trace* and  $\lambda$ -max statistics are greater than the critical values, we reject the null hypothesis at most one cointegrating relationship. If both *trace* and  $\lambda$ -max statistics are less than the critical values, we do not reject the null hypothesis that at most one cointegrating relationship.

- $r \leq 2$  vs  $r=3$

In this case, if both *trace* and  $\lambda$ -max statistics are greater than the critical values, we reject the null hypothesis at most two cointegrating relationships. If both *trace* and  $\lambda$ -max statistics are less than the critical values, we do not reject the null hypothesis that at most two cointegrating relationships.

The three sets of hypotheses are tested individually until one of them cannot be rejected. In order to use Johansen's (1988) and Johansen and Juselius's (1990) procedures, our study employs four lags because we used quarterly data in our study.

### **3.4.3 Short-run Model**

Money demand variables move in the same direction in order to achieve long-run equilibrium in the long-run level. However, short-run disturbances in the money demand function can cause the variables to either move up or down. 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 ensures the existence of a long-run relationship (Sriram, 2002). In our study, the short-run model is applied to M0, M1, and M2 respectively. The EC term can be calculated using Equations (5), (6), and (7). The number of lags in the short-run is one less than the number of lags in the cointegration tests, thus, three lags is used.

The short-run models are formulated as follows:

$$\begin{aligned}
\Delta LRM 0_t = & \alpha_0 + \alpha_1 \Delta LRM 0_{t-1} + \alpha_2 \Delta LRM 0_{t-2} + \alpha_3 \Delta LRM 0_{t-3} \\
& + \alpha_4 \Delta LRINC_{t-1} + \alpha_5 \Delta LRINC_{t-2} + \alpha_6 \Delta LRINC_{t-3} \\
& + \alpha_7 \Delta INF_{t-1} + \alpha_8 \Delta INF_{t-2} + \alpha_9 \Delta INF_{t-3} \\
& + \alpha_{10} \Delta RINTR_{t-1} + \alpha_{11} \Delta RINTR_{t-2} + \alpha_{12} \Delta RINTR_{t-3} \\
& + \alpha_{13} EC_{t-1} + e_t
\end{aligned} \tag{13}$$

$$\begin{aligned}
\Delta LRM 1_t = & \beta_0 + \beta_1 \Delta LRM 1_{t-1} + \beta_2 \Delta LRM 1_{t-2} + \beta_3 \Delta LRM 1_{t-3} \\
& + \beta_4 \Delta LRINC_{t-1} + \beta_5 \Delta LRINC_{t-2} + \beta_6 \Delta LRINC_{t-3} \\
& + \beta_7 \Delta INF_{t-1} + \beta_8 \Delta INF_{t-2} + \beta_9 \Delta INF_{t-3} \\
& + \beta_{10} \Delta RINTR_{t-1} + \beta_{11} \Delta RINTR_{t-2} + \beta_{12} \Delta RINTR_{t-3} \\
& + \beta_{13} EC_{t-1} + e_t
\end{aligned} \tag{14}$$

$$\begin{aligned}
\Delta LRM 2_t = & \theta_0 + \theta_1 \Delta LRM 2_{t-1} + \theta_2 \Delta LRM 2_{t-2} + \theta_3 \Delta LRM 2_{t-3} \\
& + \theta_4 \Delta LRINC_{t-1} + \theta_5 \Delta LRINC_{t-2} + \theta_6 \Delta LRINC_{t-3} \\
& + \theta_7 \Delta INF_{t-1} + \theta_8 \Delta INF_{t-2} + \theta_9 \Delta INF_{t-3} \\
& + \theta_{10} \Delta RINTR_{t-1} + \theta_{11} \Delta RINTR_{t-2} + \theta_{12} \Delta RINTR_{t-3} \\
& + \theta_{13} EC_{t-1} + e_t
\end{aligned} \tag{15}$$

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

Generally, all variables are integrated of the order of zero in the short-run model. Therefore, we can estimate Equations (13), (14), and (15) using the ordinary least squares. If the coefficient of the EC term is negative, we can conclude that it validates the significance of the long-run relationship.

## **Chapter 4 Empirical Results**

### **4.1 Introduction**

Chapter Three described the data and methodology used in this research. This chapter presents the data description, cointegration analysis, and short-run model on the money demand functions. The empirical results and findings on the money demand functions will also be discussed in the chapter.

### **4.2 Data Description**

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 to different measurement of macroeconomic variables, such as GDP and monetary aggregates (Holz, 2004a). CPI is expressed in quarterly terms with the previous quarter's 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.

### 4.3 Hodrick-Prescott Filter

Recall Equation (2) discussed in Chapter One, the quantity theory of money assumes three assumptions: since  $V$  is quite stable and changes slowly and  $y$  is fixed in a certain period, the increase in the money supply will lead to an increase in the price level. Rearranging Equation (2) yields the following:

$$P=V(M/y) \tag{16}$$

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

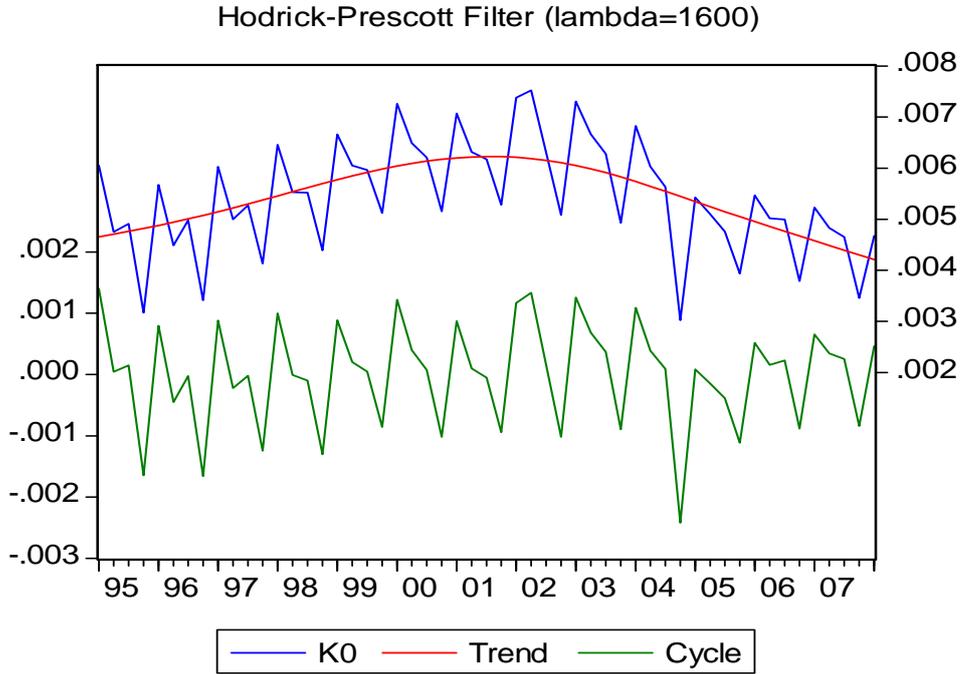
Thus, we use the Hodrick-Prescott (HP)<sup>2</sup> filter to examine whether the income velocity is unity. In other words, we need to test the constancy of  $K$ .  $K$  is inverse income velocity which equals to  $k = M / Py$ <sup>3</sup>.

