School of Economics and Finance

The Stability of Money Demand and Monetary Transmission Mechanism in Thailand

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Doctoral of Philosophy
of
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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: S. Raksong

Date: ……28/03/10…………………...

Abstract

The major objective of this thesis is to investigate whether there exists a stable long run and short run equilibrium relationship between real money balances (M1 or M2) and their determinants in Thailand. A cointegration analysis and the Vector Error Correction Model (VECM) are conducted on quarterly data over two data set periods, 1980Q1 to 2007Q1 and 1993Q1 to 2007Q1. The results indicate that there exists a long run equilibrium relationship between real money demand (both M1 and M2) and its determinants: real income, price level, exchange rates, and external interest rates.

The thesis also used the Vector Autoregression model (VAR) to test the monetary transmission mechanism in Thailand in three different channels of monetary policy: the interest rate channel, the credit channel, and the exchange rate channel. The results find that a change in the M1 money demand has more effect on economic growth while a change in M2 has a stronger effect on the price level. In addition, the results also show that the M1 money demand is responsive to the transmission mechanism in all channels tested in the thesis.

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CONTENTS

Abstract

Acknowledgement

Chapter 1 Introduction..1
1.1 Introduction...1
1.2 Research Background and Motivation...1
1.3 Objectives of Research 4
1.4 Scope of Research...4
1.5 Organization of the Thesis 5

CHAPTER 2 Theoretical Debates and Literature Reviews 6
2.1 Introduction 6
2.2 Development of Monetary Theories...6
2.2.1 Classical Monetary Theory...6
2.2.2 The Keynesian Monetary Theory 10
2.2.3 The Monetarist Monetary Theory 13
2.2.4 The New Classical Monetary Theory..14
2.2.5 The New Keynesian Monetary Theory 15
2.2.6 The Summaries of the Monetary Theories 16
2.3 The Theoretical Framework of the Monetary Transmission Mechanism 18
2.3.1 The Traditional Interest Rate Channels (money view)...............................18
2.3.2. The Credit View 21
2.3.3 Other Asset Price Effects...27
2.4 The Literature Reviews of Empirical Studies 30
2.4.1 The Empirical Studies on Demand for money 30
2.4.2 Empirical Studies of the Monetary Transmission Mechanism....................38
2.5 The Overview of Thailand's Economic Development....................................49
2.5.1 Thailand's Economic Performance in the pre-financial crisis period 50
2.5.2 Thailand's Financial Crisis and the Cause of the Crisis..........................54
2.5.3 The Monetary Framework Development 65
2.6 Conclusion...68

CHAPTER 3 Unit Root Test and the Preliminary Data Analysis.........................70
3.1 Introduction...70
3.2 Stationary Time Series and Unit Root Tests...70
3.2.1 Stationary and Nonstationary Time Series 70
3.2.2 Testing for Stationary and Unit Root Test. 71
3.2.3 The Augmented Dickey and Fuller for unit root testing (ADF).................74
3.2.4 The Procedure of the ADF Test...75
3.2.5 The Phillips-Perron Unit Root Test (PP test) 78
3.2.6 The KPSS test...79

3.3 Preliminary Data Analysis and Empirical Results of the Unit Root Test..... 80
3.3.1 The Stationary of the log of real narrow money aggregate (LnRealM1) 81
3.3.2 The Stationary of the log of real broad money aggregate (LnRealM2). 82
3.3.3 The Stationary of log GDP (LnGDP) 84
3.3.4 The Stationary of Log of Exchange Rate (LnEXC) 85
3.3.5 The Stationary of the Domestic interest rate (R) 87
3.3.6 The Stationary of LIBOR 88
3.3.7 Summary of the ADF Unit Root Test 89
3.3.8 The result of the KPSS 91
3.4 Testing for the Unit Root and Structural Break 94
3.4.1 Overview of the Concept of the Unit Root Test with Structural Break 94
3.4.2 The Testing Procedure of the Unit Root with Structural Break 99
3.4.3 Empirical Results of the Unit Root test with Structural Break: (Perron's 1997 approach ………………...100
3.4.4 Empirical Result of the Unit Root test with Structural Break: (Zivot and Andrews' approach) 108
3.5 Conclusion 110

CHAPTER 4 The Cointegration and Error Correction Model : The Empirical Results of Money Demand in Thailand 111
4.1 Introduction 111
4.2 The Cointegration and Error Correction Model 111
4.2.1 The Cointegration concept 111
4.2.2 Cointegration testing 113
4.2.3 The Johansen methodology 116
4.2.4 The Vector Error Correction Model 120
4.2.5 The Vector Error Correction Model 122
4.3 The Empirical Results of Stability of Money Demand in Thailand 124
4.3.1 Modeling of the money demand function in Thailand 124
4.3.2 The result of money demand function in Thailand (1980Q1 2007Q1)……………………………………………………………………..129
4.3.3 The result of money demand function in Thailand (1993Q1 - 2007Q1).. 167
4.3.4 Comparison and policy Implication 200
4.3.5 Conclusion 204

CHAPTER 5 The Vector Auto Regressive Model and Monetary Transmission Mechanism in Thailand 206
5.1 Introduction 206
5.2 Basic Concept of the Vector Autoregression model (VAR) 206
5.2.1 The Granger Causality Test 208
5.2.2 The Impulse Response Function 210
5.2.3 Modeling of the monetary transmission mechanism in Thailand 213

5.3 Empirical Results of the Transmission Mechanism of Monetary Policy 215
5.3.1 The lag length selection 216
5.3.2 Test for the Basic models 218
5.3.3 The channel of the monetary transmission mechanism 222
5.4 Conclusion 237

CHAPTER 6 Conclusion 239
6.1 Introduction 239
6.2 The Main Empirical Findings 239
6.3 Policy Implications and Future Research 240

Appendix A 242

Appendix B 244

References 247

List of Tables

Table 2.1 The Summary of the Monetary Theories…………………………..........17
Table 2. 2 A Summary of the Monetary Transmission Mechanism: the link between monetary policy and GDP………………… …………………………...29
Table 2. 3 Thailand's macroeconomic performances……………………………49
Table 2. 4 Thailand's economic performance during the boom period…………51
Table 2. 5 The net capital inflow (as a percentage of GDP, period average)…....56
Table 2. 6 The current account deficit……………………………………….. 57
Table 2. 7 Thailand's economic performances after the financial crisis………..64
Table 3.1 The Results of the ADF test for LnRealM1 (1993Q1-2007Q1)……...82
Table 3.2 The Results of the ADF test for LnRealM1 (1980Q1-2007Q1) ...... …82
Table 3.3 The Results of the ADF test for LnRealM2 (1993Q1-2007Q1) 83
Table 3.4 The Results of ADF test for LnRealM2 (1980Q1-2007Q1)................84
Table 3.5 The results of the ADF test for LnGDP (1993Q1-2007Q1) 85
Table 3.6 The results of the ADF test for LnGDP (1980Q1-2007Q1) 85
Table 3.7 The Results of the ADF test for LnEXC (1993Q1-2007Q1)...............86
Table 3.8 The Results of the ADF test for LnEXC (1980Q1-2007Q1)...............87
Table 3.9 The results of the ADF test for R (1993Q1-2007Q1)..........................88
Table 3.10 The results of the ADF test for R (1980Q1-2007Q1)........................88
Table 3.11 The results of the ADF test for LIBOR (1993Q1-2007Q1)..............89
Table 3.12 The results of the ADF test for LIBOR (1993Q1-2007Q1)..............89
Table 3.13 Summary of the Result of the Unit root test. 90
Table 3.14 The MacKinnon Critical Value for the data set from 1993Q1-2007Q1 ………………………………………………………………………………..90
Table 3.15 The MacKinnon Critical Value for the data set from 1980Q1-2007Q91
Table 3.16 The results of the KPSS test (1993-2007)..92
Table 3.17 The results of the KPSS test (19980-2007)..93
Table 3.18 The Results of the IO2 model (1993Q1-2007Q1) 101
Table 3.19 The Results of the IO1 model (1993Q1-2007Q1) 102
Table 3.20 The Results of the AO model (1993Q1-2007Q1)............................103
Table 3.21 Model Selection of Perron's 1997 Procedure (1993Q1-2007Q1) ...104
Table 3.22 The Results of the IO2 model (1980Q1-2007Q1) 105
Table 3.23 The Results of the IO1 model (1980Q1-2007Q1) 106
Table 3.24The Results of the AO model (1980Q1-2007Q1).............................107
Table 3.25 Model Selection of Perron's 1997 Procedure (1980Q1-2007Q1) ...108
Table 3.26 The Results of Zivot and Andrews' model (1993Q1-*2007Q1)* 109
Table 3.27The Results of Zivot and Andrews' model (1980Q1-2007Q1) 109
Table 4.1 The pair-wise cointegration results for the M1 money demand function (1980:1 – 2007:1)…………………………………………………………...130
Table 4.2 The cointegration results for M1 money demand (1980:12007:1)….131
Table 4.3 The normalizing of the M1money demand function in Thailancointegration results for M1 money demand (1980:1–2007:1) 132
Table 4.4 The test for Cointegration Restrictions for weak exogeneity (1980:1–2007:1) 133

Table 4.5 The result of the VECM for the M1 money demand (1980:1– 2007:1) 136
Table 4.6 The result of pair-wise cointegration of the M1 money demand in Thailand.. 140
Table 4.7 Cointegration of the M1 money demand function *when LnEXC and LIBOR are included* (1980:1–2007:1)……………………………………… 143
Table 4.8 The normalizing of the M1 money demand function in Thailand when LnEXC and LIBOR are included (1980:1–2007:1) 144
Table 4.9 Weak exogenous test.. 144
Table 4.10 The result of VECM for M1 money demand 146
Table 4.11 The pair-wise cointegration results for the M1 money demand function…… 150
Table 4.12 The cointegration results for M2 money demand (1980:1-2007:1). 151
Table 4.13 The Normalized cointegration for M2 money demand function (1980:1-2007:1) 152
Table 4.14 Test for Cointegration Restriction for weak exogeneity (1980:1-2007:1). 152
Table 4. 15 The result of the VECM for M1 money demand 154
Table 4. 16The result of pair-wise cointegration of the M2 money demand in Thailand.. 158
Table 4.17 Cointegration of the M1 money demand function 161
Table 4.18 The normalized M1 money demand function in Thailand when LnEXC and LIBOR are included 162
Table 4.19 Weak Exogenous.. 162
Table 4.20 The result of the Error Correction Model 164
Table 4.21 The pair-wise cointegration results for the M1 money demand function.. 167
Table 4.22 The cointegration results for M1 money demand 168
Table 4.23 The normalized M1 money demand function in Thailand............... 169
Table 4.24 Test for Cointegration Restriction for weak exogeneity.................. 169
Table 4.25 The results of the VECM for M1 money demand 171
Table 4.26 The results of bivariate (pair-wise) cointegration of M1 money demand.. 175
Table 4.27 Cointegration of the M1 money demand function 178
Table 4.28 Normalized Cointegration.. 179
Table 4.29 Weak Exogenous.. 179
Table 4.30 The results of the vector error correction for the M1 money demand function 180
Table 4.31 The pair-wise cointegration results for the M2 money demand function.. 184
Table 4.32 The cointegration results for M1 money demand 185
Table 4.33 Normalized cointegration... 185
Table 4.34 Test for Cointegration Restriction for weak exogeneity.................. 186
Table 4.35 The results of the VECM for M2 money demand. 187

Table 4.36 The result of bivariate (pair-wise) cointegration of M2 money demand in Thailand 191
Table 4.37 Cointegration of the M1 money demand function 184
Table 4.38 Normalized cointegration.. 184
Table 4.39 Weak Exogenous.. 196
Table 4.40 The results of the VECM 197
Table 4.41 Comparison of Cointegration Results.. 201
Table 4.42 Normalized Long-run elasticity of money demand in Thailand 202
Table 4.43 Error Correction Model.. 203
Table 4.44 The relationship between money overhang and inflation 204
Table 5. 1 Model of Monetary Transmission Mechanism 215
Table 5. 2 Lag Length Selection of the VAR model... 217
Table 5. 3 Granger Causality Test for basic Model 219
Table 5. 4Table Variance Decomposition for the basic model 220
Table 5. 5 Granger Causality test for interest rate channel of monetary transmission mechanism 224
Table 5. 6 *Variance Decomposition for* interest rate channel 225
Table 5. 7Granger Causality Test for Credit Channel Model 229
Table 5. 8 Variance Decomposition for the credit rate channel......................... 230
Table 5. 9 Granger Causality Test for Exchange Rate Channel Model 234
Table 5. 10 Variance Decomposition for the exchange rate channel................. 235

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents a brief introduction to the thesis, discussing both the background and the motivation of the thesis. The research objectives and the scope of the thesis are presented in section two and three and the last section outlines the structure of the thesis.

1.2 Research Background and Motivation

After floating the Thai baht in 1997, monetary policy has increasingly been the center of macroeconomic policy in Thailand because after open up the capital account, Thailand economy widely effect by external factors and external shock. In addition The financial liberalization and restructuring in Thailand has contributed to the increased importance of the financial sector in the Thailand economy. Therefore, Thailand needs more influential monetary policy to guide the financial sector in the right direction and more efficiency.

Understanding the transmission mechanism of monetary policy is the key successful to conduct monetary policy as a monetary authority has to choose the proper monetary instrument and intermediate target policy in order to reach the monetary goal. In addition, the policy maker have to understand the effect of monetary policy in economy, he central bank must have ability to control the key monetary variables.

Another important in conducting monetary policy is the stability of demand for money function since it plays a key role in real economic activities and financial markets, particularly with respect to the transmission mechanism of monetary policy. If the money demand function is stable, it implies that money multipliers are stable, and monetary authorities can carry out policy actions with greater confidence regarding their impact on the macro economy. As the study of Sriam (1999) and Siklos (1995) point that the stability of money demand is one of a key successful in conducting monetary policy. It is, therefore important for policy maker to also understand the stability of money demand.

The literature on the estimation of the demand for money is enormous and we focus here on a few papers particularly relevant to the present study, which have emphasized the importance of the stability of money demand and the long-run relationship between money demand and its determinants by using cointegration techniques. For example, Ahmed (1999) investigated the stability of the money demand function and tests for the existence of a long-run money demand function for Bangladesh during the period 1975-1997. Ghosh (2000) estimated the long-run equilibrium relationship for M1 in five industrial countries, the US, the UK, Canada, Germany, and Japan. Bahmani-Oskooee (2001) analyzed money demand in Japan. Bahmani-Oskooee and Chomsisengphet (2002) studied money demand in Australia, Austria, Canada, France, Italy, Japan, Norway, the US, Sweden, Switzerland, and the UK. Choi and Oxley (2004) estimated the stability of money demand in New Zealand. All of these papers focused on the stability of the estimated relationship, and this thesis will draw on them to consider the stability of the money demand relationship for Thailand.

Another popular issue in money demand analysis in Asian countries is to analyze the effect of financial liberation on the stability of demand function. Dekle and Pradhan (1997) claimed that the financial liberation and financial reform have contributed to the instability of money demand in Southeast Asian countries. Khalid (1999) estimated the degree of that foreign factor opportunity cost impacted on money demand in South Korea, the Philippines, and Singapore by applying the Johansen cointegration technique and estimating an error correction model with quarterly data from 1977:1 to 1993:4. He argues that money demand in those three countries has a long-run relationship with both domestic and foreign variables. James (2005) attempted to offer the new approach to analyze the effects of financial liberalization on the money demand in Indonesia. He found that liberalization played a major role in determining money demand. Moreover, he claimed that there is existence of a long-run relationship between broad money and its determinants when the proxy of liberalization is included.

In the case of Thailand, there have been relatively few empirical studies of the money demand function, and most of the studies have emphasized the relationship between money aggregates and a range of economic indicators, and placed less concern on the stability of the money demand. For example, Arize, Spalding, and Umezulike (1991) estimated the money demand function for Thailand and they found that the foreign interest rate played an important role in money demand during the sample period. Chaisrisawatsuk, Sharma, and Chowdhury (2004) tested for the stability of the money demand function and monetary policy making particular allowance for the potential for capital mobility and currency substitution in five Asian countries including Thailand, using quarterly data from 1980-1996. Bahmani-Oskooee and Techaratanachai (2001) investigated the relationship between the currency depreciation and M2 money demand function in Thailand by using the quarterly time series from 1977-1990. The results suggest that the depreciation of the Thai baht led to a fall in M2 money demand and that, therefore, monetary authorities should consider stabilizing the domestic currency to stabilize the economy and money demand.

Taking the above story, this research aims to answer the question "How monetary instrument transmit to economic variables in Thailand?" "*What* is the effective channel for monetary transmission mechanism in Thailand*?"*To answer the question, this thesis will start by testing the stability of the money demand function in Thailand, using co integration and error correction techniques. Then, we also analyze the transmission mechanism in Thailand by investigating how monetary policy has been transmitted into the macro economy in Thailand

1.3 Objectives of Research

There are three major objectives of this thesis:

1. To apply the VAR model for testing the monetary transmission mechanism in Thailand
2. To investigate how monetary policy has been transmitted into the macro economy in Thailand
3. To analyze the stability of the money demand function in Thailand

1.4 Scope of Research

The key research contributions of this thesis are in the two empirical chapters, Chapter 4 and Chapter 5. Chapter 4 focuses on the stability of demand for money in Thailand by using two quarterly data sets, data from 1993Q1 to 2007Q1 and the data from 1980Q1 to 2007Q1. The rationale for the use of two data sets is that there is limited quarterly GDP data in Thailand, as the official database provides consistent data from only 1993Q to 2007Q1. However, estimates of Thai GDP data by Abeysinghe and Gulasekaran (2004), which closely matches the official data are also available. Therefore, this thesis utilizes both data sets for testing the stability of the money demand function in order to compare the result between the short and longer data set. The chapter focuses on the estimation of both short-run and long run relationship of money demand in Thailand, using both the narrow money demand (M1) function and the broad money demand (M2) function. The result of this estimation also allows the calculation of so-called money overhang from the long-run money demand function and allows one to test whether this can help to predict inflation in Thailand.

The second key chapter of the thesis is Chapter 5, which uses the VAR model to test the monetary transmission mechanism in Thailand. There are four major channels of monetary transmission mechanism, interest channel, credit channel, exchange rate channel, and price asset channel. However, due to a limited data on asset price in Thailand, the asset price could not be tested in the thesis

This chapter is focused on three main channels of monetary policy transmission mechanism in Thailand, namely: the interest rate, the credit channel and the exchange rate channel.

1.5 Organization of the Thesis

The thesis is split into six chapters; Chapter 2 outlines the theoretical structure of money demand models and the monetary transmission mechanism. This also presents a selected literature survey, focusing on money demand in developed and developing countries, monetary policy and the transmission mechanism in different countries, and an overview of Thailand's economic development and monetary policy. Chapter 3 provides respectively a discussion of the research methodology and the results of pre-testing the time series properties of the data set utilized. These chapters identify the sources of the data used in the study. Chapters 4 and 5 provide the core of the thesis. Chapter 4 tests for the existence and stability of the simple money demand functions, whilst Chapter 5 uses the VAR framework to examine the monetary transmission mechanism. Chapter 6 provides conclusions.

CHAPTER 2

THEORETICAL DEBATES AND LITERATURE REVIEWS

2.1 Introduction

This chapter provides the overview of monetary theories, focusing on monetary theories and the money demand function, and the literature reviews of the money demand function and the monetary transmission mechanism. There are three sections included in this chapter. The first section is a brief overview of major monetary theory development. The starting point of this section is the quantity theory of money, generated by classical economists, followed by the monetary theories of the Keynesian, Monetarist, New Classical economics, and New Keynesian monetary models. In addition, this section also provides the theoretical framework on monetary policy and the transmission mechanism, the explanation of the channels in which monetary policy affects economic activities. The second section presents the review of empirical studies related to the demand for money analysis and the monetary transmission mechanism. The last section presents the overview of Thailand's economic development.

2.2 Development of Monetary Theories

In this section, we briefly review standard theories about the demand for money as developed by Classical, Keynesian and Monetarist economists. Our aim is to simply provide the background to the empirical demand for money functions examined in Chapters 4 and 5, rather than provide an exhaustive survey of the theory of the demand for money.

2.2.1 Classical Monetary Theory

It seems that the classical theory is widely regarded as the first school of economic thought. The first formal classical monetary theory is the quantity theory of money which was developed by Fisher (1911). The theory identifies money supply as the primary determinant of nominal spending and the price level. The idea behind this theory comes from the equation of exchange. This equation explains the relationship between the volume of transactions at current price (PY) and money supply times the turnover rate of money. It says that the quantity of money times the velocity of money is equal to the price level times output, which equals GDP. The equation of exchange can be written as:

$$MV = PY, \tag{2.1}$$

where M is the nominal quantity of money,
V is the transaction velocity of money,
P is the price level, and
Y is the volume of transaction or real output.

As a standard classical assumption is that the velocity of money (V) is determined by payment habits and institutional factors such as the payment technology and the efficiency of the banking system, therefore V could be fixed in the short run (V is constant in the short run). In addition, the volume of transaction (Y) is considered also to be constant due to the classical economists' belief that the economy is always in full employment situation and output is influenced by only technology and resource availability. Then, the equation implies that in the short-run equilibrium, a change in money supply causes a proportional change in price level:

$$M\overline{V} = \Delta P\overline{Y}$$
$$\Delta M = \Delta P \tag{2.2}$$

However, the quantity of money theory seems to focus on an explanation of mathematics, which could conclude that in equilibrium the price level is exactly proportional to money supply. However, the equation could not explain how a change in money supply affects the price level and economic activities. Therefore, Marshall (1923) and Pigou (1917) offered a new version of quantity of money, known as the Cambridge approach or the cash balance approach, which was less concerned about mathematics and more focused on individual decisions about the optimal amount of holding money. The Cambridge approach is said to be the first theory that puts the emphasis on the demand for money.

The assumption of Marshall and other Cambridge economists is that demand for money is a proportion of income. The equation of money demand can be written as:

$$M^d = k\,PY \qquad (2.3)$$

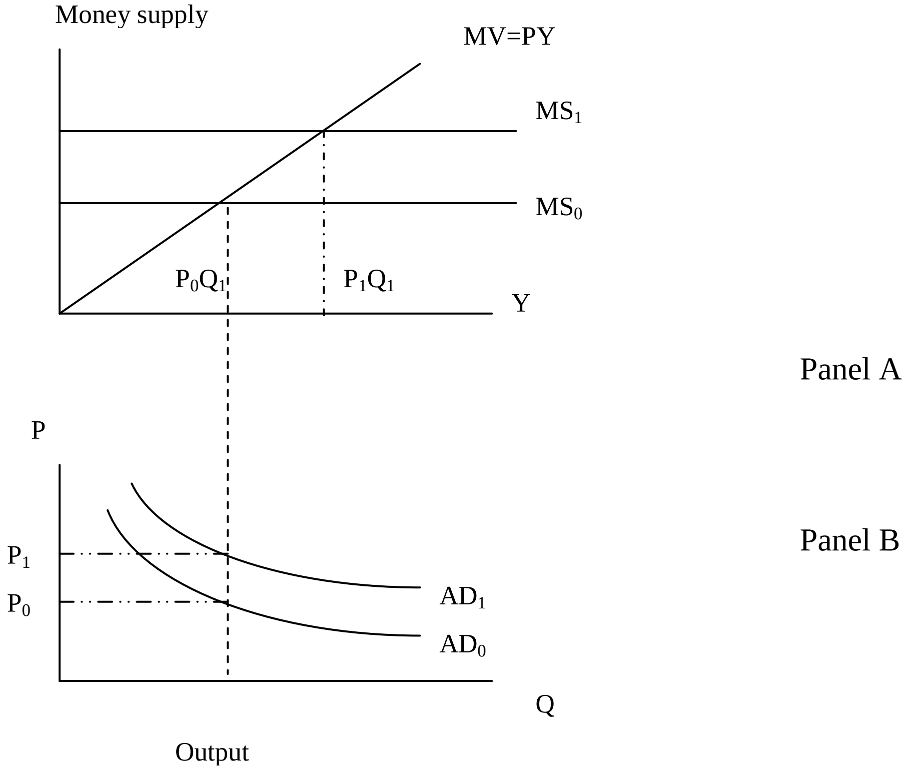
where M^d represents money demand (how much money people or enterprises want to hold), and k is a proportion of nominal income held in money balance. Note that the proportional relationship between the quantity of money and price level is dependent on the proportion of nominal income people wish to hold.

Although Equation 2.2 simply transforms mathematically Equation 2.1, it brings out the difference between the aspects of money. The quantity theory of money views money as a medium of exchange and people hold money just for the transaction approach, while Cambridge stressed the cash balance approach which seems to emphasize money as a store of value (Friedman, 1970). It is interesting to note that classical economists believe that real output (Y) or the volume of transactions is a measure of economic activity. It does not depend on any variables in the equation of exchange (M, V, and P) but it is more dependent on the supply side. Therefore, a change in monetary policy affects only the price level but does not affect real output and other economic activity. In addition, the Classical economist states that money, inflation and deflation may temporarily be disguised in the short- run equilibrium, but not in the long-run. In the long- run, money only affects the price level. It can be concluded that in the Classical view, money does not matter; it does not affect investment, consumption and other real economic activities.

The Classical Monetary Transmission Mechanism

The monetary transmission mechanism of the classical approach is focused more on the linkage between money supply and nominal income directly. The classical transmission mechanism is presented in Figure 2.1. Panel A presents the affect of monetary policy on nominal income. Panel B shows the affect of monetary policy on real income.

Figure 2. 1 The Classical views of the Monetary Transmission Mechanisms



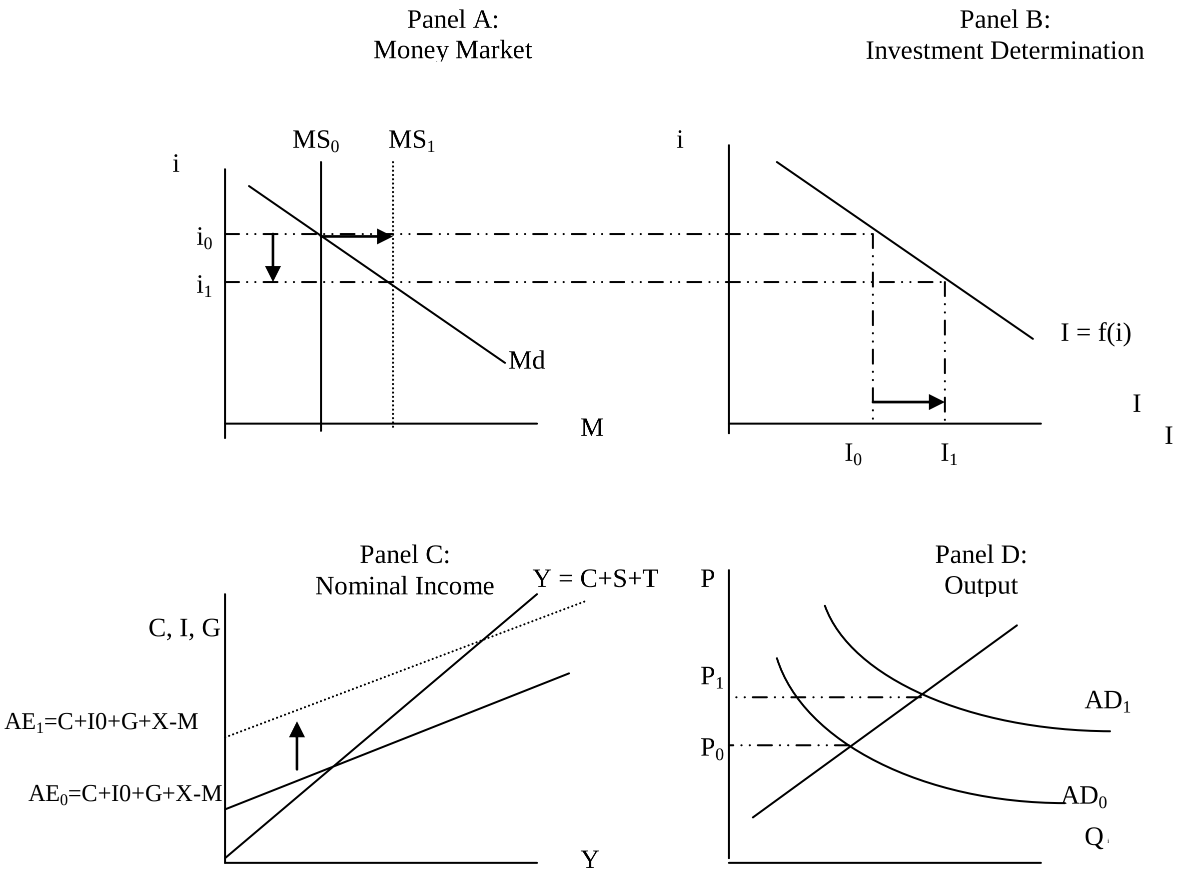
As can be seen in Figure 2.1, expansionary monetary policy led to an increase in the money supply from MS_0 to MS_1 in Panel A. This caused nominal income to grow from P_0Q_1 to P_1Q_1. As the assumption of fixed output at full employment level ($\bar{Y}$) and the velocity of money is constant ($\bar{V}$), then an increase in money supply introduced extra money into the economy. According to classical views, money is just a medium of exchange and people hold money for transactions approach. Therefore, all extra money from expansionary monetary policy will be spent in the economy. This cause an aggregate demand increase AD in Panel B shifted from AD_0 to AD_1, which pushes the price level and inflates it from P_0 to P_1. Therefore, we can conclude that any change in monetary policy will affect only the price level but will not affect other economic activity in the economy.

2.2.2 The Keynesian Monetary Theory

The stock market crash and the Great Depression of 1929, led to a massive fall in economic activity and a rise in unemployment on a worldwide scale. The inability of the Classical theory to adequately explain this major economic phenomenon meant that the time was ripe for alternative perspectives on the working of the world's economic system. The work of John Maynard Keynes is famous for *The General Theory of Unemployment, Interest and Money* (1936). The model of economic behavior–which was developed to explain the ideas in the so-called 'General theory'–the Keynesian model, provided an alternative that was capable of explaining the events of the depression. The Keynesian monetary theory attacked three basic assumptions of the Classical quantity theory of money, namely that velocity is constant, that full employment is the natural state for the economy, and that money demand is just for transaction purposes. Moreover, Keynesians argued that money affects both income and economic activity via the interest rate, which now played a central role in the monetary transmission mechanism.

Since the Great Depression, this increased role of the rate of interest in the demand for money function was also accompanied by the increased importance of the interest rate in the transmission mechanism. While the classical theory claims that the interest rate is determined by the supply of savings (mainly from households) and the demand of investment (mainly from businesses), the so-called loanable funds approach, Keynesians believe that the interest rate in financial markets is dependent on the demand for money and money supply. Therefore, an expansionary monetary policy leads to an increase in the money supply and lower interest rates in financial markets. As the interest rate reflects the opportunity cost of money, lower interest rates will push higher investment in the economy. The monetary transmission mechanism of the Keynesian approach is shown in Figure 2.2.

Figure 2. 2 The Keynesian monetary transmission mechanism

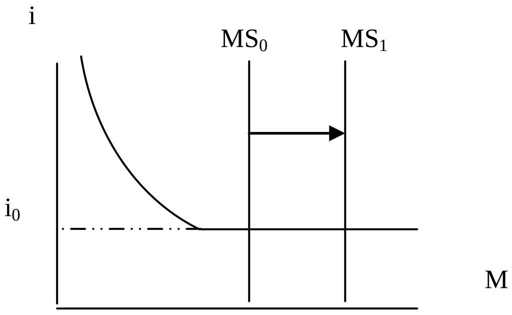


It can be concluded that Keynesians believe that monetary policy not only affects the price as the Classical economist said, but it also affects real economics activities such as output, investment and the employment rate. Therefore, Keynesians believe in intervention from the government.

However, there are some exceptions to the effectiveness of monetary policy. Some Keynesian economists claim that investment is not always responsive to interest rates in the money market. In this case, the monetary transmission mechanism would be short-circuited in the investment goods market, and the linkage between the money market and the goods market would be broken.

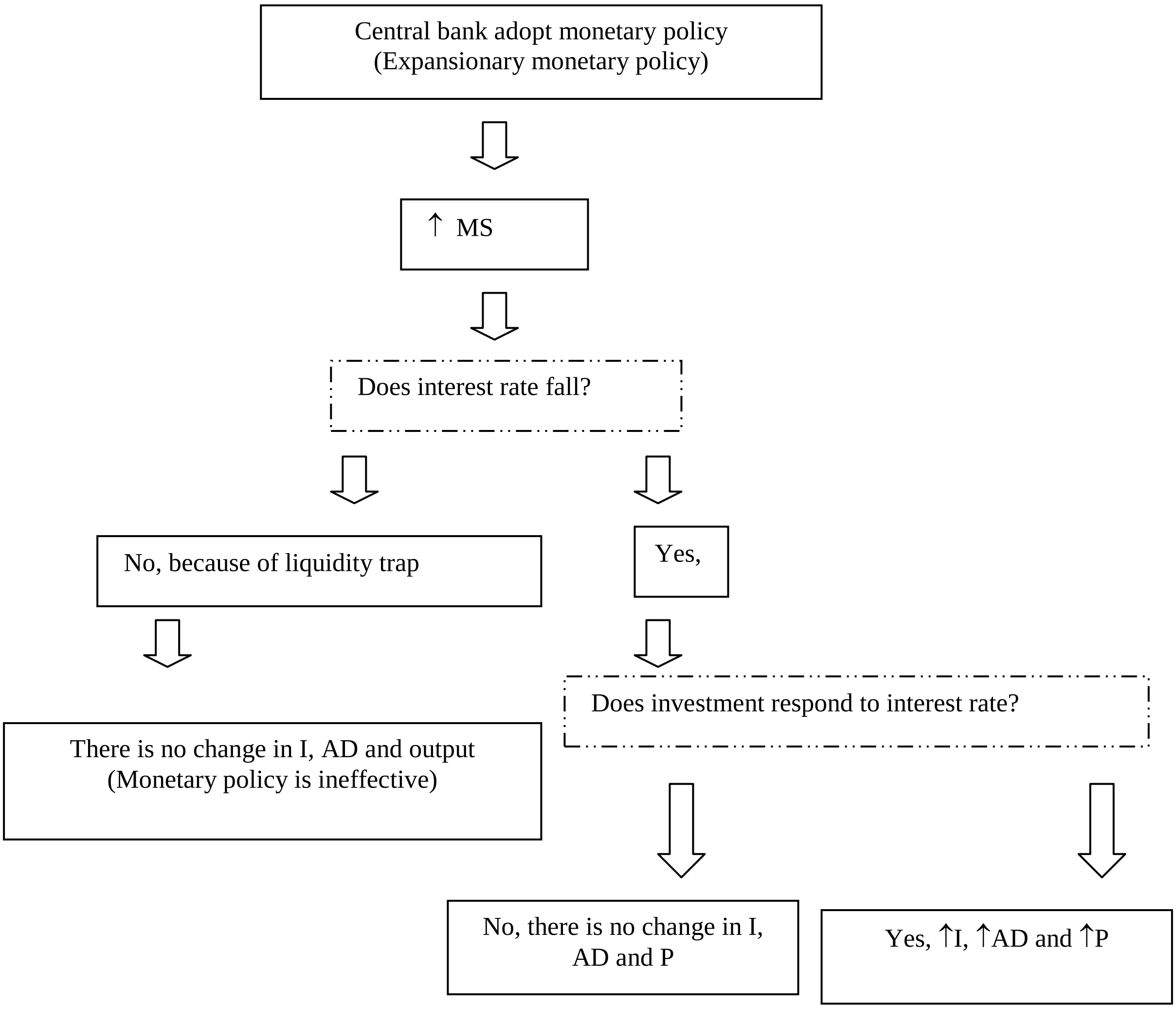
In addition, sometimes money demand in the money market could be horizontal at some low interest rate; this is called a liquidity trap (Figure 2.3). This situation can occur when people absorb any extra money into an idle balance, since they are extremely risk averse. In this case, if the money supply grows, any extra money that people receive will not be spent. Instead, it will be absorbed into the cash balance. Thus, monetary policy will not affect interest rates and other economic activities in a liquidity trap situation.

Figure 2. 3 The Monetary policy and Liquidity trap



The summary of the Keynesian monetary transmission mechanism is presented in Figure 2.4.

Figure 2. 4 The Keynesian Monetary transmission mechanism



2.2.3 The Monetarist Monetary Theory

The development of the monetarist began with the restatement of the classical quantity of money by Milton Friedman (1956). It can be said that Friedman's view was a development of the classical quantity theory of money but was more focused on the demand for money. Friedman's demand for money can be expressed as:

$$M^d = kPY \qquad (2.4)$$

The Equation 2.4 implies that money demand (M^d) is dependent on the level of nominal income (PY).

While the Keynesian theory of money demand emphasizes the three reasons that people hold money and claim that money demand is determined by income and interest rate, Monetarists argue that there is no reason to compartmentalize the money demand. Instead, Monetarists are more concerned about variables that influence the amount of money demand. Therefore, Friedman's new money demand function provides other variables that influence the amount of money demanded. Friedman's money demand function can be written as:

$$M^d = f(\overset{-}{P_e}, \overset{+}{Y}, \overset{-}{r_b}, \overset{-}{r_e}, \overset{-}{r_d}) \qquad (2.5)$$

Where M^d is the amount of money demand,

P is the price level expectation,

Y is permanent income (the expected average income in the long run),

r_B is the nominal interest rate on bonds,

r_E is the nominal interest rate on equity, and

r_D is the nominal interest rate on durable goods

.