---

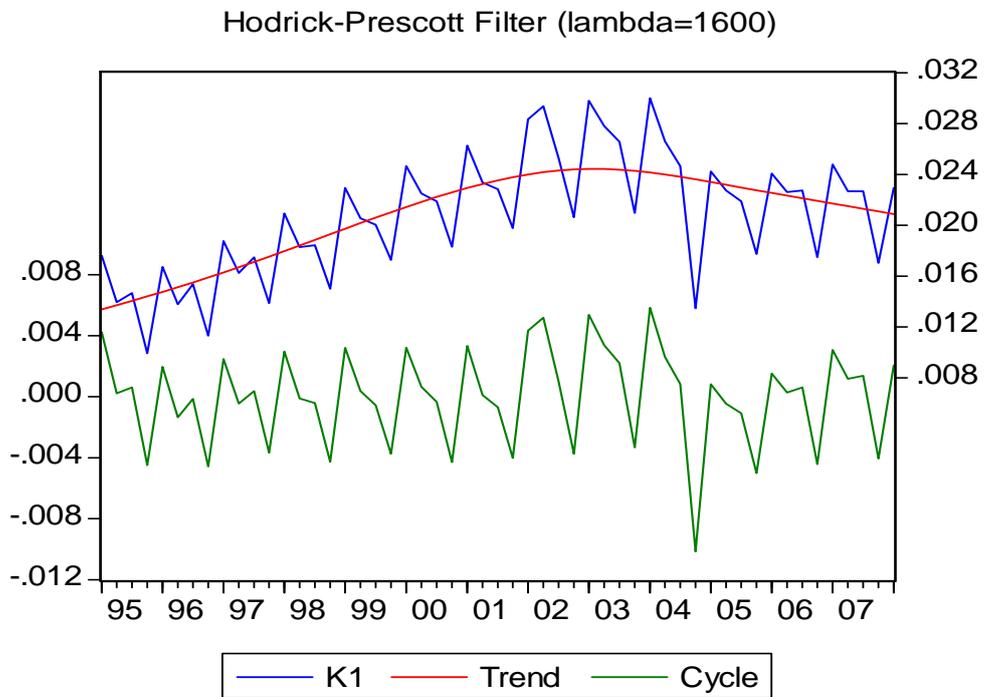
<sup>2</sup> The smoothing parameter of HP filter is 1600 for quarterly data.

<sup>3</sup>  $k_0 = M_0 / Py$ ,  $k_1 = M_1 / Py$  and  $k_2 = M_2 / Py$ .

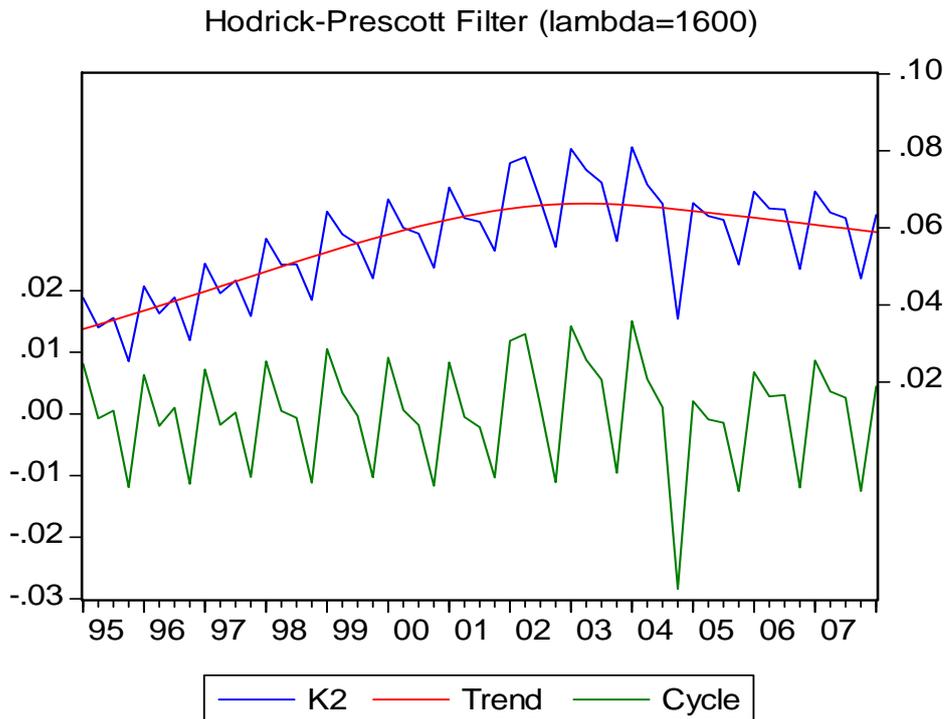
**Figure 4.1 K0**



**Figure 4.2 K1**



**Figure 4.3 K2**



According to the graphs in Figures 4.1, 4.2, and 4.3, 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 income velocities are not constant statistically.

**Table 4.1 ADF Unit Root Test Results**

Variable	Test Statistics <sup>4</sup>
$k_0$	-1.21
$k_1$	-2.13
$k_2$	-2.20

<sup>4</sup> Critical value for the test statistics is -2.92 at 5%.

Since the test statistics are all greater than the critical value at the 5% level of significance from Table 4.1, we reject the null hypothesis of  $k$  has unit root. Thus, 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 Quarter One, p5, 2005). 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. It also creates new cash flow channels among individuals. Therefore, it leads to the decreasing income velocity (Yi, 1991). The deepening financial innovations 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 Quarter One, 2005).

#### **4.4 Unit Root Tests**

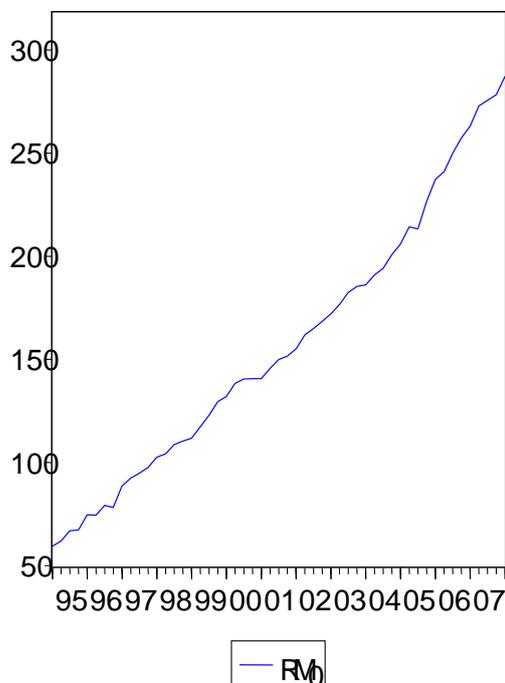
##### **4.4.1 Graphical Descriptions of Quarterly Data**

The levels of the quarterly time series of real M0, M1, M2, real income, inflation and one-year saving deposit rate are denoted as RM0, RM1, RM2, RINC, INF, and DR in Figures 4.4, 4.5, 4.6, 4.7, 4.8, and 4.9 respectively. The first differences of the

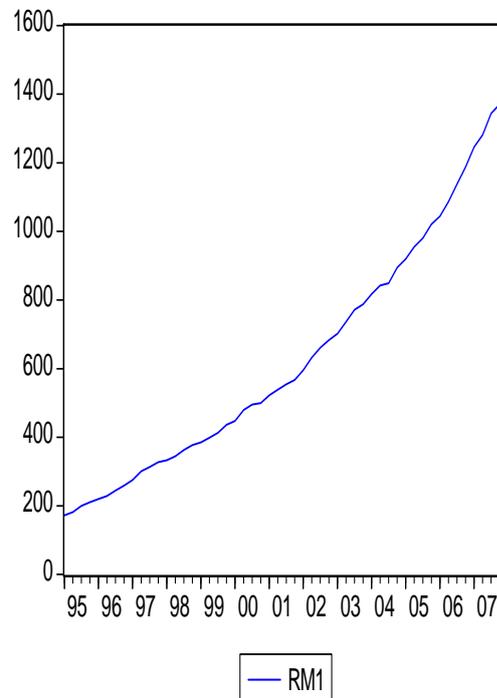
quarterly time series of real M0, M1, M2, real income, inflation and one-year saving deposit rate are denoted as DRM0, DRM1, DRM2, DRINC, DINF, and DDR in Figures 4.10, 4.11, 4.12, 4.13, 4.14, and 4.15.

First, RM0, RM1, RM2, RINC, and INF appear to be nonstationary with an upward and downward trend in their levels. However, such behavior is less apparent for RINTR because the one-year saving deposit rate has been strictly controlled by the Chinese government for a long time.

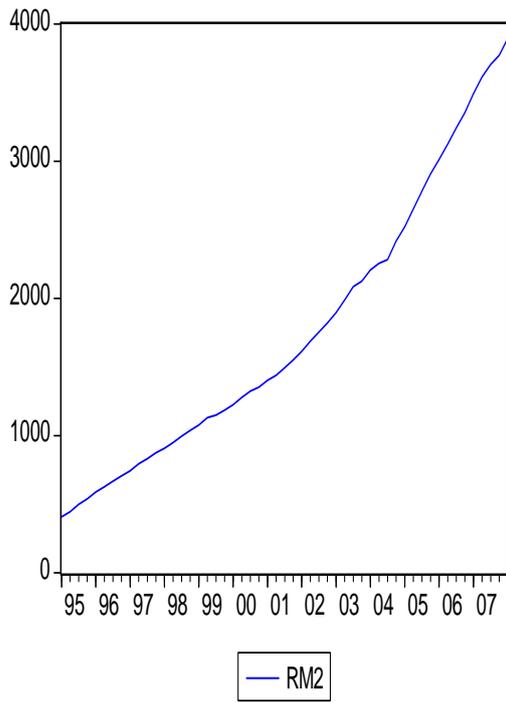
**Figure 4.4 Level of RM0**



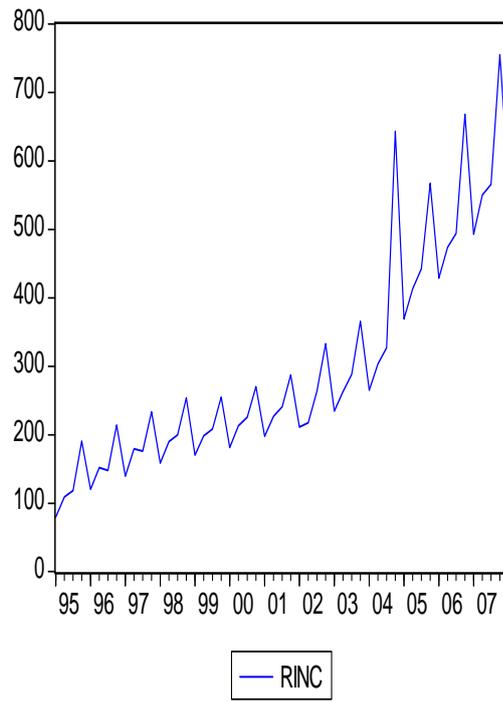
**Figure 4.5 Level of RM1**



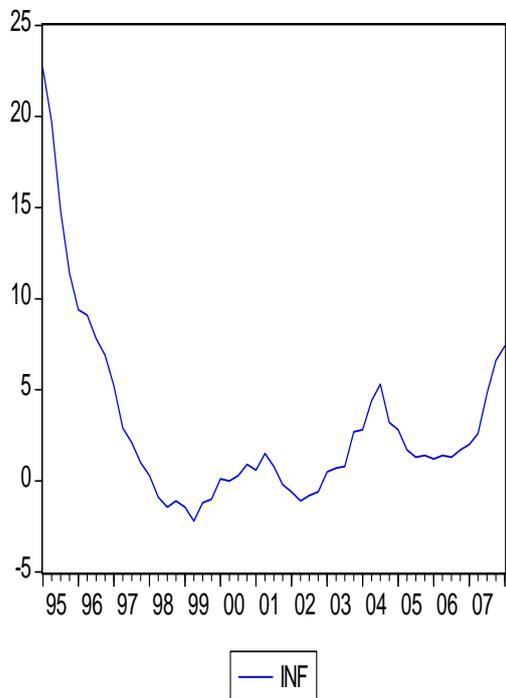
**Figure 4.6 Level of RM2**



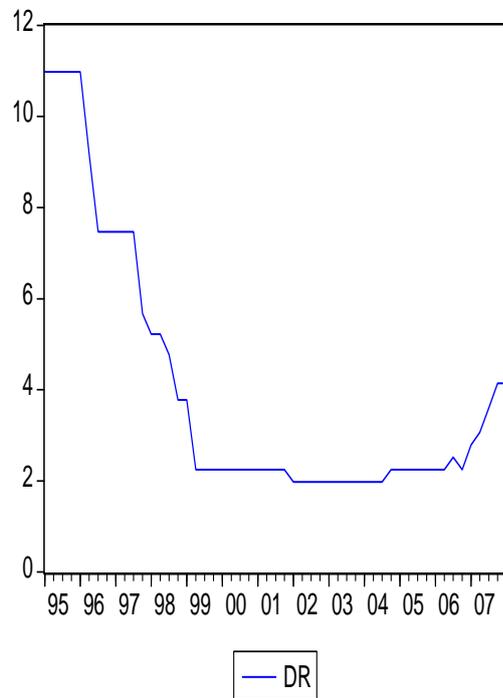
**Figure 4.7 Level of RINC**



**Figure 4.8 Level of INF**



**Figure 4.9 Level of DR**

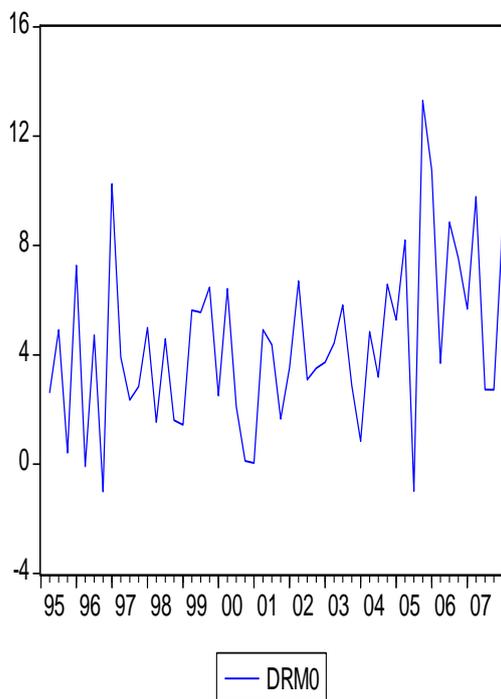


Second, the graphs in Figures 4.4, 4.5, 4.6, and 4.7 exhibit similar upward trend. This visual plot might suggest that these level variables have a long-run relationship. We

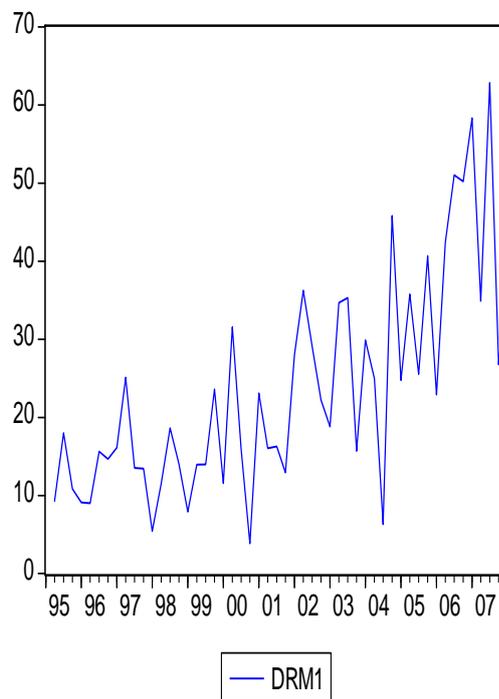
employ correlation tests between LRINC and LRM0, LRM1, and LRM2 respectively. The pairwise correlation coefficients are 0.9178, 0.9259, and 0.9282, which reinforce these variables might have a long-run relationship.

In contrast to the level series, all the first differenced time series fluctuate around different figures in Figures 4.10, 4.11, 4.12, 4.13, 4.14, and 4.15 with constant mean and variances. Such behavior is consistent with that of a stationary series. Therefore, the stationarity of the first differenced time series suggest that they might be integrated of order one or I(1).