The equation can imply that demand for money is positively related to permanent income, and is negatively related to the nominal interest rate on bonds, equity, durable goods, and the price expectation. It should be noted that monetarists believe that money demand is stable because most variables that influence money demand are relatively constant due to a stable market system in the economy.

The Monetarist Monetary Transmission Mechanism

The transmission mechanism of the monetarist approach is similar to its classical predecessors where there are direct linkages between money supply and nominal income. Monetarists consider demand for money as stable, so a change in money supply will generate a surplus of money for both consumers and investors. This surplus of money will be spent and it will quickly increase the aggregate demand.

2.2.4 The New Classical Monetary Theory

New classical economics was developed to argue against the Keynesian view that the economy should be stabilized by means of demand management by the government. New classical economists do not accept that there is a difference between short run and long run in the Keynesian analysis of the affect of monetary policy on aggregate demand and output. In addition, New classical economists believe that monetary policy actions that change aggregate demand will not affect output and the unemployment rate, even in the short run.

It can be said that the first formal theory of new classical economics was 'Rational Expectations' which was originally created by Muth (1960) and later developed by Lucas (1980). The idea of the theory is similar to the classical and monetarist approaches in that they believe in a non-interventionist policy. Lucas believes in the self-correcting. He claims that when a recession is occurring, producers will cut their prices to attract business, as well as laborers will reduce their wages to attract work. This means prices deflate and purchasing power will be strengthened, which has the same effect as increasing the money supply. Therefore, government should not do anything but wait the correction out.

The hypothesis of rational expectations has been used for supporting some conclusions about policymaking. For example, Sargent and Wallace (1976) developed the theory of Policy Ineffectiveness Proposition. They suggested that if the central bank tries to lower the unemployment rate by adopting expansionary monetary policy, economic agents would expect that money supply will increase, and their expectations of future inflation will rise. Real wages and prices remain constant and therefore output is constant. Therefore, monetary policy actions will not affect the real economy.

2.2.5 The New Keynesian Monetary Theory

New Keynesian economics was developed to respond to the new classical economic theory. The major difference between the new classical economic and the new Keynesian theory is how quickly prices and wages can be adjusted. While the assumption of new classical economists is that prices and wages are very flexible, new Keynesian economists believe that prices and wages are sticky. New Keynesian theories rely on this stickiness of wages and prices to explain why involuntary unemployment exists and why monetary policy has such a strong influence on economic activity.

The most well known theory of new Keynesian economics is the 'sticky price' or 'menu cost' model, which explains why prices adjust slowly. New Keynesians explain that the reason that firms do not change the price quickly is due to the cost that firms incur if the product price is changed, such as the cost of making a new price list. Although this cost seems to be small, New Keynesian economists describe how it can cause fluctuation in the short-run. Mankiw and Rome (1991) claim that not only do firms have to pay for the change of price cost, but also externalities that go along with the price change. They explain that if a firm reduces the price of a product because of a decrease in money supply, it will make the real income of customers increase, meaning that the purchasing power of the customers is increased and the customers might buy product from other companies. Therefore, firms will hesitate to lower the price because they do not want to assist other companies' sales.

New Keynesian economics suggests—in contrast to some new classical theories—that recessions do not represent the efficient functioning of markets. Keynesian theories say that recessions are caused by some economy-wide market failure. Thus, new Keynesian economics provides a rationale for government intervention in the economy, such as counter-cyclical monetary or fiscal policy.

2.2.6 The Summaries of the Monetary Theories

The summaries of the monetary theories of each school of thought are outlined in Table 2.1. There are four major differences among each school of thought: the demand for money functions, the impact of money on the economy, the monetary transmission mechanism, and the idea of intervention of government.

Table 2.1 The Summary of the Monetary Theories

	Classical	Keynesian	Monetarist	New-Classical	New-Keynesian
Money demand function	For transaction approach only	Demand for money for: - Transaction - Precautionary - Speculation	Money demand is stable but is determined by permanent income, interest rates and price expectations		
Impact of money on economy	ΔM → Δ P	ΔM → Δ P and Δ Q	ΔM → Δ P or Δ Q	ΔM → Δ P	ΔM → Δ P and Δ Q
Monetary Transmission Mechanism	**Direct** Base on equation $M\bar{V} = P\bar{Y}$ $M\uparrow \rightarrow P\uparrow$ *Monetary policy affects on price level but not on output*	**Indirect** *Money affect real output via interest rate :* $M\uparrow \rightarrow i\downarrow \rightarrow I\uparrow \rightarrow y\uparrow \rightarrow AD \uparrow \rightarrow P\uparrow$	**Direct** $M\uparrow \rightarrow C\uparrow \rightarrow Y\uparrow$ *or* $P\uparrow$	$M\uparrow \rightarrow P\uparrow$	$M\uparrow \rightarrow i\downarrow \rightarrow I\uparrow \rightarrow y\uparrow \rightarrow AD \uparrow \rightarrow P$
Is activist policy desirable?	**NO** **(Non-interventionist)** *Belief in self- adjustment of the economy*	**Yes** **(Interventionist)** *Fluctuation can be prevented by conducting monetary and fiscal policy*	**NO** **(Non-interventionist)** *-Fiscal policy is not an effective stabilization tool* *-Monetary policy affects nominal income but does not affect real income*	**NO** **(Non-interventionist)** *Prices are perfectly flexible, so monetary policy cannot affect real output in the short term*	**Yes** **(Interventionist)**

2.3 The Theoretical Framework of the Monetary Transmission Mechanism

Generally, the objective of monetary policy is to achieve economic growth and economic stability, particularly price stability. An understanding of the way in which change is transmitted to the rest of the economy is clearly important.

The monetary transmission mechanism is usually described as a process through which monetary policy is transmitted into change in economic activity such as output, income and the inflation rate. There are three major schools of thought which debate on the channel of monetary transmission. The first view is the traditional interest rate effect or the money view, which emphasizes the role of money and the affect of market interest rates on the economy. The second channel called the credit view focuses on the role of credit in the economy. The third channel is called the other asset price effect.

2.3.1 The Traditional Interest Rate Channels (money view)

The interest rate channel is based on a traditional Keynesian economic approach. The channel focuses on the role of interest rates in responding to monetary policy and its affect on economic activities. The schematics of the monetary transmission mechanism of traditional interest rate channels are operated through the interest rates and domestic investment. The monetary transmission mechanism of interest rates is presented in the following diagram:

$$M \uparrow \;\Rightarrow\; i_r \downarrow \;\Rightarrow\; I \uparrow \;\Rightarrow\; Y \uparrow$$

where (M$\uparrow$) represents an expansion of monetary policy, which leads to a decrease in the real interest rate ($i_r \downarrow$). The lower interest rate can imply that the cost of capital has decreased. Thus, investment spending is increased (I$\uparrow$), thereby leading to an increase in aggregate demand and a rise in output ($Y\uparrow$).

Although the original Keynes' view emphasized the interest rate channels through businesses decisions on investment spending, many economists claim that consumers' decisions about expenditure also affect investment spending. This is because consumer spending on durable goods such as housing is usually financed by borrowing. Therefore, lower interest rates should encourage the consumer to increase their spending. Hence, the interest rate channel should also apply to consumer spending. In addition, the major feature of the interest rate channel is that it puts emphasis on the real rather than nominal interest rate.

Another interesting way to present the interest channel of the monetary transmission mechanism is using the well-known IS-LM framework, which focuses on the equilibrium between demand for money and money supply, and the linkage of the money market to investment and output. The equilibrium of the money market and the LM curve can be show in Equations 2.6 to 2.8.

The demand for money function is:

$$M^d = f(y, r); \quad \text{or} \quad M^d = \varphi y_t - \delta r_t \tag{2.6}$$

The money supply function is:

$$M^s = \overline{M} \tag{2.7}$$

The LM curve is:

$$M^d = M^s = f(y, r) = \overline{M} \tag{2.8}$$

Where M^d is the money demand,

M^s is the money supply (money supply is assumed to be fixed in the short run),

y is real income, and

r is the domestic interest rate.

Substituting Equations 2.6 and 2.7 into Equation (2.8 to get the LM curve equation:

$$M^d = M^s = \varphi y - \delta r = \overline{M}$$

$$\text{Or} \quad r_t = -\frac{\overline{M}}{\delta} + \frac{\varphi}{\delta} y \tag{2.9}$$

For the IS curve, as per the Keynesian view, the IS curve is generated from the saving and investment functions. Thus the IS curve is generated by the following equations:

The saving function is: $S = a_0 + a_1 y + a_2 r$ where $a_0 < 0, 0 < a_1 < 1, a_2 > 0$

$$\text{or} \qquad S = -a_0 + a_1 y + a_2 r \tag{2.10}$$

The investment function is: $I = b_0 + b_1 r$ where $b_0 > 0, b_1 < 0$

$$\text{or} \qquad I = b_0 - b_1 r \tag{2.11}$$

The IS curve is: $I = S$ (2.12)

Substituting Equations 2.10 and 2.11 into Equation 2.12 to get the IS curve equation:

$$r = \beta_0 - \beta_1 y \tag{2.13}$$

Where $\beta_0 = \dfrac{a_0 + b_0}{b_1 + a_2}$ and $\beta_1 = \dfrac{a_1}{b_1 + a_2}$

The equilibrium of the money market (LM) and the real market (IS) is given by the intersection of Equations 2.9 and 2.13:

$$IS = LM \quad : \quad \frac{a_0 + b_0}{b_1 + a_2} - \frac{a_1}{b_1 + a_2} y = -\frac{\overline{M}}{\delta} + \frac{\varphi}{\delta} y$$

$$y = \frac{\delta a_1 + (b_1 + a_2)\varphi}{\delta (b_1 + a_2)} + \frac{1}{\left(\dfrac{\delta a1}{b1 + a2}\right) + \varphi} \overline{M} \tag{2.14}$$

Equation 2.14 demonstrates that a change in the money supply can affect the level of income. Based on Equation 2.14, we can calculate the money multiplier in the form of the coefficient ΔM as:

$$\Delta y = \frac{1}{\left(\frac{\delta a1}{b1 + a2}\right) + \varphi} \Delta \overline{M} \qquad (2.15)$$

From Equation 2.15, it is clear to represent the interest channel of the monetary transmission mechanism through the following diagram as:

δ : ($\Delta M \rightarrow \Delta r$) , b_1: ($\Delta r \rightarrow \Delta I$), and a_1 : ($\Delta I \rightarrow \Delta y$), with φ : ($\Delta y \rightarrow \Delta M^d$)

2.3.2. The Credit View

The credit view of the monetary transmission mechanism is based on a lending problem associated with asymmetric information in the financial market. According to this channel, the direct effects of monetary policy on interest rate are amplified by changes in the financial market. There are two possible linkages of the credit channel theories to explain the relationship between monetary policy and the financial market: the balance sheet channel and the bank-lending channel. Bernank and Bernanke and Gertler (1995) explain the bank-lending channel as the effect of monetary policy on the supply of loans by the banking system, while the balance sheet channel emphasizes the impact of monetary policy on the borrower's balance sheet.

The Bank-Lending Channel

The bank-lending channel is based on the financial structure in which the banks play a special role in the financial system, as they are suited to deal with certain types of borrowers who may not have access to the credit market unless they borrow from a bank. The bank-lending channel of monetary policy can be explained as in the following schematic:

$M \uparrow \Rightarrow \text{Bank Deposit} \uparrow \Rightarrow \text{Bank Loan} \uparrow \Rightarrow I \uparrow \Rightarrow Y \uparrow$

The expansionary monetary policy leads to an increase in bank deposits, which means the quantity of bank loans available also increases. If certain borrowers cannot obtain funds from outside the banking system, then the investment spending will increase and the volume of output rises.

The major implication of the bank-lending channel is that monetary policies will have greater affect on small and medium firms because large firms usually can obtain funds from other financial institutions such as stock and bond markets.

The Balance Sheet Channel

The balance sheet channel of monetary policy is based on the concept that changes in monetary policy not only affect interest rates, but also have an affect on the financial position of the borrower, both in a direct and an indirect way. Monetary policy can affect a firm's balance sheet in several channels. For example, expansionary monetary policy ($M\uparrow$) leads to an increase in equity price ($Pe\uparrow$) and higher investment spending ($I\uparrow$), and then aggregate demand will be increased. The following schematic shows the transmission mechanism of the balance sheet channel:

$$M\uparrow \Rightarrow Pe\downarrow \Rightarrow \textit{adverse selection}\downarrow \Rightarrow \textit{moral hazard}\downarrow \Rightarrow I\uparrow \Rightarrow Y\uparrow$$

The Cash Flow Channel

Another credit channel is called the cash flow channel, which focuses on monetary policy affecting economic activities though cash flow. Expansionary monetary policy, which lowers interest rates, can cause a rise in a firm's cash flow, and they improve a firm's balance sheet. As a result, adverse selection and the moral hazard problem become less severe, thereby increasing lending and economic activities, leading to the following schematic for the cash flow channel:

$$M\uparrow \Rightarrow r\downarrow \Rightarrow cash\ flow\uparrow \Rightarrow adverse\ selection\downarrow \Rightarrow moral\ hazard\downarrow,$$
$$Lending\uparrow \Rightarrow I\uparrow \Rightarrow Y\uparrow$$

It seems that the cash flow channel impact on the monetary transmission mechanism is similar to the traditional interest rate channel. In fact, they are different. The cash flow channel is more focused on the nominal interest rate that affects a firm’s cash flow, while the traditional interest rate channel emphasizes the affect of the nominal interest rate on investment.

Another interesting aspect of the balance sheet and cash flow channel is that those two mechanisms are involved in adverse selection. The expansionary monetary policy that lower interest rates can stimulate output involves the credit-rationing phenomenon. Credit rationing will occur in the case of a borrower being denied loans even when they are willing to pay a high interest rate. This is because the firms that have the riskiest projects are exactly the ones who are willing to pay the highest interest rate. Thus, high interest rates increase the adverse selection problem, and lower interest rates reduce the problem. Therefore, when the adverse selection problem is decreased, the volume of lending, investment and output in the economy are increased.

The credit channel analysis is commonly based on the study of Bernanke and Blinder (1998). They offered the alternative model that explains the credit channel of monetary policy, and the model allows roles for bank loans and money rather than focusing on only money as in the traditional IS-LM framework. The major assumption of this model is that loans and bonds are imperfect substitutes, so the borrower and lender are assumed to choose between bonds and loans according to the interest rates on the two alternative credit instruments. Therefore, the LM curve of this theory is derived from a set of portfolio-balance on the two assets, money and credit. Bernanke and Blinder (1988) also offered a commodity and credit curve (CC curve), which is generated from demand and supply for loans.

The demand for loan function is:

$$L^d = f(\overset{-}{p}, \overset{+}{i}, \overset{+}{y}) \qquad (2.16)$$

where L^d is the demand for loan,

p is the interest rate on the loan,

i is the interest rate on bonds, and

y is income.

The signs above each variable indicate that relationship of each variable to the demand for loan. This means that demands for loans positively respond to the interest rate on bonds and income, while negatively relating to the interest rate on loans.

The supply for loan function can be generated from a simplified bank balance sheet as shown in the following table:

Assets	Liabilities
Reserve (R) Bonds (B^b) Loans (L^s)	Deposit (D)

According to the above table, the bank balance sheet is $R + B^b + L^s = D$. Since the reserves consist of reserve requirement and excess reserve, so the reserve can be written as $R = \sigma D + E$ where σ is the required reserve ratio, and E is excess reserve. Thus, the banks' constraint is $B^b + L^s + E = D(1-\sigma)$. Therefore, the loan supply function is that:

$$L^s = \lambda(\overset{+}{p}, \overset{-}{i}) D(1-\sigma) \qquad (2.17)$$

The Equation 2.16 implies that the supply of loans is dependent on the interest rate for bonds and credit, the reserve requirement ration, and bank deposits.

Thus, the equilibrium of the loans market is:

$$L^d = L^s \tag{2.18}$$

By subtracting Equations 2.16 and 2.17 to Equation 2.18 to obtain:

$$L(p,i,y) = \lambda(p,i)D(1-\sigma) \tag{2.19}$$

The money market is described by the conventional LM curve. Suppose banks hold excess reserves equal to $\varepsilon(i)D(1-\sigma)$, then the supply of deposits will be equal to the bank reserve times the multiplier:

$$m = m(i).R \tag{2.20}$$

where $m(i) = \left[\varepsilon(i)(1-\sigma)+\sigma\right]^{-1}$.

The demand for deposits can be expressed as:

$$D^d = D(\overset{-}{i},\overset{+}{y}) \tag{2.21}$$

By placing Equations 2.20 and 2.21 into variable D on the right-hand side of Equation 2.19 you to obtain:

$$L = \lambda(p,i)m(i)R(1-\sigma) \tag{2.22}$$

By taking the total differencing of Equation 2.22, we will obtain:

$$dL = \lambda R(1-\sigma)m_i di + m(i)R(1-\sigma)(\lambda_p dp + \lambda_i di) + \lambda m(1-\sigma)dR \tag{2.23}$$

where $m_i > 0, \lambda_p > 0, \lambda_i > 0$.

Using the differentiation to solve the left-hand side of Equation 2.19:

$$dL = L_p dp + L_i di + L_y dy \tag{2.24}$$

where $L_p < 0, L_i > 0, L_y > 0$.

By rearranging Equations 2.23 and 2.24 to solve p as a function of i, y, and R to obtain:

$$L_p - m(i)(R(1-\sigma)\lambda_p)dp = \lambda R(1-\sigma)m_i + m(i)(R(1-\sigma)\lambda_i - L_i)d_i + (-L_y)dy + m\lambda m(1-\sigma)dR \qquad (2.25)$$

Therefore, it is clear that the loan market can be stated as:

$$p = \phi(\overset{+}{i}, \overset{+}{y}, \overset{-}{R}) \qquad (2.26)$$

Equation 2.26 clearly states that the interest rate on loans are positively related to the bond interest rate and income, but is negatively related to the bank reserve.