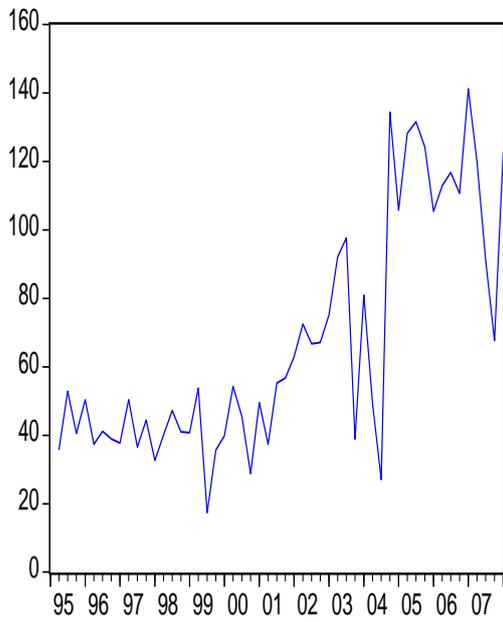
**Figure 4.10 Difference of RM0**



**Figure4.11 Difference of RM1**

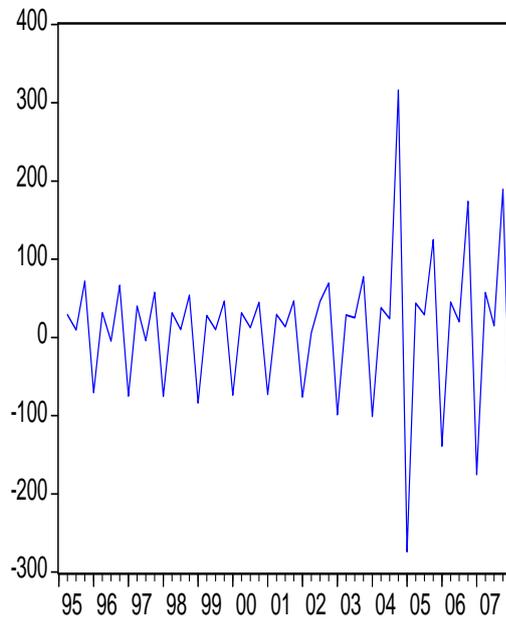


**Figure 4.12 Difference of RM2**



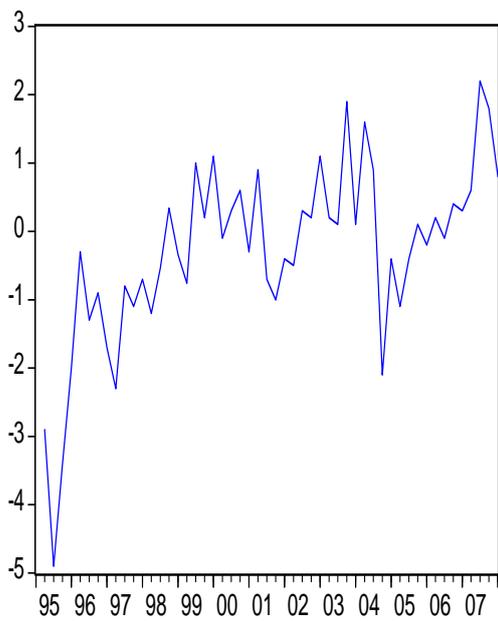
— DRM2

**Figure 4.13 Difference of RINC**



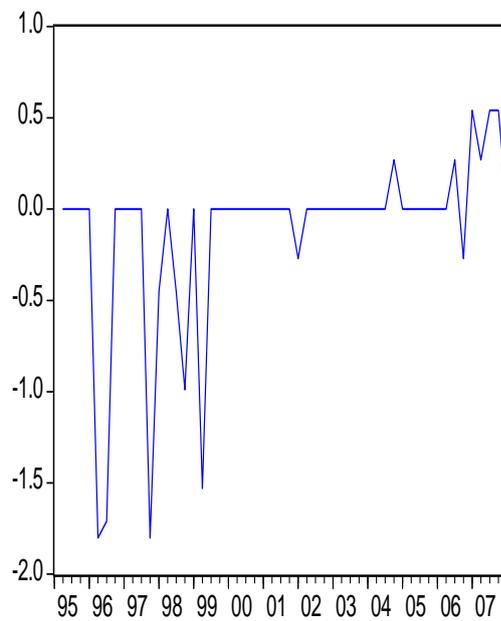
— DRINC

**Figure 4.14 Difference of INF**



— DINF

**Figure 4.15 Difference of DR**



— DDR

#### 4.4.2 Unit Root Tests

Previously we conclude that the time series might be I(1) from the visual plots. 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. If the number of lags is too small, we may over-reject a null hypothesis at any chosen significance level. If the number of lags is too large, more parameters are estimated and the numbers of effective observations are reduced. Thus, there is a high probability that we reject a true null hypothesis of a unit root against a false alternative hypothesis, which reduces the power of tests (NG and Perron, 2001). 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 gave us  $p_{\max} = 12(53/100)^{1/4} = 10.24$ . 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 4.2 Results of Unit Root Tests<sup>a</sup>**

Variable <sup>b</sup>	Calculated ADF statistic	
	Level	First differences
LRM0	-3.26[1] <sup>c</sup>	-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] (*)

- 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% level of significance respectively. They are taken from Mackinnon (1991).
- Logarithms of M0, M1, M2 and real income are used. Real inflation and real rate of one-year saving deposit are in levels.
- The numbers in parentheses are the number of lags used in the ADF test.

The results in Table 4.2 show that the null hypothesis of unit root is not rejected in each level variable. The first-differenced variables have achieved stationarity, indicating that all variables are integrated of order one. Therefore, we can use the Johansen's procedure to test for possible cointegrating relationships and all variables in the procedure should be differenced once.

#### 4.5 Cointegration Tests

This section estimates the long-run relationship between monetary aggregates and their determinants using the Johansen (1988) and Johansen and Juselius (1990) cointegration procedures. Cointegration implies that the cointegrating variables are non-stationary but the linear-relationship between them is stationary. Thus, the variables are cointegrated and the vectors of coefficients of the liner combination are cointegrating vectors. The results obtained from the unit root tests indicates ( see Section 4.4.2) 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 4.3 Cointegration Test Results<sup>a</sup>**

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

- The cointegration tests include four lags for each variable. The estimation period is 1996:Q2-2008:Q1.
- r stands for number of cointegrating vectors.
- (\*) and (\*\*) indicate the rejection of null hypothesis at the 1% and 5% level of significance respectively
- Linear deterministic trend is employed.

The data in table 3 is obtained using the Johansen (1988) and Johansen and Juselius's (1990) cointegration procedures. It shows three cointegrating vectors and the number of cointegrating relationship in each cointegrating vector.

For example, the first cointegrating vector in Table 4.3 includes LRM0, LRINC, INF, and RINTR. The null hypothesis of no cointegration relationship is rejected by both  $\lambda$ -Max and trace statistics at the 1% level of significance. The null hypothesis of  $r \leq 1$  is also rejected at the 5% level of significance. Therefore, we have two cointegrating vectors among those variables.

The second cointegrating vector in Table 4.3 includes LRM1, LRINC, INF and RINTR. The null hypotheses of no cointegrating vector and at most one cointegrating vector are rejected by  $\lambda$ -Max statistics because the statistic values are greater than the critical values 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. Johansen and Juselius (1990) estimated the demand for money in Denmark and their cointegration results suggest that there are at least two but possibly three cointegrating vectors. The authors used the third cointegrating relationship because the hypothesis of proportionality between money and income seems consistent with the data for the three eigenvectors. In other words, we should choose the vector which provides correct signs of coefficients. In addition, the  $\lambda$ -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). In our study, the two eigenvectors are selected for the same reason. Thus, we have two cointegrating vectors among those variables.

The third cointegrating vector includes LRM2, LRINC, INF and RINTR (see Table 4.3). In contrast to the second cointegrating vector, the null hypotheses of no cointegrating vector and at most one cointegrating vector are rejected by trace statistic because the statistic values are greater than the critical values at the 1% and 5% level of significance. The  $\lambda$ -Max statistic only rejects the null hypothesis of no cointegrating vector. For the same reason discussed above, we conclude that there is one cointegrating vector among LRM2, LRINC, INF, and RINTR.

After determining the cointegrating relationships of the three cointegrating vectors, our goal is to examine the signs of the estimated coefficients and income elasticity in cointegration tests.

The cointegrating relationships among variables are summarized by the unnormalized coefficients in the cointegration tests. In order to have long-run money demand functions, we normalize all the coefficients on one variable in all three cointegrating vectors. 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 4.4 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:

$$LRM0 = 0.0903LRINC - 0.0095INF - 0.0039RINTR \quad (17)$$

$$LRM1 = 1.0506LRINC - 0.1865INF - 0.1666RINTR \quad (18)$$

$$LRM2 = 2.7481LRINC - 0.6918INF - 0.4221RINTR \quad (19)$$

From the Equation (17), 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).

According to these studies, the larger than unity income elasticity is caused by the monetization process because the real money balance increase faster than income. A possible explanation for the lower than unity income elasticity is that people have access to more financial instruments included in 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 funds. Thus, the

increase in income would be faster than the increase in narrow measure of money, which leads the lower than unity income elasticity (Austin, Ward, and Dalziel, 2007). The signs of coefficients are same as what we expected. 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 and an increase in domestic interest rate increases the opportunity cost of holding domestic money Therefore, people will hold less RMB when one-year saving deposit rate increases.

Equation (18) and (19) indicates that the long-run income elasticities of M1 and M2 are greater than one, 1.0506 and 2.7481 respectively. The money demand studies on developed countries (Hafer and Jansen 1991; Bahmani-Oskooee and Shabsigh 1996; and Hueng 1998) suggested that the long-run income elasticity is greater than one. Empirical results of the money demand studies for developing countries also provide greater than unity long-run income elasticity (for example, see Feltenstein and Farhadian, 1987; Chow, 1987; Hafer and Kutan, 1994; Huang, 1994; Chen, 1997; Sriram, 2002; and Narayan, 2007). For developed countries, Hueng (1998) found that the income elasticity is 3.432 of divisia M2 for Canada. The author suggested that the larger than unity income elasticity may be caused by the broader definition of money. For developing countries, Feltenstein and Farhadian (1987) and Hafer and Kutan (1994) found the income elasticity is 1.373 for M0 and 1.42 for M2 respectively in

China. These results imply that the velocity of money is not constant and suggest the evidence of monetization process. Sriram (2002) estimated the demand for money in Malaysia and found greater than unity income elasticity (1.0358). The long-run income elasticity is close to one which suggests the financial system is well-developed.

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, including households, private firms, farmers, the development of free markets, and government, of the monetization process that explain the acceleration of the demand for money. Second, financial innovation may impact the demand for money and the long-run income elasticity. Hafer and Kutan (2003) examined the relationship between the money demand and income elasticity in Philippines. The authors found that the financial innovations have a measurable effect on M1, not on M3. In addition, the long-run income elasticity is 1.54. Financial innovations in China basically changed the economic structure and the financial system. For example, Gu (2004) pointed out the former led to the market to allocate resources. Thus, the demand for money and financial assets increased in order to facilitate transactions. This is the result of switching from the centrally planned economy to the market economy. Shi (2001) suggested that the later includes three major factors: financial institutional innovations, financial market innovations, and instrument innovations in banking

sector. Financial Institutional Innovations include the establishment of the central bank and four major commercial banks, including the Bank of China, the People's Construction Bank of China, the Agricultural Bank of China, and the Industrial and Commercial Bank of China. It also includes the establishment of some non-bank financial institutions, such as trust and investment companies. Financial market innovations created money market (interbank market, repurchase agreement market and commercial paper market), capital market (bond market and stock market), and the foreign exchange market. Instrument innovations in banking sector include liability instruments, assets instruments and off-balance-sheet business. 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's (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. However, the interest rate coefficients in our study may not reflect the opportunity cost of holding money accurately since the interest rates in China have been regulated by the government for a long time. The regulated interest rates also do not reflect the expected inflation accurately. Gu (2004) points out that the regulated interest rates do not reflect the true variation in domestic money market. People prefer to substitute between money and real assets rather than between money and financial assets because people do not have many options to invest in interest-bearing financial assets. The coefficients of real inflation are congruent with the economic theory in terms of the hypothesized signs. Three money aggregates are proportional to changes in the real inflation.

The diagnostic tests are performed to detect autocorrelation and heteroscedasticity.

**Table 4.5 Diagnostic Tests**

Vector	autocorrelation	heteroscedasticity
LRM0, LRINC, INF& RINTR	p-value=0.0765	p-value=0.0396
LRM1, LRINC, INF& RINTR	p-value=0.2157	p-value=0.0341
LRM2, LRINC, INF& RINTR	p-value=0.5847	p-value=0.0419

From Table 4.5, the p-values of autocorrelation are greater than 5%, which means we do not reject the null hypothesis of no serial correlation at the 5% level of significance. The p-values of heteroscedasticity are greater than 1%, which suggests evidence of no heteroscedasticity at the 1% level of significance. Therefore, the

diagnostic tests show no problem with autocorrelation and heteroscedasticity.

## **4.6 Short-run Model**

### **4.6.1 Unrestricted model**

In order to understand how changes take place among the variables to achieve long-run equilibrium, it is necessary to use the error correction model (ECM). The ECM includes an error correction (EC) term which ensures the existence of a long-run relationship. First, 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. Second, the restricted model is applied by gradually eliminating the insignificant variables. If any model that has a positive EC term, it will not enter into the restricted model. Since one lag of a difference term equals second lag of the level, the number of lags in the short-run model is one less than what is applied to the cointegration tests (Sriram, 2002). Further, since the variables in the short-run model are generally integrated of order one, the OLS can be employed to estimate the short-run model.

In our study, we construct the short-run model using the first difference of LRM0, LRM1 and LRM2 ( $\Delta LRM0$ ,  $\Delta LRM1$  and  $\Delta LRM2$ ) on the left hand side of the Equations (20), (21), and (22) and the first differences in LRM0, LRM1 LRM2, LRINC, INF, and RINTR on the right hand side of the Equations (20), (21), and (22). Three lags are applied to LRM0, LRM1 LRM2, LRINC, INF, and RINTR

respectively in order to match the lag length of four in the cointegration tests. The right hand side of Equations (20), (21), and (22) also include an EC term, which is calculated as LRM0, LRM1, and LRM2 minus the estimated LRM0, LRM1, and LRM2 in time t-1 (from the cointegrating vectors shown in Equations (17), (18), and (19). The EC term means the excess money demand in previous period in economic term (Sriram, 2002). Thus, we have the following EC terms:

$$EC0 = LRM0 - 0.093LRINC + 0.0095INF + 0.0039RINTR$$

$$EC1 = LRM1 - 1.0506LRINC + 0.1865INF + 0.1666RINTR$$

$$EC2 = LRM2 - 2.7481LRINC + 0.6198INF + 0.4221RINTR$$

The short-run model functions are given as follows:

$$\begin{aligned} \Delta LRM0_t = & \alpha_0 + \alpha_1 \Delta LRM0_{t-1} + \alpha_2 \Delta LRM0_{t-2} + \alpha_3 \Delta LRM0_{t-3} \\ & + \alpha_4 \Delta LRINC_{t-1} + \alpha_5 \Delta LRINC_{t-2} + \alpha_6 \Delta LRINC_{t-3} \\ & + \alpha_7 \Delta INF_{t-1} + \alpha_8 \Delta INF_{t-2} + \alpha_9 \Delta INF_{t-3} \\ & + \alpha_{10} \Delta RINTR_{t-1} + \alpha_{11} \Delta RINTR_{t-2} + \alpha_{12} \Delta RINTR_{t-3} \\ & + \alpha_{13} EC_{t-1} + e_t \end{aligned} \quad (20)$$

$$\begin{aligned} \Delta LRM1_t = & \beta_0 + \beta_1 \Delta LRM1_{t-1} + \beta_2 \Delta LRM1_{t-2} + \beta_3 \Delta LRM1_{t-3} \\ & + \beta_4 \Delta LRINC_{t-1} + \beta_5 \Delta LRINC_{t-2} + \beta_6 \Delta LRINC_{t-3} \\ & + \beta_7 \Delta INF_{t-1} + \beta_8 \Delta INF_{t-2} + \beta_9 \Delta INF_{t-3} \\ & + \beta_{10} \Delta RINTR_{t-1} + \beta_{11} \Delta RINTR_{t-2} + \beta_{12} \Delta RINTR_{t-3} \\ & + \beta_{13} EC_{t-1} + e_t \end{aligned} \quad (21)$$

$$\begin{aligned}
\Delta LRM 2_t = & \theta_0 + \theta_1 \Delta LRM 2_{t-1} + \theta_2 \Delta LRM 2_{t-2} + \theta_3 \Delta LRM 2_{t-3} \\
& + \theta_4 \Delta LRINC_{t-1} + \theta_5 \Delta LRINC_{t-2} + \theta_6 \Delta LRINC_{t-3} \\
& + \theta_7 \Delta INF_{t-1} + \theta_8 \Delta INF_{t-2} + \theta_9 \Delta INF_{t-3} \\
& + \theta_{10} \Delta RINTR_{t-1} + \theta_{11} \Delta RINTR_{t-2} + \theta_{12} \Delta RINTR_{t-3} \\
& + \theta_{13} EC_{t-1} + e_t
\end{aligned} \tag{22}$$