To analyze the aggregate demand, Bernanke and Blinder (1988) adopted the IS curve as in the following equation:

$$\text{IS}: \quad y = (\overset{-}{i}, \overset{-}{p}) \qquad (2.27)$$

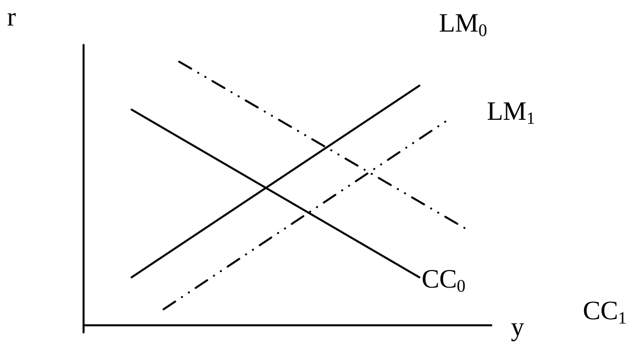
Then, subtract Equation 2.26 into 2.27 to get:

$$y = Y(i, \phi, \{i, y, R\}) \qquad (2.28)$$

Equation 2.28 is called ‘the commodity and credit curve (CC curve)’ in Bernanke and Blinder’s terms. The CC curve is negatively sloped like the IS curve which means that when interest rates on bonds and loans are increased, the volume of aggregate credits will be decreased which leads to a drop in investment and income. The different between the IS and CC curve is that while the CC curve is shifted by monetary policy actions and credit shocks in the loan market, the IS curve does not directly respond to monetary policy.

The credit channel on the monetary transmission mechanism, analyzed by the LM-CC curve can be presented in Figure 2.5.

Figure 2. 5The LM-CC curve and Monetary Policy



Expansionary monetary policy caused both the LM and CC curves to shift rightward. The LM curve is shift due to increasing money supply while the shift in the CC curve is because of increasing bank credit. This led to a rise in output.

2.3.3 Other Asset Price Effects

It seems to be that a key monetarist objective to Keynes' traditional view of the transmission mechanism of monetary policy is that it only focuses on one asset price, which is interest rates, rather than considering other asset prices. Hence, monetarists envision a transmission mechanism in other asset prices, as well as real wealth transmitting a monetary affect on economic activities. There are several channels of asset price effects on monetary policy.

Exchange Rate Effect on Net Exports

It should be noted that the exchange rate channel relates to the interest rate channel because when domestic real interest rates change, it may lead to changes in the exchange rate. For example, when domestic real interest rates decrease, domestic currency becomes less attractive compared with deposits in foreign currency. It causes depreciation of domestic currency (E↓). However, the lower value of domestic currency makes domestic products cheaper than foreign goods, thereby causing a rise in the value of exports and net exports *(NX↑)*. The exchange channel can be characterized by the following schematic showing the effect of a monetary policy expansion:

$$M \uparrow \;\Rightarrow\; i_r \downarrow \;\Rightarrow\; E\downarrow \Rightarrow NX \uparrow \Rightarrow\; Y\uparrow$$

Tobin's q Theory

James Tobin developed the theory called Tobin's q theory, to explain how monetary policy can affect economic activities through its effect on the valuation of equities (stock). Tobin defines q as the market value of a firm divided by the replacement of capital cost. If q is high, the market price of the firm will also be high. The new equipment is cheap compared to the market value of the firm. Thus, the firm can buy much new equipment following a rise in investment spending.

The importance of the theory is the link between Tobin's q theory and investment spending, and how monetary policy affects the price of equity. While monetary policy is expanding, the public knows that there is more money than demand, so it gets rid of spending. This causes an increase in stock demand and stock price. Then, it leads to high q and investment spending as can be shown in the following schematic:

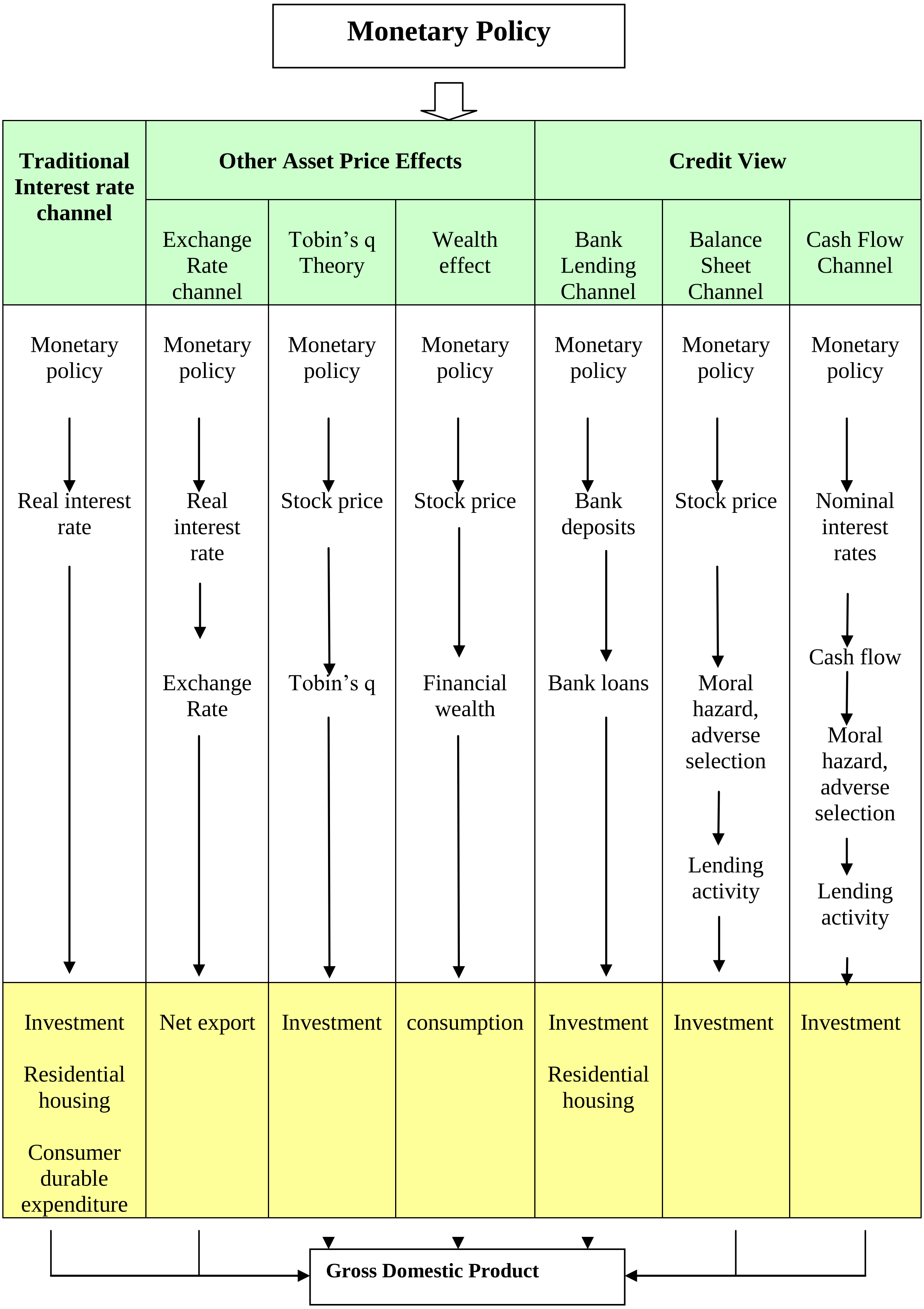
$$M \uparrow \;\Rightarrow\; Pe \uparrow \Rightarrow\; q\uparrow \Rightarrow I \;\uparrow \Rightarrow\; Y\uparrow$$

The wealth effect

This channel was first advocated by Modigliani (1971). The theory is based on his famous life cycle model of consumption, spending by the consumer on non-durable goods and service, and it is determined by the lifetime resource of the consumer, not just present income. The major component of lifetime resource is financial wealth, which is common stock. When stock prices increase, this implies that the value of financial wealth rises, thereby increasing the lifetime resource. Hence, expansionary monetary policy led to an increase in stock price and wealth, consumption, and output. The feature of the wealth effect can be shown by the following schematic:

$$M \uparrow \;\Rightarrow\; Pe\uparrow \;\Rightarrow\; Wealth \uparrow \Rightarrow Consumption \;\uparrow \Rightarrow\; Y\uparrow$$

Table 2. 2 A Summary of the Monetary Transmission Mechanism: the link between monetary policy and GDP



2.4 The Literature Reviews of Empirical Studies

As the theoretical debate in the previous section states that, the stability of the money demand function is a major role in monetary policy action particularly in terms of selecting the appropriate monetary target. Therefore, much empirical research has been carried out about the demand for money analysis and the monetary transmission mechanism in macroeconomic analysis. This section presents the review of empirical studies related to the demand for money analysis and the monetary transmission mechanism. This section consists of two parts: the first part provides the empirical study of the money demand function, focusing on the stability of money demand in both developed and developing countries. The second section is the literature review on the monetary transmission mechanism.

2.4.1 The Empirical Studies on Demand for money

The stability of money demand has long been a major concern in monetary analysis because money demand plays a major role in the financial market and it relates to real economic activities. As the aim of monetary policy is to control money supply in order to achieve economic growth and price stability, if the money demand function is stable, it implies that the money multiplier is stable and its measure of the prediction of the money supply effect on aggregate output is stable. In addition, theoretically, the money demand function is dependent on economic variables such as real income, wealth, and other variables, which reflect the opportunity cost of holding money, such as interest rates. Therefore, the relationship between money demand and its determinants has important implications for selecting an appropriate monetary policy.

As a result, empirical studies on the money demand function have been carried out over the past several decades. This section provides the empirical studies' surveys of money demand analysis, focusing on the stability of money demand and the relationship between money aggregate and economic activities in different countries. There are two major groups of countries concerned in this section, the surveys of money demand in developed and developing countries.

One of the pioneer studies on the money demand function in developed countries was generated by Lucas (1988). He used post-war data to estimate the money demand in the United States. He concludes that there is evidence of a stable long-run relationship between M1 money holding, domestic interest rates, and income in the United States over the sample period. After the study of Lucas, many researchers attempted to analyze the money demand in the United States. For example, Miller (1991) adopted the Eagle and Granger cointegration approach (EG) and the Error Correction model to analyze the money demand function in the USA during 1959-1987. He found that there is a single cointegration relationship between broad money and its determinants. After that Lucas (2000) re-estimated the M1 money demand in the United States but was more focused on the interest rate elasticity of money demand during 1900-1994, and the result was similar to the previous study that the M1 money demand in the United States appeared to be stable.

There is also a huge amount of literature about money demand in the industrial countries. For instance, Ghosh (2000) applied the cointegration approach to estimate the existence of the long-run equilibrium relationship of the M1 demand function in five industrial countries, including the US, the UK, Canada, Germany, and Japan. The empirical results of his study indicate that there is a long-run relationship between the M1 money demand and short-term and long-term interest rates in the US, the UK and Canada while only long-term interest rates appeared to be strongly significant in Japan. In addition, he found that there is no evidence about a stable relationship for Germany's money demand function. This study was supported by Hansen and Kim (1995) and Bahmani-Oskooee and Bohl (2000). They claimed that the M3 money demand in Germany appeared to be unstable.

Bahmani-Oskooee (2001) used the Johansen cointegration model to test the long-run relationship between the M2 money holding and interest rates in Japan. This research shows that the long-run M2 money demand function in Japan is stable. Similarly, Bahmani-Oskooee and Chomsisengphet (2002) applied the same model to test a long-run relationship in the M2 money demand function in 11 OECD countries, including Australia, Austria, Canada, France, Italy, Japan, Norway, the US, Sweden, Switzerland, and the UK. In addition, they also used the CUSUM and CUSUMSQ to test the stability of M2 money demand in those industrial countries. The results show that there is some sign of instability in the money demand function in Switzerland and the UK. However, money demands of the remaining countries are stable. Choi and Oxley (2004) estimated the stability of money demand in New Zealand, using the quarterly data from 1990-2000 based on the cointegration and error correction models. The result indicates that there exists a long-run relationship for the money demand function.

Some of the empirical studies emphasize the linkage between the money demand function and monetary policy. For instance, Cargill and Parker (2004) analyzed the money demand and monetary policy in Japan, China, and the United States during a deflation period. They review the history of deflation of those three countries and analyze the affect of deflation on money demand. The empirical results show that money demand in Japan is influenced by the deflation process, similar to the results from the United States. However, deflation has no affect on money demand in China. Coenen, Levin, and Wieland (2005) consider money demand as a monetary indicator when conducting monetary policy. In addition, they attempt to answer the question whether there is a linkage between money demand and current real output. The result indicates that money demand has limited information content as an indicator of contemporaneous aggregate demand in the Euro area.

Another interesting empirical study about the money demand function is the study of Lim (1993). He used a set of Australian quarterly and monthly data from 1974-1990 to examine the relationship between the broad money demand and its determinants. The variables included in the model are 90-day bank bill rates, two and five-year t-bond rates, the inflation rate and the dummy variable, which represent the structural change. The cointegration result shows that there exists a long-run relationship for both the monthly and quarterly money demand function and the error correction model (ECM) indicates that the short-run money aggregate in Australia was influenced by the 90-day bank bill rate. This was followed by Felmingham and Zhang (2001) who tested the broad money demand function but with a different method. They used the Gregory and Hansen (GH) methodology to examine the stability of money demand when a structural break is included, and the results indicate that the structural break was found in 1991 with the deep recession. Valadkhani (2005) re-examined the long-run determinants of the broad demand money function in Australia during 1976-2002 by using the Johansen cointegration technique. The result is similar to the previous study in that demand for broad money is cointegrated with real income, the rate of return on 10-year treasury bonds, the cash rate and the rate of inflation.

In recent years, there are many empirical studies analyzing the money demand function in developing countries. Most of the studies emphasize the stability of money demand and the long-run relationship between money demand and its determinants. Ahmed (1999) using the cointegration and error correction approach to investigate the stability of the money demand function and test the existence of a long-run money demand function for Bangladesh during the period 1975-1997. He also examines the parameter stability of the money demand function. The results suggest that there exists a single long-run relationship between real broad money demand, real income, and the real exchange rate. The short-term money demand function estimated with an error correction model found that real GDP and the real exchange rate have emerged as important determinants of the demand for money in Bangladesh. In addition, the results indicate that there is no evidence of a structural break in the money demand function in Bangladesh. Similarly, Siddiki (2000) applied the Eagle and Granger cointegration approach to estimate the money demand function in Bangladesh during 1975-1995. The empirical results suggest that there exists a unique long-run relationship among broad money demand (M2) and the real income, domestic interest rates and the unofficial exchange rate. Das and Mandal (2000) used the VAR model to examine the long-run stability of M3 money demand in India during the period 1981-1998. They found that M3 money demand appeared to be stable although there was a financial shock during 1990. Wu et al. (2005) employed the ARMAX to examine the demand for money in Taiwan and used the rolling estimation approach to examine the stability of parameter estimates over time. The empirical analysis concludes that the money demand in Taiwan is stable and the income elasticity is less than one.

Several studies focused on money demand in China such as Hafer and Kutan (1994) who used annual Chinese data from 1952-1988 to test the long-run relationship between money aggregate and its determinants. The results indicate that monetary aggregate is cointegrated with income and interest rates. Chen (1997) also studied the stability of the long-run money demand functions for the M0 and M2 money aggregate in China. The author states that M0 and M2 have a stable long-run relationship with their determinants both in pre- and post-financial reform. Deng and Liu (1999) re-estimated the demand for money in China, both narrow money (M1) and broad money (M2), during 1980-1994.

Several empirical studies of money demand in developing countries attempt to compare the stability of the narrow money demand and broad money demand in the sense of which money aggregate should be selected for monetary action. For example, Sriram (2002) studied the stability of long-run money demand in Malaysia and found that the demand for money (M2) in Malaysia was stable both in the short run and long run. He also suggests that monetary authorities should put more emphasis on the behavior of broad money in monetary management. This evidence is supported by the study of Dahalan, Sharma, and Sylwester (2005). They compared the stability of M1 and M2 money demand in Malaysia and found that M2 money demand is more stable, and said it should be considered as the monetary target in Malaysia when conducting monetary policy. After that**,** Hussain and Liew (2006) employ the CUSUM and the error correction model with monthly data from 1979-2002 to analyze the M1 and M2 money demand function in Malaysia. The CUSUM result suggests that both M1 and M2 appeared to be stable although the Asian financial crisis occurred during the sample period.

Bahmani-Oskooee and Rehman (2005) employ the CUSUM and CUSUMSQ test to analyse seven developing countries, including India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore and Thailand. The authors conclude that the M1 money demand is cointegrated with its determinants and the estimates of elasticity are stable over time for India, Indonesia and Singapore, while the M2 money demand appeared more stable for, Malaysia, Pakistan, the Philippines, and Thailand.

Another popular issue on money demand analysis in Asian countries is to analyse the affect of financial liberation on the stability of demand function. Dekle and Pradhan (1997) studied the impact of financial liberalization on money demand in Southeast Asian countries including Indonesia, Malaysia, and Thailand. They claim that the instability in economic activities, the financial liberation, and the financial reforms have contributed to the instability of money demand in Southeast Asian countries. Khalid (1999) estimates the degree that foreign factor opportunity cost variables impact money demand in South Korea, the Philippines, and Singapore by applying the Johansen cointegration and the error correction model with the quarterly data from 1977:1 to 1993:4. He states that money demand in those three countries has a long-run relationship with both domestic and foreign variables. However, only income appeared to be a significant relationship with money demand while the interest rate has no affect on money demand in the short-run equilibrium. The author suggests that foreign factors have a stronger affect on money demand than the effect from domestic interest rates after financial liberation.

It is very interesting that many empirical studies found that the financial liberalization has an effect on the money demand function in the short-run equilibrium, but the long-run relationship appeared to be stable. Pradhan and Subramanian (2004) study the effect of the financial innovation process on the stability of demand for money. They state that although financial deregulation and innovation has occurred in the Indian economy, the demand for money relationship is stable. Indeed**,** this research is similar to the research of Cheong (2003). He investigated whether financial liberalization has caused instability in the money demand function in Korea. The results of the research show that the financial liberation has an effect on the money demand relationship but it does not cause instability in the money demand function in Korea. James (2005) attempts to offer a new approach to analyse the effects of financial liberalization on money demand in Indonesia by including a proxy for the process in the money demand function. He found that liberalization is a major role in determining money demand and it appears to fluctuate. Moreover, he claims that there is existence of a long-run relationship between broad money and its determinants when the proxy of liberalization is included.

In the case of Thailand, there are not many empirical studies on the money demand function. Most of the studies in Thailand emphasize the relationship between money aggregate and economic indicators but have less concern about the stability of the money demand function. For instance, Arize, Spalding, and Umezulike (1991) estimated demand for money in Thailand based on the quarterly time series data for the period 1973:1 to 1985:4. They found that the foreign interest rate appeared as an important role in the money demand function during the sample period. They suggest that the Bank of Thailand should consider the relationship between money aggregate and external factors such as the foreign interest rate when operating monetary policy. Similarly, Chaisrisawatsuk, Sharma, and Chowdhury (2004) analyze the stability of money demand function and monetary policy under the capital mobility and currency substitution in five Asian countries including Thailand, using quarterly data from 1980-1996. The result of the cointegration vector indicates that capital mobility and currency substitution appeared to be significant factors in the money demand function with respect to the US dollar, the British pound and the Japanese yen for Thailand. Monetary effectiveness is influenced by capital mobility and currency substitution. They also conclude that the money demand function in Thailand is less stable over the sample period because of the transmission of international shock. The authors suggest that the monetary authorities should consider more about external factors when making decisions on monetary police action.

There are some studies attempt to develop econometric techniques to analyze the relationship of the narrow and broad money demand function in Thailand. For example, Chowdhury (1997) used the Johansen cointegration and VAR technique to analyze the demand for money in Thailand. The aim of the study is to test the long-run relationship among nominal money aggregate (both M1 and M2), real GDP, price levels, exchange rates, and interest rates. The results show that there is evidence of stability of money demand in the long-run relationship for both M1 and M2 money demand. However, he suggests that M2 money demand appeared to be more desirable since the long-run elasticity for the M2 money demand equation is within the expected range, while M1 money demand functions are not. On the other hand, Arize, Malindretos, and Shwiff (1999) analyzed the money demand function for 12 developing countries, including Thailand. The cointegration approach was adopted to examine the long-run equilibrium between real M1 or M2 money aggregate, real income, the inflation rate, the exchange rate, foreign exchange risk, and foreign interest rates when structural change is included. The results show that although M1 money demand has a slower response to changes in the determinants compared with M2 money demand, both M1and M2 need to be considered in the sense of conducting monetary policy.

Another popular issue about money demand studied in Thailand is whether an external factor such as the exchange rate has a relationship with money holding in Thailand. For example, Bahmani-Oskooee and Malixi (1991) analyzed the effects of effective exchange rates of demand for money in developing countries (including Thailand) by using quarterly data from 1973-85. They found that currency depreciation causes a decline in the demand for domestic currency in most developing countries, including Thailand. The paper was supported by Tosporn and Pandey (1997) who investigated the aspects of financial liberalization and the role of the expectation on exchange rate on money demand in Thailand, Taiwan and South Korea by using the Box-Cox extended autoregressive model with data from 1970-1989. The empirical results show that the expected depreciation in the black market exchange rate has a negative long-run relationship with money holding in Thailand. In addition, they found that there is no evidence to indicate that the exchange rate influences the money demand differently over the period before and during the ongoing financial liberalization process. Therefore, the central bank must carefully select an appropriate exchange rate policy to support their economic goals. Another interesting paper that focused on the relationship of the exchange rate and money demand in Thailand is the study of Bahmani-Oskooee and Techaratanachai (2001)**.** They investigate the relationship between currency depreciation and the M2 money demand function in Thailand by using the quarterly time series from 1977-1990. They tried to investigate whether currency depreciation has resulted in currency substitution in Thailand. The results showed that the depreciation of the Thai baht led to a decrease in baht holding in Thailand (M2) and a slow fall in economic activities. Therefore, monetary authorities should not only consider about stabilize the economy, but they also need to stabilize the domestic currency.

Few empirical studies emphasize money demand and the inflation rate in Thailand. Arize, Malindretos, and Grivoyannis (2005) investigate the effect of inflation-rate volatility on the money demand function in Thailand and other seven less developed countries. The authors apply the cointegration methodology with the quarterly data from 1973:2–1999:4 to estimate the demand function. The major result concerned the relationship between the real money demand and the inflation rate volatility. They found that there is a negative relationship between real money demand and the inflation rate in Thailand. The authors suggest that if the policy maker ignores price, it is hardly going to stabilize the domestic economy. Therefore, monetary policy in Thailand should be operating under inflation targeting, which is more concerned about price stability.

2.4.2 Empirical Studies of the Monetary Transmission Mechanism

Since Keynes introduced the link between the monetary sector and the real sector, the effect of monetary policy on economic activities became an important issue in macroeconomics analysis. A large amount of literature has studied about the channels of monetary policy effect on economic activity, especially the affect of monetary policy on inflation and economic growth. The major aim of this section is to present the surveys of empirical studies relating to monetary policy and the transmission mechanism in the different channels of the transmission mechanism. Three main channels are the concerned in this section: the money view or traditional interest rate channel, the credit view (including the bank-lending channel and bank balance channel), and other asset price channel (including the exchange rate channel and the wealth effect.

2.4.2.1 The Traditional Interest Rate Channel

The interest rate channel has long been an important topic in monetary analyses since the traditional Keynesian approach explained that the relationship between the financial sector and real economic activities works directly through interest rates. The monetary policy action has an impact on nominal and real interest rates, which then affects consumers and investment spending, aggregate demand and output (Mishkin 1996). Many empirical studies on the monetary transmission mechanism focus on the interest rate channel and the role of interest rates in the economy.

The pioneer literature on the interest rate channel is the study of Sims (1972). He employed Granger's causality criteria with the post-war US data during 1947-1969 to examine whether money can be treated as exogenous in the money-income relationship. He found that the causality was unidirectional from money to income. After that Sims (1980) used a multivariate linear time series model to test whether there is some relationship between potential policy instruments such as interest rates and output, and the author found that the upward shock in nominal interest rates cause a fall in both money and output.

After the study of Sims (1972, 1980), there are a number of monetarists who studied the transmission mechanism of monetary policy, focusing on the interest rate channel. Friedman and Kuttner (1992) investigate the long-run relationship between money, interest rates and income in the US, using a cointegration approach. The research shows that there is no close relationship between M2 and nominal income or price. On the other hand, the Treasury bill rate contains significant information about the future movement in real output. Taylor (1995) presents the simple framework for analyzing the monetary transmission mechanism of monetary policy focusing on the changes in monetary policy that affect real GDP and inflation. He found that there was strong empirical evidence for substantial interest rate affects on consumption and investment. Meltzer (1995) studied the Japanese experience in the 1980s and 1990s during which the monetary policy had important impact on the economy through its affect on land and property value. His research stated that the asset price effect extends beyond those operating through interest rates, equity price and the exchange rate. Similarly, Nagahata and Sekine (2002) investigate the affect of monetary policy on firms after the collapse of the asset price bubble in Japan. The results show that monetary policy after the bubble burst works well under the interest rate channel, but it was ineffective under the credit channel. The credit channel was blocked because of the deterioration in the balance sheet condition.

2.4.2.2 The Credit View of the Monetary Transmission Mechanism

Since the traditional interest rate channel seems to ignore the importance of the bank credit role in affecting the aggregate spending in the economy, Bernanke and Gertler (1995) offered the credit channel as an alternative view of the monetary transmission mechanism. There are two major channels relying on the credit view, the balance sheet channel and the bank-lending channel. While the balance sheet channel focuses on the affect of monetary policy on the balance sheet of borrowers, the bank-lending channel emphasizes the impact of monetary policy action on the supply provided by the banking system.

Much of the literature used the credit views' framework for analyzing the monetary transmission mechanism. One of the most popular models of the bank-lending channel was proposed by Bernanke and Blinder (1988). In this model, bank loans and bonds are assumed imperfect substitutes for the bank and the borrower. This implies that along with the bond rate, the bank lending rate is determined by loan demand and supply (Brissimis and Magginas 2005, p 882). The major results of the Bernanke and Blinder (1988) study are that the bank-lending channel is not effective when the elasticity of loan supply is infinite and the loan demand is perfectly elastic with the loan rate. After that, Bernanke and Blinder (1992) re-investigate the monetary transmission mechanism in the US during 1959-1992, using a semi-structured VAR model to examine the impulse functions of bank loans, deposits and securities to an innovation in the Federal fund rate. They found that monetary policy in the US during the sample periods works well through the bank deposit and bank loan channels with monetary tightening leading to a decrease in the size of deposits as well as a short-run sell of the banks' security holding, but had little affect on loans. On the other hand, changes in Federal rates affect immediately on the volumes of deposits and securities while having a delayed affect on the volume of bank loans.

Kashyap, Stein, and Wilcox (1993) attempted to examine the movement of the mix between bank loans and commercial paper when monetary policy is changed. They found that tightening monetary policy caused the bank loan supply to decrease more than the reduction in commercial paper. They also stated that monetary policy does not affect the composition of external finance if the central bank operates the monetary policy through only the interest rate channel. Oliner and Rudebusch (1996) criticized the findings of Kashyap, Stein, and Wilcox (1993). They questioned whether the use of the mix between bank loans and commercial paper as an indicator of the operation of a bank-lending channel is useful in terms of conducting monetary policy. They re-estimated the monetary transmission mechanism in the US, focusing on the affect of monetary policy on business investment. The results show that tightening monetary policy not only led to the reduction of the demand for external finance, but also redirected all types of credit from small to large firms, which rely more on commercial paper financing. This causes commercial paper to increase although the bank loan supply is unchanged. In response to Oliner and Rudebusch criticism, Kashyap, Stein, and Wilcox (1996) re-estimated the effects of monetary policy on large and small firms using their original definition of the financial mix, and the results were found to support their original results.

Dale and Haldane (1995) adopted the VAR approach to uncover a number of stylized features of the monetary transmission mechanism in the UK, using data from 1974-1992. They used sector data to facilitate the identification of distinct money and credit channels in the transmission of monetary policy and to investigate the different responses of the private and corporate sector to monetary policy action. The results found that the corporate sector deposit significantly dropped because of monetary tightening, while the volumes of bank loans for firm rose in the short term. Similarly, lending volumes to the private sector fell immediately following the monetary policy action, while the deposits rose.

Miron, Romer, and Weil (1995) applied the Bernanke-Blinder (1988) model to investigate the importance of the lending channel in the transmission of monetary shocks to the real economy. The research found that the most important feature of the model was that changes in the money supply could affect aggregate demand through its affect on the amount of bank credit available. Their model suggests that in the context of monetary policy, lending credit was a significant and a valid contributor in explaining the monetary transmission mechanism**.** Similarly, Ramirez (2004) extended the Bernanke-Blinder (1988) approach to the open economy. The aim of his paper was to compare the effectiveness of monetary policy that predicted from the Mundell-Fleming model and the Bernanke and Blinder approach. He concluded that the credit channel of the monetary transmission mechanism under the Bernanke-Blinder model has more potential than the standard Mundell-Fleming model due to the Bernanke-Blinder model separating loans from the bond market, which makes the aggregate investment and spending more directly responsive to monetary policy.

Wu (1999) studied the role of monetary policy under a fixed exchange system, focusing on the credit channel of the monetary transmission mechanism. The major assumptions of the study were that the foreign reserve is constant, and that there is perfect capital mobility in the bond market and imperfect substitution between loans and bonds. He found that monetary policy could be effective in stimulating aggregate output though the bank loan channel although the country is under a fixed exchange rate regime. However, the study of Wu was criticized by Ramirez (2001). He claimed that the assumption of a fixed foreign exchange reserve is incorrect because the quantity of foreign exchange reserves appears as endogenous under a fixed exchange rate regime. He examined the credit channel of monetary policy under the fixed exchange rate system when the foreign exchange reserves are flexible and the results indicate that monetary policy is ineffective in stimulating aggregate output under the fixed exchange rate system. Kim (1999) examined whether the credit channel was a majority monetary transmission mechanism in the Republic of Korea after a financial crisis period, using both aggregate financial data and disaggregated bank balance sheet data over the period 1987-1998. He found that the lending channel has a significant independent role in monetary policy after a financial crisis.

Suzuki (2004) studied the monetary transmission mechanism in Australia, using the VAR model to examine the feature of banks' behavior, in which banks make the lending channel less dominant in the Australian economy. The result of this paper regarding the credit channel shows that Australian monetary policy is different from other developed countries such as the United States and the UK, where the credit channel usually appeared to be a significant operative in monetary policy. As Australian banks mostly borrow money from abroad to mitigate the effect of monetary contraction, the bank loans appeared to be less important in monetary action.

Ahmed et al. (2005) applied the VAR model, with seasonally adjusted monthly data from 1996-2004, to examine the monetary transmission mechanism in Pakistan. The major conclusion of this study was that the bank-lending channel appeared to be the most important channel in the monetary transmission mechanism, as a monetary tightening directly led to a decrease in the volume of bank lending and domestic demand, while it had less affect on the exchange rate.

Brissimis and Magginas (2005) developed the methods of Bernanke-Blinder (1988) to investigate the monetary transmission mechanism. The multivariate cointegration approach was used in a sample of six major industrial countries, including the US, the UK, Germany, France, Italy, and Japan. The major aims of this paper were to test whether the degree of asset substitutability was influenced by monetary policy under the credit channel operation. The authors found that the lending channel played an important role for the monetary transmission mechanism in Japan, but was not operative in the US and the UK. For others European countries, the lending channel lost its potency in the last decade.

Chrystal and Mizen (2002) provided a framework of monetary policy in the United Kingdom in which to analyze the importance of the credit channel. Both credit offered by banks and non-bank financial institutions were included in the model. They found that the credit channel is the most important channel of monetary policy in the UK. Then, Chrystal and Mizen (2005) confirmed their previous study by using an interdependent equation to test the significance of lending for consumption and money. The results show that a stable credit equation does exist in parallel with money demand and consumption. This implied that the credit channel is effective in the UK.

Hulsewig, Mayer, and Wollmershauser (2006) applied the VAR model to estimate the response of bank loans to a monetary policy shock, with an emphasis on the reaction of the output level and the loan rate on monetary policy. The results indicated that bank loan supply dropped within an expected decrease in the credit margin after a monetary shock; demand for loans fell as a result of a drop in the output and an increase in the loan rate.

2.4.2.3 The Other Asset Price Channel

There are three categories which are included in the other asset price channel of the monetary transmission mechanism: the wealth effect channel, the exchange rate channel, and Tobin's q theory (Mishkin 2001).

In an open economy, the exchange rate is one of the most important factors that need to be considered when conducting monetary policy. Taylor (1995) states that under the flexible exchange rate regime, when domestic interest rates increase, domestic currency deposits are more attractive and can lead to currency appreciation. The higher values of domestic currency make domestic products' price higher than foreign products, and the net export and output fall. However, under a fixed exchange rate, expansionary monetary policy initially lowers domestic interest rates, the net capital flow and the current account deficit. Most literature on the exchange rate channel of the monetary transmission mechanism focuses on the affect of the exchange rate on the net capital account. Taylor (2000) described how alternative channels of the monetary transmission mechanism influence the choice of a monetary policy rule and he found that the exchange rate channel has a very strong affect on monetary policy. However, he suggests that the central bank needs to adjust the interest rate in response to the change in the exchange rate when conducting monetary policy.

The exchange rate channel usually involves an interest rate effect. Therefore, many studies analyze the exchange rate channel through the effect of interest rates on the exchange rate. Cunningham and Haldane (2000) showed the relationship between interest rates and the real exchange rate in the UK. They claimed that the exchange rate channel is an effective channel in monetary policy. Hwee (2004) used the real effective exchange rate as a measure of monetary policy and he found that the exchange rate was more effective than interest rates in the monetary transmission mechanism in Singapore.

Another other asset price channel of monetary policy is based on the effect of monetary policy on the bank balance sheet, called the balance sheet channel. Meltzer (1995) highlights that monetary policy has an important impact on the Japanese economy through its effect on the property value base in Tobin's q theory. The result shows that through the balance sheet effect, monetary contraction led to a decrease in property value, spending on housing and finally aggregate output dropped. The importance of the balance sheet for monetary policy was also addressed by Morsink and Bayoumi (2001).They used the VAR model to examine the monetary transmission mechanism in Japan. The empirical results indicated that banks play a crucial role in transmitting monetary shocks to economic activity. The bank balance sheets and business investment are sensitive to monetary shocks. In addition, the bank balance sheet has a strongly significant affect on private demand and consumption, so that the central bank probably used the bank balance sheet as a major channel of monetary policy. Hosono (2006) used Japanese bank data from 1975-1999 to investigate how commercial banks responded to monetary policy according to their balance sheet. He states that the effect of monetary policy on the bank balance sheet depended on the bank type. Smaller banks that have less liquidity and more abundant capital are more sensitive to a monetary shock because the larger banks can diversify their risk and they can overcome the information problem.

Some literature focuses on other channels of the monetary transmission mechanism. For example, Angelopoulou and Gibson (2007) used a panel of UK firms in manufacturing to examine the sensitivity of investment to cash flow. They found that UK firms showed greater investment sensitivity to cash flow during periods of tight monetary policy. Den Haan, Sumner, and Yamashiro (2007) studied the banks' portfolio behavior following the tightened monetary policy, comparing the responses of bank loan components to the monetary tightening with the responses to negative output shocks. The results indicate that monetary tightening led to a decrease in consumer and real estate loans while commercial and industrial loans increased.

In the case of Thailand, there are not many empirical studies concerning the monetary transmission mechanism. Hataiseree (1994) applied the conventional IS-LM model to investigate the relationship between income and money aggregate in Thailand during 1980-1990, using a cointegration approach to examine the long-run relationship between the set of variables included in money-income model. M1, M2 and the monetary base (MB) were used as a proxy of monetary aggregate while credit aggregate is proxied by business and household credit. The results show that there is evidence to support using monetary aggregate as an intermediate target in monetary policy. Following this, the study of Sirivedhin (1998) adopted the VAR model to characterize the dynamic relationship between key economic indicators in order to understand the monetary and transmission mechanism in Thailand. The major aims of the paper were to explain the impact of financial regulation and monetary policy on real economic activities as well as comparing the impact of a shock on interest rates and credit on economic indicators. The results indicate that financial liberalization brings about a closer lineage between domestic and foreign markets. The financial market in Thailand is largely influenced by foreign interests although the domestic interest rate is a major channel in the monetary transmission mechanism. However, the interbank rate shock has no impact on private investments, while household savings are influenced by wealth.

Recently, the issue of the monetary transmission mechanism was reviewed by Disyatat and Vongsinsirikul (2003). They used the VAR approach with seasonally adjusted data from 1993-2001 to examine the degree of pass-through from monetary policy to economic activities. The results of this paper stated that tightening monetary policy led to a decrease in output within four to five quarters after the policy was adopted, while the domestic price received very little effect from monetary policy. The authors also found that the exchange rate and asset price channels have been less significant compared with the credit channel. This implies that the credit channel, which banks play an important role in, is the major transmission mechanism in Thailand. After that, Hesse (2007) re-estimated the monetary transmission mechanism by applying the cointegration vector autoregression (VAR) approach to study monetary policy and the monetary transmission mechanism in Thailand, focusing on how monetary shocks are transmitted to the Thai economy, pre-crisis and post-crisis. The results of this research point out that monetary policy is inconsistent in the pre-crisis period due to Thailand's open capital markets while operating the monetary policy under the fixed exchange rate regime. Monetary policy and money shock impact on inflation but not output. In contrast, monetary policy appeared to be more effective in the post-crisis period because the exchange rate becomes more flexible.

This evidence is supported by the study of Disyatat, Pongsaparn, and Waiquamdee (2005). They claimed that the flexible exchange rate has a very important role in the monetary transmission mechanism in Thailand. Charoenseang and Manakit (2007) investigated the transmission of monetary policy after inflation targeting was adopted in Thailand. They also examined the long-run relationship between the policy rate and financial market interest rates. The conclusion of this paper show that there exists a long-run relationship between the 14-day repurchase rate and the financial market rates, except for the finance company lending rate. They also claim that under inflation targeting, the interest rate channel of transmission of monetary policy has become weak while the credit channel through the commercial bank lending is still a valid monetary transmission mechanism in Thailand.