**Table 4.6 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

- the first difference of LRM0 is denoted as DLRM0
- Three lags of first difference in LRM0 are denoted as DLRM01, DLRM02, and DLRM03.
- Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3.
- Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3.
- Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3.
- The EC term in time t-1 is denoted as ECTERM0.

**Table 4.7 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
DRINTR3	0.006337	0.002975	2.12975	0.0403
ECTERM1	-0.066468	0.022902	-2.902239	0.0064

- the first difference of LRM1 is denoted as DLRM1
- Three lags of first difference in LRM1 are denoted as DLRM11, DLRM12, and DLRM13.
- Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3.
- Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3.
- Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3.
- The EC term in time t-1 is denoted as ECTERM1.

**Table 4.8 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

- a. the first difference of LRM2 is denoted as DLRM2
- b. Three lags of first difference in LRM2 are denoted as DLRM21, DLRM22, and DLRM23.
- c. Three lags of first difference in LRINC are denoted as DLRINC1, DLRINC2, and DLRINC3.
- d. Three lags of first difference in INF are denoted as DINF1, DINF2, and DINF3.
- e. Three lags of first difference in RINTR are denoted as DRINTR1, DRINTR2, and DRINTR3.
- f. The EC term in time t-1 is denoted as ECTERM2.

The EC term is positive as shown in Table 4.6, which did not validate the significance of the long-run cointegrating relationship for M0. The EC term reflects how much the disequilibrium is corrected in order to achieve long-run equilibrium and it has a negative sign to respond any deviation from long-run equilibrium. However, the significance of the long-run relationship is plausible because of the positive sign of the EC term. 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 4.7). 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 4.8 shows 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,

which validates the significance of the long-run cointegrating relationship for M2. The negative sign of EC terms as shown in Tables 4.7 and 4.8 suggest that the increases in excess money demand in the previous period decrease the growth in demand for money in present period (Sriram, 2002).

#### 4.6.2 Restricted Model

The restricted models of M1 and M2 are constructed by eliminating the insignificant variables shown in Tables 4.7 and 4.8. For example, DLRM12, DINF1, DINF2, DRINTR1, and DRINTR2 are insignificant (see Table 4.7) since their p-values are greater than 1% and 5% level of significance respectively. DLRM22, DRINTR1, and DRINTR3 are insignificant (see Table 4.8) since their p-values are also greater than 1% and 5% level of significance respectively. After determining the insignificant variables, the OLS estimation is again applied to M1 and M2 respectively. The final results are shown in Tables 4.9 and 4.11.

**Table 4.9 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 4.9). DINF3 is significant at the 5% level of significance. DLRINC3, DRINTR3 and ECTERM1 are significant at the 10% level of significance. The diagnostic tests of autocorrelation, normality and heteroscedasticity have been carried out. The p-value of autocorrelation, 0.015, is greater than 1%, which means we do not reject the null hypothesis of no serial correlation at the 1% level of significance. The p-value of normality test, 0.1698, is greater than 5% level of significance. However, the p-value of heteroscedasticity, 0.0064, is less than 1% and 5% level of significance. Thus, the evidence suggests the presence of heteroscedasticity. In the presence of heteroscedasticity, the t and F statistics in OLS estimation can be highly misleading and the standard errors of the OLS coefficients are not accurate. One way of solving this problem is to re-estimate the model with the presence of heteroscedasticity using the Whites' method (see Table 4.10).

**Table 4.10 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 (see Table 4.10). Thus, the insignificance of the EC term does not validate the long-run cointegrating relationship.

**Table 4.11 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

The data in Table 4.11 show all variables are significant at the 5% level of significance since their p-values are less than 0.05. The results are consistent with the unrestricted model for DLRM2. The EC term has a negative sign.

**Table 4.12 Diagnostic Tests**

Vector	Autocorrelation	Heteroscedasticity	Normality	ARCH
LRM2, LRINC, INF& RINTR	p-value=0.400	p-value=0.062	p-value=0.613	p-value=0.480

Table 4.12 results show the model does not have autocorrelation, heteroscedasticity,

normality and ARCH.

## **Chapter 5 Conclusions and Discussion**

### **5.1 Introduction**

This study tests the positive or negative relationship and estimate the long-run relationship between real M0, M1, and M2 and their determinants, namely real income, real inflation, and real rate of one-year saving deposit in China over the period 1995Q1 to 2008Q1. We employed the Johansen's (1988) and Johansen and Juselius's (1990) procedures to achieve our research objectives. Further, we also employed the unrestricted and restricted short-run model to test whether the error term is negative to validate the significance of the long-run relationship using the OLS estimation.

### **5.2 Research Findings**

First, we used the Hodrick-Prescott (HP) filter to examine whether the income velocity is unity. The data in Figures 4.1, 4.2, and 4.3 show the non-constant income velocities over time with a downward trend followed by an upward trend. In addition, the ADF unit root tests also confirm that the income velocities are not constant since the test statistics are all greater than the critical value at the 5% level of significance. The downward trend of the income velocity is caused by the monetization process because it leads to an increase in demand for money at a faster rate than income. The deepening financial innovations and economic growth accelerate the growth of

income and make income grows at a rate faster than the demand for money. Therefore, the income velocity has an upward trend. The non-constant income velocity is not consistent with the quantity theory of money; however, some previous studies have shown the non-constant income velocity in both developing and developed countries (see for example, Hafer and Jansen's (1991) study on money demand in the US; Bahmani-Oskooee and Shabsigh (1996) in Japan; Hueng (1998) in Canada; and Chow (1987); Feltenstein and Farhadian (1987); and Hafer and Kutan (1994) in China). Hafer and Jansen (1991) used two different data period and interest rates in estimating the money demand functions in the US. The authors found that the income elasticities of M1 and M2 in the two data period with different interest rate are non-constant. The income elasticities of M1 are less than one and the income elasticities of M2 are greater than one. The non-constant income elasticities might be caused by the financial innovations and the monetization process during the two data period. Hueng (1998) employed the cash-in-advance model to estimate the demand for money in Canada. The author found that the income elasticity of divisia M2 is larger than one (3.432) and suggests that broader measure of money may produce higher income elasticity of the money demand function. Feltenstein and Farhadian (1987) and Hafer and Kutan (1994) suggested that the large than unity income velocity in China is caused by the monetization process, which leads to demand for money increases at a rate faster than income. In addition, Yi (1991) identified five channels of monetization process in China which impact the demand for money on different sectors, such as the household, the government, the private enterprises, and

the farms. Further, the non-constant income velocity is not only caused by the monetization process, but also by the financial innovations, which also impact the demand for money in China. In general, the financial innovations in China changed the economic structure and the financial system. The former switched from the centrally planned economy to the market economy and the later includes financial institutional innovations, financial market innovations, and instrument innovations in banking sector. Thus, it is not surprising that we have non-constant income velocity.