Recently, the Bank of Thailand (2008) studied on change on monetary transmission mechanism in Thailand. The paper focuses on the transmission mechanism in Thailand after the financial crisis in 1997 and during the monetary tightening from mid of 2004 onward. The paper concluded that interest channel is generally the most important channel of monetary transmission mechanism in Thailand. However, the interest rate became less significantly for sometime in post crisis due to the excess liquidity in banking sector.

Overall, most empirical studies in transmission mechanism of monetary policy in Thailand mainly focus on the degree of pass-through from the monetary instrument to the monetary target, especially the impact of monetary policy on interest rate. This thesis will add on the literature of the transmission mechanism in Thailand and re estimated the monetary transmission mechanism in Thailand by testing three main channels; interest rate channel, credit channel, and exchange channel.

2.5 The Overview of Thailand's Economic Development

This section presents the overview of Thailand's economic development. There are three parts included in this section: the economic performance in the pre-financial crisis (1990-1996), the financial crisis, and the development of monetary policy after the financial crisis. Table 2.3 show the overview of economic performance in Thailand by dividing the Thai economy into three periods: the pre-financial crisis from 1990-1996, the post-financial crisis under monetary targeting from 1997-2000, and the post-crisis after Thailand adopted the inflation targeting from 2000-2006.

Table 2. 3 Thailand's macroeconomic performances

Variable	Pre-crisis 1990-1996	Post crisis (1997-2000) Monetary target	Post crisis (2001-2006) Inflation target
Real Economic Indicators			
GDP growth rate [a]	8.6	-0.69	5.04
Inflation rate	5.1	3.59	1.1
Unemployment Rate	1.6	1.9	2.3
Monetary indicators			
Money Supply Growth(M2)	11.6	7.9	6.3
Interest rate	13	10.3	7.75
International Indicators			
(% of GDP)			
Trade Balance	-10.7	5.6	0.2
Current Account	-6.8	7.13	3.35
Net Capital Flow	13.3	-8.08	-1.5
- Private Capital Flow	*12.9*	*-11.59*	*-1.9*
- Public Capital Flow	*0.4*	*3.51*	*0.4*

[a] **:** GDP growth at constant 1988 price

2.5.1 Thailand's Economic Performance in the pre-financial crisis period

Since the early 1990s, Thailand has achieved a remarkably good economic performance with high economic growth rate and stability of the inflation rate. As can be seen in Table 2.3, Thailand has grown very fast with an average 8.6% per year during 1990-1996. The inflation rate was stable with an annual average rate of 5.1%, together with a narrow fluctuation of the exchange rate; it was fixed between 24.9-25.7 baht per US dollar. As a result, Thailand was classed by the World Bank as one of the eight Highly Performing Asian Economies (HPAES) along with Japan, Hong Kong, Malaysia, Singapore, South Korea, Taiwan and Indonesia (Dixon 2001).

Much of the literature attempted to explain the key ingredients of the economic boom in Thailand during 1990-1996. For example, Jansen (1997) claims that the major boom in Thailand came from the high level of private investment. Similarly, the study of Chowdhry (1997) demonstrated that the economic expansion in Thailand was driven by private investment and the growth of exports. Vongsiirikul and Sriphayakard (2007) suggested that Thailand's economic boom was mainly from foreign direct investment and the real estate boom. Overall, most of the literature demonstrates that the key ingredients of the economic boom in Thailand were a high rate of private investment, a growth in the export rate and a massive capital inflow from abroad.

Over the boom period between 1990 and 1996, the private investment growth rate in Thailand has increased sharply from 21.0% in 1991 to 30.0% in 1994. This evidence is supported by the study of Jansen (1999). He showed that there is a close relationship between the level of private investment and high economic growth. The private investment in Thailand appeared around 26% of GDP in 1990, and it sharply increased to 40% of GDP in 1996. He also stated that while the investment rate in Thailand grew rapidly, domestic saving grew slower than the investment. The growth of investment exceeding domestic saving can imply that Thailand's investment was funded by capital inflow from abroad. It is not surprising that the private capital movement in Thailand grew very fast from 11.0 % in 1991 to 20.8% in 1995 (see Table 2.4).

The export growth rate is one of the major ingredients of Thailand's Economic boom. The study of Ciminero (1997) claimed that due to Thailand's low wages for its labor force, it attracted foreign direct investment (FDI) into Thailand, particularly in export industries. Therefore, Thailand's export grew very fast. As can be seen in Table 2.4, the export growth rate grew from 12.1% in 1990 to about 24.6% in 1995.

Table 2. 4 Thailand's economic performance during the boom period

Year	GDP Growth rate (%)	Private Investment Growth (%)	Private Capital Movement (%)	Export Growth (%)
1990	11.2	33.2	13.7	15.1
1991	5.6	21.0	11.0	23.6
1992	8.1	20.5	8.0	13.8
1993	8.3	23.3	10.3	13.7
1994	9.0	30.0	12.0	22.1
1995	9.2	24.1	20.8	24.6
1996	5.9	14.4	18.2	-1.8

Another key factor in the economic boom was the huge capital inflow. Before 1990, Thailand's economy carried on a closed financial system, in which capital inflows and foreign borrowing were limited. However, the globalization during the 1990s and a high demand for investment funds encouraged Thailand to change its economic system to liberalization. In 1992, Thailand opened up the foreign exchange market and there was concurrent liberalization of capital transactions. In addition, the Bangkok International Banking Facility (BIBF), an offshore banking center, was established in 1993 in order to facilitate capital mobilization. The financial liberalization under a stable exchange environment, and good economic performance, induced huge capital inflows into Thailand. The net capital flow increased rapidly from 7.8% of GDP in the period 1987-1990 to about 13.3% of GDP in the period 1990-1996. It is important to note that the proportion of net capital inflow after liberalization was dominated by private sector, the concentration of net capital inflow during 1990-1996 was an average of 12.9% of GDP, while only an average annual 0.4% of GDP of net capital inflow came from the public sector (see Table 2.3).

Monetary policy before the financial crisis

Prior to 1997, the Bank of Thailand (BOT) conducted monetary policy under a fixed exchange rate system. As the monetary policy of this period aimed to achieve economic growth, the BOT liberalized the financial system by allowing the investors easy access to foreign funds. At the same time, the BOT kept high domestic interest rates in order to attract capital inflow from abroad. The pegged exchange rate supported a good export performance and encouraged foreign investment. In the meantime, liberalization and the high interest rate in Thailand induced large inflows of foreign investment to Thailand. Therefore, foreign capital significantly contributed to rapid economic growth in Thailand during this period.

After the liberalization in Thailand and the establishment of the BIBF in 1993, the foreign investor had more confidence in Thailand's economy and started giving funds to Thailand. The borrowing from BIBF sharply increased from zero in 1992 to 197 billion baht in 1993, and it continued to increase to 807.6 billion baht in 1996. As a result, the total loans in Thailand rose from 21% in 1991 to more than 30% in 1994. It is interesting to note that while the private loans increased dramatically around 22.55% on an annual average during 1991-1996, the GDP growth rate was only 8.6% per year in the same period.

As a result of huge borrowing from overseas, the current account deficit in Thailand increased from -4.85% of GDP in 1993 to approximately -7.9% of GDP in 1996. To reduce the volume of lending in Thailand during the boom period, the BOT introduced a restriction on monetary policy by increasing the minimum lending rate from 10.5% in 1993 to 13.75% in 1995. However, the rise in the domestic interest rate reduced lending by a very small amount since the private investors could borrow money from overseas with a lower interest rate. This implies that the action from the BOT did not have much affect on Thailand's economy.

The fixed exchange rate regime meant the Bank of Thailand had very limited room to maneuver its conduct of monetary policy. Moreover, monetary policy was significantly affected by the financial liberalization era (Sirivedhin 1998). The power of the central bank to influence monetary policy was reduced due to the lack of control over monetary aggregates and the uncertainty about its effect on real variables. Thai financial companies became less dependent on the Bank of Thailand. The funds that the Bank of Thailand lent to financial institutions sharply reduced from 54% of the monetary base at the end of 1988 to about 20% at the end of 1996. Over the same period, borrowing abroad by financial companies significantly increased.

The bank rate, which is the interest rate that the central bank lends to commercial banks, has become less important. The bank rate, money market interest rate, and the inter-bank rate, used to be close to each other, but after financial liberalization, the gap has widened significantly. The Bank of Thailand used to employ the bank rate as guidance for the domestic rate. However, the opening of financial markets implied that the inter-bank rate was determined by the international interest rate (Bank of Thailand 1995). This means the ability of the Bank of Thailand to control the interest rate was reduced. However, the Bank of Thailand has changed its strategy by changing the main monetary instrument. The open market operation on the repurchase market was adopted as a major instrument of monetary policy. Through this channel, the Bank of Thailand can influence liquidity in the money market and the short-term interest rate (Jansen 2001).

Overall, the Bank of Thailand still has difficulty in conducting monetary policy due to increasing liquidity and capital inflows. To reduce liquidity, the Bank of Thailand used open market operations by selling government securities. In addition, the Bank of Thailand tried to reduce credit growth by reducing the maximum line of overdraft for commercial banks in 1990.

2.5.2 Thailand's Financial Crisis and the Cause of the Crisis

Over the boom period (1990-1996), while Thailand enjoyed a good-looking economy, there were some symptoms of economic problems. For example, the high level of the current account deficit (accounting for around -6.8% of GDP), high interest rates (13% per year on the average) and the instability of commercial banks and financial markets in terms of the huge amount of bad loans. However, most Thai investors and policy makers had ignored these problems until they were getting serious in 1996 when some terrible situations appeared. The business environment was getting worse due to oversupply in real estate. Moreover, the export growth rate fell dramatically from 24.1% in 1995 to about -1.8% in 1996. As well, the GDP growth rate dropped from 9.2% in 1995 to 5.8% in 1996. Subsequently, foreign investors lost confidence in the Thai economy and the financial system and stopped investing in Thailand. In addition, they withdraw their money from Thailand. The economic fundamentals continued to deteriorate and it is led to heavy speculative attacks and the development of the financial crisis in 1997.

After the financial crisis in Thailand in 1997, the issue of the cause of the crisis became a hot topic among economists. Corsetti, Pesenti, and Roubini (1999) believe that the cause of the financial crisis involved the fundamental weakness of economics, such as the weakness of the financial system, the export performance, and the inefficiency of policy makers. Similarly, Siamwala (2000) also claimed that the crisis in Thailand was generated from the bubble economy and the bubble bursting. He also blamed the inconsistency of policy makers as the main problem in Thailand. Rajan (2000) indicated that the root of the financial crisis in Thailand was the bank panic and the devaluing of the Thai baht in July 1997, while Radelet et al. (1998) blamed the instability of the international financial market for the crisis in Asia, including Thailand. Overall, the major cause of the financial crisis was that too much foreign capital inflow that could not satirize, the instabilities on financial market, international speculation and inconsistency of monetary policy.

The huge amount of capital flow and external debt

It seems to be that the huge foreign capital inflow was the most important reason for the financial crisis. As the international capital markets were accessed easily due to liberalization, there was a sharply increase in foreign borrowing, especially foreign borrowing from commercial banks and financial institutions. Thai investors and financial companies borrowed a huge amount of short-term funds from abroad in dollars or other foreign currency without currency risk protection because they believed that the fixed exchange rate would eliminate the currency risk. At the same time, the high interest rate in Thailand attracted foreign investors to invest and lend to Thailand. It can be implied that the high growth rate in Thailand during the period of economic boom was largely financed by external funds, as reflected by the deficit of the capital account being around 5.4 to 8.3% of GDP during 1990-1996.

As can be seen in Table 2.5, the capital inflow from abroad started to increase rapidly from about 7.8% of GDP in 1987-1992 to an average of 10.1% of GDP for the period average in 1993-1996. It should be noted that the proportion of net capital inflow after liberalization was dominated by the private sector. The concentration of net capital inflow during 1993 -1996 was an average of 10.1% of GDP, while only an average annually of 0.4% of GDP came from the public sector. Another interesting point is that after 1992 foreign direct investment became less proportional, while the proportion of portfolio investments and other investment were greater. The proportion of foreign direct investment dropped from 2.3% of GDP during 1987-1992 to 0.8% of GDP during 1993-1996, while the portfolio investment increased from 0.7% of GDP to 2.1% of GDP at the same period. In addition, the borrowing from financial institutions significantly increased from 0.8% of GDP during 1987-1992 to 7.3% of GDP during 1993-1996.

Table 2. 5 The net capital inflow (as a percentage of GDP, period average)

	1980-1986	1987-1992	1993-1996
Total Capital Inflow	***5***	***7.8***	***10.1***
Total Private Capital Inflow	2.6	8.1	9.3
Direct investment	*0.7*	*2.3*	*0.8*
Portfolio investment	*0.1*	*0.7*	*2.1*
Financial institution	*0.1*	*0.8*	*7.3*
Other investment	*1.7*	*4.5*	*-0.5*
Official Capital Inflow	2.4	-0.3	0.4

Source: The Bank of Thailand

It is generally accepted that huge capital inflow was reflected in the external debt performance of Thailand. As a result of the huge capital inflow, the external debt of Thailand increased sharply from 40.6% of GDP in 1993 to around 60% of GDP in 1996. The financial crisis started when foreign investors saw some terrible problems in the Thai economy. Some of them withdrew money from Thailand and some foreign creditors recalled their debts. In the meantime, foreign speculators started attacked the Thai baht by buying baht in the spot market and selling in the forward market.

Under the fixed exchange rate system, where the baht was steadfastly pegged with the US dollar and other major currencies such as the Japanese yen, the Bank of Thailand had to buttress the baht by selling the baht in the foreign exchange market in order to defend the baht against speculator attacks. However, it seems to be that this defense did not work well. The speculators continued attacking the Thai baht, while the capital outflow problems and others weaknesses of economic fundamentals still emerged in Thailand. Finally, the Bank of Thailand could not continue defending the speculators due to inadequate foreign reserves in the Bank of Thailand. Therefore, the Bank of Thailand decided to change the exchange rate system from a fixed exchange rate regime to a flexible exchange rate regime in July 1997. This caused the Thai currency to suddenly depreciate by 17% and it continued to depreciate. The Thai baht depreciated from 25 baht per US dollar in 1996 to over 55 baht per US dollar by January 1997. As a result, the external debt became much more valuable in terms of the Thai baht, and the external debt increased sharply from 60% of GDP in 1996 to over 90% of GDP by the end of 1997. Some domestic investors, especially financial companies, could not respond to the debt. This led to the non-performing loan (NPLs) problem and it developed into the financial crisis in 1997.

The current account deficit

The issue of the growth of the current account deficit had been discussed among Thai economists for several years before the financial crisis. However, the dramatic growth of exports during 1990-1996 helped stabilize the current account deficit. As can be seen in Table 2.6, the export growth rate grew from 15.6% per year in 1990 to 24.6% in 1995, and the current account deficit narrowed from -8.3% of GDP in 1990 to -5.4% of GDP in 1994. However, the problem of the current account deficit appeared in the Thailand economy in 1995 when the import growth dramatically increased from 18.4% of GDP in 1994 to 31.8% of GDP in 1995, while the export growth grew around 24.6% during the same period. This caused the current account deficit to rise from -5.4% of GDP to 7.9% of GDP in 1996.

Table 2. 6 The current account deficit

Year	Export Growth (%)	Import Growth (%)	Trade balance/GDP (%)	Current Account/GDP (%)
1987	32.8	41.49	-0.03	-0.59
1988	37.07	48.87	-0.06	-2.34
1989	25.16	27.27	-0.07	-3.32
1990	15.08	29.76	-0.11	-8.32
1991	23.58	15.6	-0.1	-7.53
1992	13.78	6.08	-0.07	-5.47
1993	13.66	12.47	-0.07	-4.87
1994	22.13	18.4	-0.06	-5.4
1995	24.61	31.84	-0.09	-7.86
1996	-1.8	0.57	-0.09	-7.9
1997	3.66	-13.42	-0.03	-2
1998	-6.75	-33.77	0.11	12.7
1998	7.43	16.9	0.08	10.2

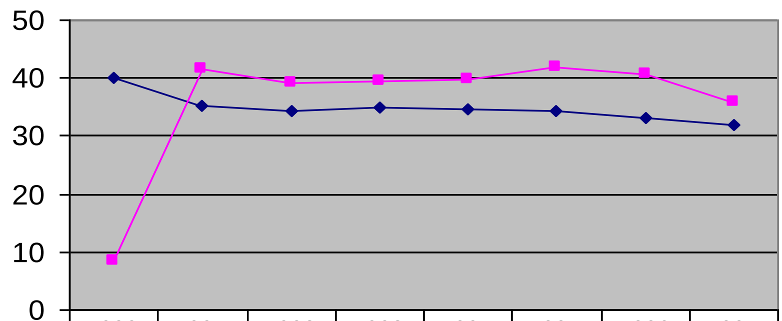
Source: The Bank of Thailand (online)

The current account deficit reflects the overspending in Thailand's economy. It can be said that the huge current account deficit in Thailand was mainly due to the domestic consumption and domestic investment exceeding local production.

In addition, the current account deficit in the boom period was also shadowed by the domestic investment and saving gap in Thailand. As can be seen in Figure 2.4, domestic private investment had exceeded domestic private savings since 1990. The savings to GDP ratio dropped from 40.2% of GDP in 1990 to 35.2% of GDP in 1991, and then the ratio steadily declined to 31.8% of GDP in 1997. On the other hand, the investment ratio dramatically increased from 8.4% of GDP in 1990 to 41.6% of GDP in 1991. After that, this ratio stayed at around 39-41% of GDP during 1991-1996. This evidence can imply that the growth in Thailand was heavy dependent on foreign funds due to domestic funds not being enough for the domestic investment demand.

Overall, the problem of the current account deficit was not caused only by external stability problems, but also showed the deficiencies of the domestic financial market. Thailand entered into an economic recession period.