Second, before we performed the cointegration tests, the graphical descriptions of the quarterly data and the ADF unit root tests were applied to each series to test whether all series are integrated of order one since the cointegration tests require all series must be integrated of order one. The graphical descriptions of the quarterly data include both level and first difference of each series, namely real M0, M1, M2, real income, inflation, and one-year saving deposit rate. The level series of real M0, M1, M2, and real income exhibit a similar trend, indicating that we might have a long-run relationship among those series and the first difference series suggest that all variable might be integrated of order one. Further, the ADF unit root tests confirm that all variables are integrated of order one since the null hypothesis of unit root is not rejected at each level variable and rejected at each first difference variables at the 1%, 5%, and 10% level of significance respectively.

Third, the Johansen's (1988) and Johansen and Juselius's (1990) cointegration

procedures were used to determine the long-run cointegrating relationships between real M0, M1, and M2 and their determinants. In the cointegration tests, we have three sets of cointegrating vectors with LRM0, LRM1, and LRM2 as dependent variable and the same independent variables in each cointegrating vector respectively. The first and second cointegrating vectors (LRM0 and LRM1) have two cointegrating relationships and the third one has one cointegrating relationship. The signs of coefficients are consistent with our expectation. In addition, the income elasticity of LRM0 (0.0903) is less than one, indicating the increase in income would be faster than the increase in narrow measure of money. In contrast to LRM0, the income elasticities of LRM1 (1.0506) and LRM2 (2.7481) are both larger than one, which suggest the evidence of the monetization process and the financial innovations. Further, the interest rate coefficient of LRM2, 0.4421, is greater than that of LRM0 and LRM1. The larger interest rate coefficient of LRM2 means that it will take a smaller change in interest rate to influence the demand for money. In addition, previous studies (see Hafer and Kutan, 1994 and Luke Chan, Cheng and Deaves, 1991) have shown that the interest rate coefficient has a positive impact on the demand for money, which is not consistent with our finding. The data periods in those studies were from 1952-1988 and 1952-1987, and the interest rates were controlled by the PBC and were not adjusted frequently. However, our study data include 1995Q1-2008Q1 in which the PBC adjusted the interest rates more frequently to account for people's expectation of inflation. The negative sign of inflation implies that people tend to hold more real assets rather than holding money when inflation

increases. In addition, the inflation coefficient of LRM2 (0.6918) is greater than that of LRM0 (0.0095) and LRM1 (0.1865), which means the inflation has a large impact on M2. In other words, any increase or decrease in M2 may influence inflation stronger than M0 and M1. Thus, M2 might be effective in stabilizing inflation rate.

Fourth, the unrestricted short-run model was applied to M0, M1, and M2 respectively using the OLS estimation. We found that the EC term of M0 is positive, which did not validate the significance of the long-run cointegrating relationship for M0. However, the EC terms of M1 and M2 are negative and significant at the 1% level of significance, which ensures the existence of the long-run relationships. The restricted model was applied to M1 and M2 by eliminating the insignificant variables from the unrestricted model. M1 was not included in the restricted model since the EC term is positive. By using the OLS estimation, the EC term of M1 is negative but is not significant at the 10% level of significance. Compared to M1, M2 has a negative EC term and is significant at the 1% level of significance. The EC coefficient term shows that the last period disequilibrium is corrected by approximately 3.1% a quarter. The negative EC term not only implies a proportion of previous disequilibrium in the demand for money is corrected in the current period, it also validate the significance of cointegration relationship obtained from the cointegration tests. In addition, the diagnostic tests show no presence of autocorrelation, heteroscedasticity, normality and ARCH. As a result, M2 has the best performance in our estimation process.

### **5.3 Policy Implications and Limitations**

China started using the broad measure of money to conduct monetary policy in 1994. However, China abandoned money targeting and has started using interest rate targeting as the intermediate goal in conducting monetary policy since 2004. Since the inflation is still high under interest rate targeting, monetary targeting may be used again to stabilize inflation. The following section explains that three policy implications obtained from our research findings. In addition, there are three issues should be carefully considered although they are not obtained from the research findings. Further, three limitations are summarized afterwards.

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. Our result is also consistent with Hafer and Kutan (1994), Huang (1994), and Gu (2004) and they suggest that M2 is a better indicator in conducting monetary policy because there is a stable long-run relationship for M2. Further, in the presence of the fast development of financial markets, such as money market, bond market and stock market, 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. For example, firms may borrow from the stock market rather than borrowing from banks. However, M0 does not account for the money in the stock market, it only

includes the currency in circulation. If M2 is selected as monetary target, then it should grow no more than 37% to control inflation under 10%. Further, our results suggest that the monetization process and the financial innovations also impact the demand for money in China. In order to have a stable growth in monetary aggregates, the monetization process and the 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. During 1990s, bank loans borrowed by the state-owned enterprises were not sensitive to the changes in interest rates because they did not have to repay their loans. In addition, customers had no access to bank loans, which means their spending was also not sensitive to the changes in interest rates. However, more private firms and customers have access to bank loans and stated-owned enterprises have to repay their loans in the last few years (Green, 2005). Thus, the demand for money in these sectors is sensitive to the changes in interest rates and interest rates have a greater impact on the demand for money in China than before. 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. There is an important factor that should be considered since bank loans are more accessible to households and private firms. Poor credit rating system and asymmetric information increase credit risk. Thus, banks should be able to decrease credit risk by having sound credit rating system.

Three important factors should be addressed when considering the Chinese money demand. First, the huge capital inflows into China require a huge demand for money. The huge capital inflows may cause increase in inflation. On the other hand, the demand for money may decrease suddenly if huge capital outflow takes place. For example, the current global financial crisis may force many foreign investors to decrease their investments and take capitals out of China to absorb losses elsewhere during the financial crisis. 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 has become a member of WTO. For example, exporters exchange their receipts denominated in foreign currency to RMB at commercial banks, then commercial banks hand over the foreign currency to the PBC in exchange for the assets denominated in RMB on their balance sheets. As a result, the money supply increases, which may increase inflation. Third, the movements of exchange rate 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. This implies the PBC should be able to stabilize the exchange rate and revalue the RMB gradually in order to prevent a sudden increase or decrease in the demand for RMB.

There are three limitations in our study:

- i. The first limitation is the accuracy of the data. The accuracy of the data is questioned by Holz (2004b). The author questioned and challenged the accuracy of China's GDP. The official annual GDP is calculated differently annually without much consistency. In addition, the National Bureau of Statistics of China does not explain explicitly the calculation mechanism when publishing the official data. The significant variations of data indicate that the National Bureau of Statistics of China is unwilling or incapable in explaining the validity of their estimations and reports.
- ii. The one-year saving deposit rate may not be an appropriate variable to represent the opportunity cost of holding money. For example, Austin, Ward, and Dalziel (2007) suggest that real interest rates are not allowed to change frequently and movements are not large and indistinguishable from the negative inflation. In addition, the data period is not long in our study. Therefore, the sign and the coefficient of the real interest rate may be sensitive to the data length.
- iii. Divisia monetary aggregates may provide more stable long-run relationship than simple sum monetary aggregates do in estimating the money demand function. Dahalan, Sharma, and Sylwester (2005) found that there are more variables can be omitted in the estimation when using simple sum monetary aggregates. However, when using divisia monetary aggregates, there is only one variable fails to have a long-run relationship with money.

#### **5.4 Recommendations for future research**

Since China has switched from the pegged exchange rate system to managed floating regime, the exchange rate may have some influences on the demand for money in China. Although such influences may not appear fast, it will impact the Chinese money demand sooner or later. Therefore, the exchange rate might be used in the future research in order to test its relationship with the money demand function and to find any evidence of currency substitution.

The period that the present study covers is not long enough for conducting reliable tests on structural breaks. The future research might use the longer data period to capture the impact of the structural break. However, the measurements of macroeconomic variables have changed since the National Bureau of Statistics of China switched to the United Nations system of national accounts. Thus, future research should consider the inconsistency of the data and should transform the data to have the same measurement.

Future research may use divisia monetary aggregates in estimating the Chinese money demand functions if they are collectable. Thus, the research findings may be more accurate in the use of conducting monetary policy.