Figure 2. 6 The investment/GDP ratio and the savings/GDP ratio



	1990	1991	1992	1993	1994	1995	1996	1997
Saving to GDP ratio	40.2	35.2	34.3	34.9	34.6	34.3	33.1	31.8
Investment to GDP ratio	8.4	41.6	39.2	39.4	39.9	41.8	40.8	35.8

The attack on the Thai baht by international speculators

Another major cause of the financial crisis was the attack on the Thai currency (baht) by foreign speculators. The speculators started attacking the Thai baht in May 1997 when they saw some signs of economic problems in Thailand, such as a sharp fall in exports and huge capital outflows into Thailand, while the Thai government continued to defend the Thai baht. The common strategy of attacking the Thai currency was by buying the Thai baht in the spot foreign exchange market while selling in the forward market. Under the fixed exchange rate system, where the Baht was steadfastly pegged with the US dollar and other major currencies such as the Japanese yen, the Bank of Thailand had to buttress the baht by selling the baht in the foreign exchange market. Consequently, the Bank of Thailand spent 90% of its foreign reserve in order to defend the baht against speculator attacks. This defense worked until June 1997, but the speculators continued attacking the Thai baht; also, the capital outflow problems and others weaknesses of economic fundamentals still emerged in Thailand. Finally, the Bank of Thailand could not continue defending against the speculators due to inadequate foreign reserves in the Bank of Thailand. Therefore, the Bank of Thailand decided to change the exchange rate system from a fixed exchange rate regime to a flexible exchange rate regime in July 1997. This caused the Thai currency to a suddenly depreciate by 17%. As a result, the external debt became much more valuable in terms of the baht. Some domestic investors, especially financial companies could not respond to the debt. This led to non-performing loan (NPLs) problems and developed into the financial crisis of 1997.

Financial instabilities

After the liberalization, Thai commercial banks and financial companies borrowed dollars from abroad and lent in Thai baht. Actually, the borrowing in US dollars and lending in baht were running an exchange rate risk, but Thai banks and financial companies ignored that risk because of the experience of the fixed exchange rate as well as the confidence of policy makers. In addition, these loans were used for long term domestic lending. Then, after the exchange rate system was changed from a fixed to a flexible exchange rate regime, the currency went from 25 US dollars in July 1997 to over 50 US dollars in January 1999. Companies that had borrowed dollars suddenly had much more debt in terms of the Thai baht. The foreign creditors started recalling their debts and withdrew money from Thailand. At the same time, many financial companies suffered from overexposure to the real estate sector where the prices were falling. Borrowers who had borrowed from domestic financial companies could not generate enough income to cope with their debt, as well as those who had borrowed from abroad could not generate enough local currency income to service the dollar debt. Then, the total size of non-performing loans became larger.

Inconsistent monetary policy

There is much literature that blames the inconsistent monetary policy in Thailand for the financial crisis in 1997. For example, Anwar and Gupta (2006) stated that Thailand's financial crisis was driven by policy errors, particularly the process of capital account convertibility (CAC) in 1990 and the creation of the Bangkok International Banking Facility (BIBF) in 1993 while the financial system in Thailand was unstable. Similarly, the study of Jansen (2001) stated that the inconsistent monetary policy was seen in the liberalization of the financial market and increasing capital mobility while maintaining the fixed exchange rate. With the liberalization and large capital inflow, the domestic interest rate should have fallen. Instead, due to the tight monetary policy there remained high interest rates and the gap between domestic rates and foreign rates was large. The gap between domestic interest rates (inter-bank rate) and the international interest rate (LIBOR) was 1.5% on the average during 1985-1990, and increased to about 3.6% on the average during 1990-1995. The large interest rate gap led to exchange rate expectations. Hence, the exchange rate market started speculating against the baht in the second half of 1996. During this period, the Bank of Thailand had to defend the exchange rate by using foreign reserves. Finally, the Bank of Thailand had not enough foreign reserve to defend the baht, and so changed the exchange rate regime. Moreover, the high gap brought about large foreign borrowings by bank and other private companies which led to the external debt problem during the crisis (Alba, Hernandez, and Klingediel 1999).

The Monetary Policy after the Financial Crisis

After the financial crisis in 1997, Thailand demanded an immediate policy decision to solve the major problems such as the financial instability, the fluctuation of the exchange rate, and the external debt problem. Then, the policy priority turned toward the restoration of external and internal stability, including the reform of the weaknesses of the domestic financial system, restoring external and internal stability, and recovering the investors' confidence.

Financial restructuring

To restore the confidence of the investors in the financial market, the Bank of Thailand managed to turn the financial crisis into an opportunity to reform the financial system. Therefore, financial restructuring was adopted as a major and urgent policy to solve the crisis. The financial restructuring in Thailand has involved the injection of liquidity into the financial market by the Bank of Thailand, the closure of insolvent commercial banks and financial companies, and transferring the bad loans and bad assets from financial companies to the central management agency.

To save the overall financial system, the commercial banks and financial institutions were forced to take the initiative to clear their own assets and borrowings from their balance sheet. After the Bank of Thailand publicly announced that 58 financial companies were suspended during June and August in 1997, the Financial Institutions Development Fund (FIDF) was entrusted to provide a guarantee of deposits and liabilities for the remaining financial institutions. Furthermore, the Financial Restructuring Authority (FRA) was created in October 1997 to review the rehabilitation plans of the 58 suspended financial institutions and to supervise their liquidity process. After that, on 8 December 1997, the FRA announced that 56 financial companies were permanently closed and the assets of these companied were transfer to the FRA. In addition, the Asset Management Corporation (AMC) was established. The AMC was entrusted with the responsibility of bidding for the lowest quality assets as a buyer of last resort to prevent a fire sale of the 56 closed financial companies' assets.

The weakness of the financial system in Thailand still appeared after the first process of financial restructuring. Thus, the Thai government continued to the second process by announced the comprehensive financial restructuring package on 14 August in 1998. This plan contained four major aspects.

Firstly, to accelerate consolidation of the commercial banks and financial companies, the Bank of Thailand committed 7.5 billion US dollars for viable financial companies to recapitalize those companies.

The second aspect was the encouragement of private investment in the banking system. This measure started by recapitalizing commercial banks and financial companies and thereby restoring and maintaining their solvency.

The third aspect was the development of a framework to create the private Asset Management Companies (AMCs) which gave greater flexibility to manage the non-performing loans of the financial institutions. In these aspects, financial institutions were allowed to set the individual AMC. The aim of the policy was to encourage the creation of private AMCs, through which the banks could separate the good assets and bad assets and improve the balance sheets. The benefit of establishing the AMCs was that the commercial banks could concentrate on the management of good assets and new landing.

The last aspect was providing the public funds to recapitalize viable financial institutions. For commercial banks and financial companies which were unable to recapitalize, the Bank of Thailand intervened by taking over, merging companies, and closing down some commercial banks and financial companies.

The IMF package

The internal and external stability needed to be restored immediately after the financial crisis started in July 1997. Thus, just a few weeks after floating the exchange rate, the Thai government decided to receive assistance from the International Monetary Fund (IMF) for a stand-by credit. On 20 August 1997, a package of 17.2 billion US dollars including multilateral assistance from other donors was granted. However, Thailand also had to adopt the IMF program for recovering from economic problems. The main requirements from the IMF were identifying and effectively closing the 58 financial institutions, targeting the fiscal policy (fiscal policy surpluses 1% of GDP), maintaining the managed float exchange rate system with intervention limited to small fluctuations, and targeting the broad money growth rate of 7% at the end of 1997. In addition, this program also targeted other economic indicators such as the target of GDP growth rate for 2.5 % in 1997, and 3.5% in 1998, and the inflation rate should be 4 to 5 %.

Thailand's economic performance after the financial crisis

After adopting monetary targeting in the monetary policy in 1997, the economic performance in Thailand recovered very fast. As can be seen in Table 2.7, the GDP growth rate recovered from a fall of 10% in 1998 to grow approximately 4.4% in 1999 and it continue to grow around 4.8% in 2000. In addition, the inflation rate dramatically decreased from 7.2% in 1998 to 1.8% in 1999. The export growth rate also grew vary fast from -33.8% in 1998 to 16.9% in 1999. However, the good economic growth did not imply the financial sector was completely recovered. As can be seen in Table 2.7 the growth of net capital flow continued to decline and private investment growth also decreased continually due to investors still having no confidence in Thailand's financial system.

Later on, after Thailand had finished the IMF program and formally adopted the inflation targeting as a new monetary framework in May 2000, Thailand's economy achieved economic consistency with price stability and sustainable economic growth. The inflation rate in Thailand was stable at 0.7% in 2000 and slightly increased to 1.3% in 2001. The annual GDP growth rate during 2000-2005 averaged 5%; private investment growth rate became positive from 2000.

Table 2. 7 Thailand's economic performances after the financial crisis

	Monetary Targeting			Inflation Targeting					
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
GDP growth rate (%)	-1.4	-10.5	4.4	4.8	2.2	5.3	7.0	6.2	4.5
Inflation rate (%)	4.7	7.2	1.8	0.7	1.3	0.4	0.2	0.4	1.6
Growth of private investment (%)	30.5	-7.9	-5.7	-8.5	-7.5	8.5	3.1	5.9	2.4
Growth of private Saving (%)	16.0	8.8	-0.5	5.3	4.0	2.5	4.4	2.6	8.4
Import growth rate (%)	-6.8	7.4	19.5	-7.1	4.8	18.2	21.6	15.0	16.4
Export growth rate (%)	-13.4	-33.8	16.9	31.3	-3.0	4.6	17.4	25.7	26.0
Current account balance (% of GDP)	-2.0	12.7	10.2	7.6	5.4	5.5	5.6	4.2	-2.1
Growth of net private capital flow	-7.6	-15.5	-13.5	-9.8	-3.9	-5.7	-8.8	-0.7	6.9

The effectiveness of the Thai monetary policy

Theoretically, the efficiency of monetary policy can be explained by the IS-LM model. The affect of monetary policy in the real economy is dependent on the elasticity of the IS and LM curves. For example, expansionary monetary policy can have a small affect on output if the IS curve steeply, while it can have much affect if the IS slope is flat, and it has no affect in the case of the IS curve being vertical. On the other hand, if the LM curve is flat, monetary policy has less affect on output than when the LM curve is steep. In addition, the efficiency of monetary policy is also related to the exchange rate system in each country. Under the fixed exchange rate system and open capital account, the effectiveness of monetary policy was limited because the central bank had to sterilize the exchange rate. Moreover, there is a conflict between domestic goals and the external balance. For instance, expansionary monetary policy led to an increase in the quantity of money and a falling interest rate and an increase in domestic investment. However, low interest rates can make a capital account deficit due to capital outflow. This means monetary policy was ineffective in the fixed exchange rate regime. In contrast, monetary policy appears more effective under the flexible exchange rate system. The current account deficit from expansionary monetary policy would affect exchange rates, the domestic currency would depreciate and it would cause higher exports and lower imports. This implies that a trade balance can restore the current account deficit.

In Thailand's case, the monetary policy during the boom period seemed to be ineffective because of policy inconsistency. The major inconsistency in monetary policy conduct was that Thailand had an open capital account while maintaining a fixed exchange rate, which traditional theory explains is clearly ineffective. This policy led to huge capital inflow into Thailand. However, with the liberalization and large capital inflow, the domestic interest rate should have fallen but the Bank of Thailand attempted to use tight monetary policy by keeping the interest rates high. This led to a large gap between domestic and international interest rates and the exchange rate expectations. The exchange rate market started speculating against the baht in the second half of 1996. At the same time, the interest rate gap also brought about large foreign borrowing by domestic banks and other private companies. During this period, the Bank of Thailand had to defend the exchange rate by using foreign reserves. Unfortunately, the Bank of Thailand did not have enough foreign reserve to defend the baht and so changed the exchange rate regime to a flexible exchange rate regime. This led to the external debt problem during the crisis (Alba, Hernandez, and Klingebiel 1999).

2.5.3 The Monetary Framework Development

After Thailand's exchange rate system was changed from basket currency to a managed floating currency on July 1997, Thailand demanded immediate policy decisions to solve the major problems such as the financial instability, the fluctuation of the exchange rate, and external debt. Therefore, Thailand received financial assistance from the International Monetary Fund. During the IMF program, the Bank of Thailand had to use the IMF program. The major objectives of the IMF program were sustainable growth and price stability.

The primary objective of the monetary policy was stabilization of local currency and inflation. The monetary policy framework was aimed to defend the local currency at the fixed rate. However, the changing of the exchange rate regime in July 1997 and financial liberalization affected the way in which monetary policy was conducted in Thailand (Sirivedhin 1998). It automatically moved from direct control of financial market to indirect control and a market-conforming instrument. The Bank of Thailand needed to consider the new monetary framework. To conduct monetary policy under the flexible exchange rate to reach the ultimate goal of sustainable economic growth, the Bank of Thailand had considered three alternative frameworks (Jantarangs and Sodsrichai 2000), namely a discretionary monetary policy with multiple targets, monetary targeting, and inflation targeting.

In the discretionary monetary policy with multiple targets, the central bank would consider many monetary goals like inflation, the exchange rate, the money supply aggregate, as well as sets of monetary instruments to achieve some optimal combination of them. However, this system works well for a country where the central bank has a very strong reputation, like the USA. The second framework is called monetary targeting. Under this framework, the domestic money supply is used as an intermediate target in order to reach the ultimate goals of sustainable growth and the stability of price. This approach will be ineffective if the relationship between the monetary aggregate and inflation is unstable. There was some argument about using this framework in Thailand. For example, Jansen (2001) addressed the fact that many countries have observed that financial liberalization and the integration of the international financial market has made less predictability in money demand and money aggregate. This led to difficulties in conducting the monetary policy. The last framework is the inflation targeting. Under this framework, the inflation rate will be set as the objective of monetary policy. The central bank has to announce publicly the inflation target that it wants to achieve. In addition, the central bank also needs to make and publish the inflation forecast regularly.

Based on monetary targets, the monetary targeting will be efficient if the money supply, which is chosen as the intermediate target, has a stable long-run relationship with the ultimate target (GDP or inflation rate). For instance, the change in money supply must be closely related to the GDP growth rate and the relationship should move in the same direction. In addition, the central bank must be able to control the intermediate target. In Thailand's context, the previous report seems to provide empirical evidence, which supports the adoption of monetary targeting in Thailand. For instance, the reports of Hataiseree (1994) and Hataiseree and Phipps (1996) show that the changes in narrow money (M1) and broad money (M2) were found to cause a change in GDP in the same direction. Therefore, after adopted the floating exchange rate system on July 1997, a monetary targeting was adopted as a new framework in Thailand in order to control money supply and affect economic growth. Under that framework, the domestic narrow money supply (M2a) was used as an intermediate target as the Bank of Thailand found that M2a seemed to be more stable, predicable, and controllable compared with M3. In addition, the ultimate goals of this framework were low inflation and sustainable growth.

However, the monetary targeting did not work very well in Thailand due to the Bank of Thailand having difficulty in controlling the money supply as a result of the open capital mobility, particularly the period of huge capital flow; as well, there was an instability in the relationship between the money aggregate and macroeconomic variables. In addition, the Bank of Thailand found that the monetary targeting was inefficient due to fact that the relationship between the money aggregate and economic growth could not be predicted. Thus, the Bank of Thailand announced the adoption of inflation targeting as a new monetary policy framework in Thailand in May 2000 and they continue using this framework until present.

Under inflation targeting, the Bank of Thailand has appointed the Monetary Policy Committee (MPC) in 2001 to set the monetary policy in order to attain price stability conducive to sustainable economic growth. In addition, the MPC also monitors the factors contributing to external stability and financial imbalance. The main instrument of monetary policy is the short-term interest rate under central bank control. Since the Bank of Thai first adopted the inflation targeting in 2002, the 14-day repurchase is used as a key instrument of monetary policy. However, the Bank of Thailand has changed the key instrument to 1-day repurchase interest rate in 2007, as it is more flexible.

Moreover, the PMC adopted core inflation (exclude raw food and energy) as its policy target with the range of 0-3.5% in a quarterly average. However, if the target is missed the MPC will be required to explain the reason to the public. In the case of Thailand

2.6 Conclusion

This chapter started by reviewing the development of monetary theories and the framework of the monetary transmission mechanism. In general, the monetary theory was first created by classical economists who believed in a self-adjusting economy and non-invention from government. In the classical view, money demand is for just transaction approach, and then any action from monetary authorities will affect only the price level but will not affect real economic activities. However, Keynesian economists argued that money demand is not only for transaction, but people also want to hold money for unexpected spending and precautionary reasons, and demand is dependent on income and interest rates. As changes in interest rates affect money holdings, then monetary policy affects economic activities via interest rates. The second part of the chapter has presented the surveys of the empirical studies on money demand analysis and the monetary transmission mechanism. Although there is much literature on the money demand and the monetary policy in different countries, there were only a few studies in the case of Thailand. Most of the studies in Thailand emphasize the relationship of money demand and its determinants, and the relationship between monetary instruments and economics activities. This thesis will draw on that literature to consider the stability of money demand and the transmission mechanism in Thailand.

CHAPTER 3

UNIT ROOT TESTS AND THE PRELIMINARY DATA ANALYSIS

3.1 Introduction

As one of the most important conditions for economic time series analysis is to use stationary data, therefore we need to make sure that all variables included in the model appeared to be stationary. This chapter provides the overview of stationary time series analysis and the result of unit root tests. The chapter is divided into five parts. The first part briefly reviews the concept of nonstationary time series and unit root tests. The second part of this chapter provides the empirical results of unit root tests, focusing on the Augmented Dickey and Fuller, and the KPSS unit root tests. The third section presents unit root tests under the assumption of structural change. Two procedures are used in this section: Perron's (1997), and Zivot and Andrew's (1992) procedure. Section four presents the empirical results of structural break test and the conclusion of the chapter is presented in the last section.

3.2 Stationary Time Series and Unit Root Tests

3.2.1 Stationary and Nonstationary Time Series

To use stationary data is the major condition for analysing time series because if nonstationary variables are used in the time series analysis, the result of testing may be biased and it may lead to *spurious regression*[1] and the statistic cannot be used properly. Spurious regression is first suggested by Yule (1926). He claimed that if the trending nonstationary is used in the regression equation, the estimated coefficients in regression are statistically significant when there is no true relationship between the explained and explanatory variables. This was supported by the study of Granger and Newbolt (1974). They concluded that the regression equations which contained nonstationary time series frequently encountered high R^2 and very low Durbin-Watson statistics. They also

[1] *Spurious regressio*n is the regression with no economics meaning, although R^2 is high and t-statistic appears to be significant.

suggested that when estimating regression with series data, if the value of R^2 is greater than Durbin-Watson statistics, then one should suspect a spurious regression. To detect the stationary data, we need to understand the nature of stationary and nonstationary time series.

3.2.2 Testing for Stationary and Unit Root Test.

In general, there are two common ways to detect nonstationary variables of time series data. The first way is an informal observance of a time series plot of variables to see there is any obvious trend in the series or not. Another method is the unit root testing, which is a more formal method of detecting nonstationary data.

The pioneer formal standard test for detecting unit roots was developed by Dickey and Fuller (1979). The basic objective of the Dickey and Fuller approach is to test the null hypothesis that ρ = 1 for the first order auto regression, AR(1) as in Equation 3.1:

$$Y_t = \rho Y_{t-1} + \varepsilon_t \qquad (3.1)$$

where Y_t is the time series variable at time t,

Y_{t-1} is the lag of the time series variable,

ρ is the coefficient of lag of the time series,

t is time, t = 1, 2…, and

ε_t is the disturbance term which is independent and identically distributed (iid) with zero mean and variance.