Finally, the one-year saving deposit rate may be replaced by other interest rate, such as Treasury bill rates and government bond rates, to see whether we will have

different conclusions on which monetary aggregate should be used in conducting monetary policy in China.

## References

1. Austin, D., Ward, B., and Dalziel, P. (2007). The Demand for Money in China 1987-2004: A Non-Liner Modelling Approach. *China Economic Review*, 18, 190-204.
2. Bahmani-Oskooee, M. B., and Shabsigh, G. (1996). The demand for money in Japan: Evidence from Cointegration Analysis. *Japan and the World Economy*, 8, 1-10.
3. Brandt, L., and Zhu, X. D. (2000). Redistribution in a Decentralized Economy: Growth and Inflation in China under Reform. *Journal of Political Economy*, 108 (2), 422-439.
4. Chen, B. (1997). Long-run Money Demand and Inflation in China. *Journal of Macroeconomics*, 19(3), 609-617.
5. Chen, C. (1989). Monetary Aggregates and Macroeconomic Performance in Mainland China. *Journal of Comparative Economics*, 13, 314-324.
6. China Monetary Policy Report Quarter One. (2005). Retrieved May 15, from the People's Bank of China Web site:  
<http://www.pbc.gov.cn/english/huobizhengce/huobizhengcezhixingbaogao/2005.asp>
7. China Monetary Policy Report Quarter Three. (2007). Retrieved May 15, from the People's Bank of China Web site:  
<http://www.pbc.gov.cn/english/huobizhengce/huobizhengcezhixingbaogao/2007.asp>
8. China Monetary Policy Report Quarter Four. (2007). Retrieved May 15, from the People's Bank of China Web site:

<http://www.pbc.gov.cn/english/huobizhengce/huobizhengcezhixingbaogao/2007.asp>

9. Chow, G. C. (1987). Money and Price Level Determination in China. *Journal of Comparative Economics*, 11, 319-333.
10. Dahalan, J., Sharma, S. C., and Sylwester, K. (2005). Divisia Monetary Aggregates and Money Demand for Malaysia. *Journal of Asian Economics*, 15, 1137-1153.
11. Dai, M. (2006). Inflation-targeting under a Managed Exchange Rate: the Case of the Chinese Central Bank. *Journal of Chinese Economic and Business Studies*, 4(3), 199-219.
12. Dekle, R., and Pradhan, M. (1999). Financial Liberalization and Money Demand in the ASEAN Countries. *International Journal of Finance and Economics*, 4, 205-215.
13. Fang, X. et al. (2000, February). A general history of Chinese economy, the Qing Dynasty Volume. Retrieved May 25, 2008, from [http://bic.cass.cn/english/infoShow/Arcitle\\_Show\\_NewsBook\\_More\\_show.asp?Title=New%20books%20in%202000&ID=399](http://bic.cass.cn/english/infoShow/Arcitle_Show_NewsBook_More_show.asp?Title=New%20books%20in%202000&ID=399)
14. Feltenstein, A., and Farhadian, Z. (1987). Fiscal Policy, Monetary Targets, and the Price Level in a Centrally Planned Economy: An Application to the Case of China. *Journal of Money, Credit, and Banking*, 19(2), 137-156.
15. Figure 1.1, "Consumer Price Index", available on the web at [http://www.stats.gov.cn/was40/gjtjj\\_en\\_detail.jsp?searchword=CPI&channelid=9528&record=12](http://www.stats.gov.cn/was40/gjtjj_en_detail.jsp?searchword=CPI&channelid=9528&record=12)
16. Figure 1.2, "Movements in the of Index of Future Price Expectations and the CPI since 1999", available on the web at <http://www.pbc.gov.cn/english/huobizhengce/huobizhengcezhixingbaogao/>
17. Forssbäck, J., and Oxelheim, L. (2007). The Transition to Marker-Based Monetary Policy: What Can China Learn from the European Experience? *Journal of Asian Economics*, 18, 257-283.

18. Green, S. (2005). Making Monetary Policy Work in China: A Report from the Money Market Frontline. *Stanford University Working Paper No. 245*.
19. Gu, C. (2004). Empirical Analysis of Money Demand in China: A Cointegration Approach. Unpublished doctoral thesis, American University, Washington, D. C. The United States of America.
20. Hafer, R. W., and Jansen, D. W. (1991, May). The Demand for Money in the United States: Evidence from Cointegration Tests. *Journal of Money, Credit, and Banking*, 23(2), 155-168.
21. Hafer, R. W., and Kutan, A. M. (1994). Economic Reforms and Long-run Money Demand in China: Implications for Monetary Policy. *Southern Economic Journal*, 60(4), 936-945.
22. Hafer, R. W., and Kutan, A. M. (2003). Financial Innovation and The Demand for Money: Evidence from the Philippines. *International Economic Journal*, 17(1), 17-27.
23. Holz, C. A. (2004a). China's Statistical System in Transition: Challenges, Data Problems, and Institutional Innovations. *The Review of Income and Wealth*, 50(3), 381-409.
24. Holz, C. A. (2004b). Deconstructing China's GDP statistics. *China Economic Review*, 15(2), 164-202.
25. Honohan, P. (1994). Inflation and the Demand for Money in Developing Countries. *World Development*, 22(2), 215-223.
26. Huang, G. (1994). Money Demand in China in the Reform Period: An Error Correction Model. *Applied Economics*, 26, 713-719.
27. Huang, H., and Wang, S. (2004). Exchange Rate Regimes: China's Experience and Choices. *China Economic Review*. 15(3), 336-342.
28. Hueng, C. J. (1998). The Demand for Money in an Open Economy: Some Evidence from Canada. *The North American Journal of Economics and Finance*, 9(1), 15-31.
29. Johansen, S. (1988). Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control*, 12, 231-254.

30. Johansen, S., and Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration-With Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52(2), 169-210.
31. Khalid, A. (1999). Modelling Money Demand in Open Economies: the Case of Selected Asian Countries. *Applied Economics*, 31(9), 1129-1135.
32. Luke Chan, M. L., Cheng, W., and Deaves, R. (1991). Money Demand in China Revisited: Some New Empirical Evidence. *Journal of Asian Economics*, 2(1), 137-144.
33. Mackinnon, J. G. (1990). Critical Values for Cointegration Tests. Working Paper, University of California, San Diego.
34. McNown, R., and Wallace, M. S. (1992). Cointegration Tests for a Long-Run Relation between Money Demand and the Effective Exchange Rate. *Journal of International Money and Finance*, 11, 107-114.
35. Mookerjee, R., and Peebles, G. (1998). Endogenous Money in China: Evidence and Insights on Recent Policies. *Journal of Asian Economics*, 9(1), 139-158.
36. Narayan, P. K. (2007) Is Money Targeting an Option for the Bank Indonesia? *Journal of Asian Economics*, 18, 726-738.
37. NG, S. B. and Perron, P. (2001). Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power. *Econometrica*, 69(6), 1519-1554.
38. Ping, X., and Zhang, X. (2003). The Coordination between Monetary Policy and Exchange Rate Policy in an Open Economy in Transition. A Case Study on China from 1994 to 2000. *Journal of Asian Economics*, 14, 327-336.
39. Qin, D. (1994). Money Demand in China: The Effect of Economic Reform. *Journal of Asian Economics*, 5(2), 253-271.
40. Schwert, W. (1989). Tests for Unit Roots: A Monte Carlo Investigation. *Journal of Business and Statistics*, 7(2), 147-159.
41. Shi, JianHuai. (2001). Financial Innovations in China, 1990-2000. *China Centre for Economic Research Working Paper Series* (E2001006).

42. Sriram, S. S. (2002). Determinants and Stability of demand for M2 in Malaysia. *Journal of Asian Economics*, 13, 337-356.
43. Yi, G. (1991). The Monetization Process in China During the Economic Reform. *China Economic Review*, 2(1), 75-95.
44. Yu, Q., and Tsui, A. K. (2000). Monetary Services and Money Demand in China. *China Economic Review*, 11(2), 134-148.
45. Yu, Q., and Xie, P. (1999). Money Aggregate Management: Problem and Prospects in China's Economic Transition. *Contemporary Economic Policy*, 17(1), 33-43.