If |ρ| = 1, the equation can be written as $\Delta y_{t-1} = e_t$ and Y_t series is said to be co-integrate order 1, or time series Y_t contains a unit root and the series is nonstationary

|ρ| < 1, time series Y_t will converge (as $t \to \alpha$) to a stationary series.

|ρ| > 1, time series Y_t is nonstationary and variance of the series grows exponentially.

Indeed, instead of testing for ρ =1, there is an alternative version of the same equation. Equation 3.1 can be re-written by subtracting Y_{t-1} on both sides to obtain a different version on the test:

$$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + \varepsilon_t$$

$$\Delta Y_t = (\rho - 1)Y_{t-1} + \varepsilon_t \qquad (3.2)$$

Equation 3.2 can be re-written as:

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \; ; \qquad \delta = (\rho - 1) \qquad (3.3)$$

where δ is the coefficient of the lag in the first difference time series. If δ = 0, it implies that ρ = 1, meaning that the series Y_t contains unit roots and it can be conclude that the series Y_t is nonstationary.

The null hypothesis of the unit root test can be written as Ho: δ = 0 and the alternative hypothesis is H_1: δ < 0

Consider the hypothesis δ = 0. This hypothesis states that there is a unit root present in the variable. The alternative hypothesis is always expressed as H_1: δ < 0. It implies that the test considers only one side test (or left side) and the relevant critical values are all negative values. If a t-statistic is less negative than the critical value, the null hypothesis of the unit root test cannot be rejected. On the other hand, the hypothesis is rejected when the t-statistic is greater negative value than critical value.

To avoid the undesirable effect of misspecification, Dickey and Fuller (1981) developed their model to take into account two different classes of nonstationary process. The first model contains a drift in the random walk process, as present in Equation 3.4:

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \varepsilon_t \qquad (3.4)$$

where α is constant

Since most macroeconomic time series often exhibit strong time trends, Dickey and Fuller take account of the time trend in the model. Hence, another equation is that:

$$\Delta Y_t = \alpha + \beta_t T + \delta Y_{t-1} + \varepsilon_t \qquad (3.5)$$

where T is time trend

β_t is the coefficient of time trend.

Therefore, three different equations can be used for detecting the unit root. Those three equations can be written as:

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \qquad (3.6a)$$

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \varepsilon_t \qquad (3.6b)$$

$$\Delta Y_t = \alpha + \beta_t T + \delta Y_{t-1} + \varepsilon_t \qquad (3.6c)$$

The difference between the three equations concerns the presence of deterministic element α and β. Equation 3.6a presents a random walk model, the second equation, 3.6b, adds interception term (drift), called a random walk with drift model. The last equation, 3.6c, represents random walk with drift and linear time trend.

The common interest in those three equations is the coefficient δ. In case $\delta = 0$, the null hypothesis of a unit root is not rejected, then the series Y_t contains a unit root and it can be said that series Y_t is nonstationary. On the other hand, the null hypothesis of a unit root is rejected and series Y_t is stationary if $\delta > 0$.

In practice, the DF test is represented by the t- statistic for the lagged dependent variable. If the DF statistic has more negative than critical value, then the null hypothesis of a unit root is rejected and it can be concluded that the series is a stationary process.

3.2.3 The Augmented Dickey and Fuller for unit root testing (ADF)

An original Dickey-Fuller test (DF test) is valid if only the error term (ε_t) appeared to be white noise. In other words, the assumption of the DF test is that the error term is uncorrelated. Indeed, the error term ε_t will be auto-correlated if there are autocorrelations in the dependent variable of the regression model. Therefore, Dickey and Fuller (1981) introduced an alternative approach to test a unit root in the case where the error term is unlikely to be white noise. This model is well known as the Augmented Dickey-Fuller test (ADF test).

The Augmented Dickey-Fuller (ADF test) test is actually the extension of the DF test by including the extra ρ lag value on the dependent variable ΔY_t in order to eliminate autocorrelation.

Consider the simple autoregressive process AR (ρ):

$$Y_t = \alpha + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_\rho Y_{t-\rho} + \varepsilon_t$$

Subtract Y_{t-1} from both sides of the equation to obtain:

$$Y_t - Y_{t-1} = \alpha + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_\rho Y_{t-\rho} - Y_{t-1} + \varepsilon_t$$

It can be re-written as:

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t$$

where $\delta = \phi_i - 1$

Similar to the original DF test, there are three possible alternative models of the ADF models:

$$\Delta y_t = \delta Y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \qquad (3.7a)$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \qquad (3.7b)$$

$$\Delta y_t = \alpha + \beta t + \delta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \qquad (3.7c)$$

The hypothesis of ADF testing is the same as the original DF test. Therefore, the null hypothesis of the unit root test is that H_0: $\delta = 0$ and the alternative hypothesis is H_1: $\delta < 0$

Practically, the ADF procedure will be tested by comparing the absolute value of the ADF statistic (t-statistic of δ) with the MacKinnon critical value[2]. If the absolute value of the ADF statistic is greater than the absolute value of the critical value, then the null hypothesis of a unit root is rejected and the series is stationary. On the other hand, if the ADF test is smaller than the critical value, then the series is nonstationary. However, in case the time series is nonstationary at level, then it would be first differenced, second differenced, and so on. The differencing method will continue until the null hypothesis can be rejected.

3.2.4 The Procedure of the ADF Test

As there are three possible forms of the Augmented Dickey- Fuller test (ADF), those forms are based on the ordinary least square regression equations, 3.7a, and 3.7b and 3.7c. Unless the researcher knows the actual generating process, it is possible to have a question about which equation is the most appropriate model to test the null hypothesis of the unit root. As there is no standard criteria for model selection, Dolado, Jenkinson, and Sosvilla-Rivero (1990) suggest the strategy to select the model is by starting from estimating the most general model, which contains drift and linear time trend. Then, use the ADF statistic to test the null hypothesis of $\delta = 0$. If the null hypothesis can be rejected, there is no need to continue to the next step and you can conclude that the series is stationary. In case the null hypothesis is not rejected, the next step is to test whether or not there were too many determinants included in the first step

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[2] The critical values which were provided by MacKinnon (1991) which carucate from the equation are:

$$CV = \phi_\infty + \phi_1^{N-1} + \phi_2^{N-2}$$

where CV is the critical value, N is the sample size and the parameters ϕ_∞ , ϕ_1 ,ϕ_2 are provided by MacKinnon for the differing models (constant with no trend, constant and trend).

because it may reduce the power of the test. Then, testing for significance of trend term by testing $\beta=\delta = 0$. If the trend term is significant, then retest for the presence of a unit root by using the standardized normal distribution. Step three is to estimate the model without time trend. If the null hypothesis is rejected, conclude that the model does not contain a unit root. If it not rejected, test for significance of the constant by testing $\alpha=\delta = 0$. If it is significant, the model appears appropriate.

The procedure of testing in this thesis is following the suggestion of Dolado, Jenkinson, and Sosvilla-Rivero (1990) by starting with estimating the regression model including intercept and trend. If the null hypothesis cannot be rejected at this stage, then process another equation that includes the intercept but no trend.

After testing the model above, the next step is selecting an appropriate lag length. According to the study of Campbell and Perron (1991), the ADF test is very sensitive to the lag length number in an estimated equation. If the number of lags is too small, it might cause the over-rejection of a null hypothesis of a unit root at any significant level. On the other hand, too many lag length numbers may reduce the power of the test due to more parameters being estimated and less numbers of effective observations. This can lead to falsely rejecting a null hypothesis of a unit root.

Since there is no standard method to select the appropriate lag length, Ng and Perron (1995) suggested that to select the appropriate lag length may start by setting the upper bound ρmax for ρ, and then estimate the ADF test regression with $\rho=\rho max$. If the absolute values of the t-statistic of the last lag included is significant, then $\rho=\rho max$. If not, reduce the lag length by one and repeat the process until the coefficient on the last included lag is significant.

Therefore, this thesis follows Ng and Perron (1995) procedure by starting from $\rho max = 5$. The lag length selection of this paper was chosen by the Akaike Information Criteria (AIC) where:

$$AIC = T \log |\Sigma| + 2k \qquad (3.8)$$

where T is the number of usable observations:

k is the total number of parameters estimated in all equations of the system, and Σ is the matrix of cross product of residuals.

The selection of lag length is given by the smallest AIC criteria.

However, since the assumption of the ADF test is that the series are non auto-correlative residual, it would seem more essential to include a residual autocorrelation in the test. Therefore, instead of using only the AIC criteria to select the lag length of ADF, this research includes the Ljung-Box Q-statistic to check any autocorrelation in the ADF regression model up to the fifth lag length order. The null hypothesis is that the Ljung-Box Q-statistic is that and there is no serial autocorrelation up to the lag order ρ.

The Ljung-Box Q-statistic are given by Equation 3.9:

$$Q_{LB} = T(T+2)\sum_{j=1}^{k}\frac{r_j^2}{T-j} \qquad (3.9)$$

where r_j is the jth autocorrelation and

T is the number of observations.

The null hypothesis of no autocorrelation is that the first k autocorrelation is zero ($\rho 1=\rho 2=\ldots=\rho_k = 0$). The Q-statistic is distributed as chi-squared with a degree of freedom equal to the number of autocorrelations or k. If the result of Q-statistic shows that the null hypothesis of no autocorrelation is not rejected, it indicates that there is no evidence of autocorrelation in the series up to k lags.

Overall, the optimum lag length selection in this thesis was chosen by the smallest AIC criteria, and the Ljung-Box Q-statistic is not significant (no autocorrelation).

3.2.5 The Phillips-Perron Unit Root Test (PP test)

An important assumption of the standard DF test is that the error terms are independent and identically distributed and the ADF test had already adjust the DF test by adding the lagged different terms of regression. However, when using the ADF test method, we need to make sure that the error terms are uncorrelated and they really are constant variance; if not, the test may be biased.

An alternative approach to reduce the problem was tested by Phillips and Perron (1988). This method differs from the ADF method in which they use a non-parametric statistic method to take care of serial correlation in the error terms without adding the lagged difference. They also make a non-parametric correction to the standard deviation, which provides a consistent estimator of the variance by using the equation:

$$s_{Tl}^{2} = T^{-1}\sum_{t=1}^{T}(\varepsilon_t^2) + 2T^{-1}\sum_{t=1}^{l}\ \sum_{t=j+1}^{T}\varepsilon_t\varepsilon_{t-j} \qquad (3.10)$$

$$S_{\varepsilon}^{2} = T^{-1}\sum_{t=1}^{T}(\varepsilon_t^2) \qquad (3.11)$$

where l is the lag truncation parameter which is used to ensure that the autocorrelation of the residuals is fully captured.

The regression of the PP test is the AR (1) process, which can be written as Equation 3.12:

$$\Delta y_{t.-1} = \alpha + (\Phi - 1)y_{t-1} + e_t \qquad (3.12)$$

where $e_t \sim iid(0,\sigma^2)$.

While the ADF test corrects higher order serial correlation by adding lagged different terms on the right-hand side, the PP test makes a correlation to the t-statistic of coefficient δ in the ADF test from AR(1) regression to account for serial correction. Therefore, the PP method is just a modification of the ADF t-statistic that takes into account the less restrictive of nature process. However, both the ADF and PP tests will be tested by comparing the t-statistic of δ with MacKinnon's (1991) critical value. The hypothesis of the unit root will be rejected if the t-statistic is greater than the critical value.

3.2.6 The KPSS test

One of the most popular alternative models to test a unit root is the KPSS test, proposed by Kwiatkowski et al. (1990). While the ADF test was created for the null hypothesis of the presence of a unit root in the series, the KPSS test aims to test for the null hypothesis of stationary around a deterministic trend (trend stationary).

The test of KPSS starts from the linear regression model:

$$y_t = \beta t + r_t + \varepsilon_t \quad (3.13)$$

where r_t is a random walk, i.e., $r_t = r_{t-1} + u_t$, and u_t is iid $N(0, \sigma_u^2)$
βt is a deterministic trend, and
ε_t is a stationary error.

To test the KPSS model, if y_t is a trend stationary process or the series is stationary around a deterministic trend, the null hypothesis of stationary will be $\sigma_u^2 = 0$, which means the intercept is a fixed element, the alternative of $\sigma_u^2 > 0$.

Another stationary is the level stationary. If the series is stationary around a fixed level, the null hypothesis will be $\beta = 0$.

Therefore, under the null hypothesis, in the case of a trend stationary, the residuals e_t (t = 1, 2, …,T) are from the regression of y on an intercept and time trend, $e_t = \varepsilon_t$, while in the case of a level stationary, the residuals e_t are from a regression of y on intercept only, that is $e_t = y_t - \bar{y}$.

The residual from the regression of y_t on the intercept is e_t = 1, 2, 3…,T. Then, the partial sum process of the residual (e_t) can be defined as:

$$S_t = \sum_{i=1}^{t} ei$$

The long run variance of e_t is defined as:

$$\sigma^2 = \lim_{T\to\infty} T^{-1} E(S_T^2)$$

The consistent estimator of σ^2 is constructed from the residual e_t by Newey and West (1987):

$$\hat{\sigma}^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s}$$

where *(s,l)* represents an optional lag window which corresponds to the choice of a spectral window.

The KPSS test adapted the Bartlett window, w*(s,l)=1-s(l+1)*, created by Newey and West (1987), which ensures the non-negatively of $S^2(l)$. The lag l is correct for residual serial correlation. The choice of l is appropriate if the residual series are independent and identically distributed.

Therefore, the KPSS test for null hypothesis is given as:

$$KPSS = T^{-2}\sum_{t=1}^{T} S_t^2 \big/ \hat{\sigma}^2(l) \qquad (3.14)$$

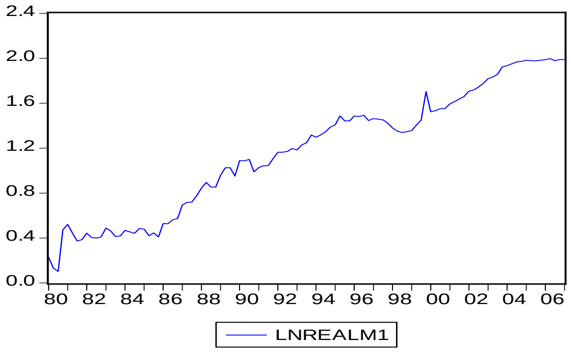
3.3 Preliminary Data Analysis and Empirical Results of the Unit Root Test

This section presents the empirical results of the preliminary data analysis of each variable that will be used in this thesis. The preliminary data analysis in this thesis was first detected by the plotting graph to see whether there was any obvious trend in the series or not. After that, the formal method of the unit root was applied. Two major formal approaches were used to test stationary data in this section, the ADF and KPSS approaches. The estimations of a unit root in this thesis were generated by the RATS program with the DFUNIT procedure written by Dickey-Fuller (1976) and were applied to estimate the ADF test. The procedure of KPSS by Kwiatkowski, Phillips, and Schmidt (1990) is adopted for the KPSS test.

3.3.1 The Stationary of the log of real narrow money aggregate (LnRealM1)

Figure 3.1 shows the plots and data description of narrow money holding in Thailand. As can be seen, the log of real money aggregate for M1 (LnRealM1) seems to be stable for the period between 1981 and 1986. After that, it appeared to be nonstationary with an upward trend over the sample period. As the Jarque-Bera is the statistic for the normal distribution, and the probability of Jarque-Bera is lower than 0.05, this indicates that the hypothesis of normal distribution is rejected at 5% but cannot be rejected at 1% significant.

Figure 3.1 Plot of the log of real narrow money aggregate (LnRealM1)



Mean	1.16
Median	1.24
Maximum	1.99
Minimum	0.10
Std. Dev.	0.54
Skewness	-0.15
Kurtosis	1.84
Jarque-Bera	6.51
Probability	0.03

The result of the ADF for the data set from 1993-2007 in Table 3.1 shows that the ADF statistics for both with and without trend do not rejected the hypothesis of a unit root since the ADF statistic is smaller than the critical value. Similarly, in the unit root test for the series from 1980-2007 (see Table 3.2), the hypothesis of a unit root is not rejected for both the series with and without trend. This implies that the variable LnRealM1 is nonstationary without differencing.

Consider the variable LnRealM1 with the first differencing of the ADF test. The null hypothesis of a unit root can be rejected at 1% significant for the lag length of zero to the lag length of two as the ADF statistic is greater than the critical value for the data set from 1993-2007. If one considers only the AIC criteria, among the zero to the second lag length, LnRealM1 (2) seems to be the most appropriate due to having the smallest AIC. However, the Ljung-Box Q-statistic result of LnRealM1 (2) indicates that there is autocorrelation in the series

LnRealM1 using two lags, as the hypothesis of no autocorrelation is rejected at 1% significant. Therefore, the lag length selection for the series LnRealM1 is the first lag, which is the second smallest AIC and there is no evidence of autocorrelation.

The first differencing of the ADF test for LnRealM1, using the data set from 1980-2007 in Table 3.2, indicates that the null hypothesis of a unit root can be rejected for every lag length included up to the lag of five. Given a smallest AIC criteria and the series free from serial autocorrelation, LnRealM1 (3) is selected for the series LnRealM1.

Table 3.1 The Results of the ADF test for LnRealM1 (1993Q1-2007Q1)

	ADF test				Ljung-Box Q-statistic
	ADF at level		ADF at		
Variables	No trend	With trend	first difference	AIC	
LnRealM1 (0)	-1.15	-2.95	-8.28*	-5.28	
LnRealM1 (1)	-1.25	-2.79	-9.65*	-5.55	0.92
LnRealM1 (2)	-1.06	-1.6	-6.52*	-5.58	16.27*
LnRrealM1 (3)	-0.58	-1.3	-3.08	-5.74	16.60*
LnRealM1 (4)	-0.57	-2.08	-2.07	-5.75	37.32*
LnRealM1 (5)	-0.85	-2.91	-2.33	-5.72	37.34*

Note: 1. Note that * and ** indicate the significance level at 1% and 5%.

2. The critical value is presented in Table 3.14.

Table 3.2 The Results of the ADF test for LnRealM1 (1980Q1-2007Q1)

	ADF test				Ljung-Box Q-statistic
	ADF at level		ADF at		
Variables	No trend	With trend	First difference	AIC	
LnRealM1 (0)	-0.89	-3.26	-11.67*	-5.58	
LnRealM1 (1)	-1.20	-3.10	-9.79*	-5.61	5.76
LnRealM1 (2)	-1.39	-2.63	-8.99*	-5.98	2.35
LnRealM1 (3)	-0.36	-1.87	-6.14*	-5.99	2.96
LnRealM1 (4)	-0.13	-2.29	-4.45*	-5.98	1.61
LnRealM1 (5)	-0.27	-2.61	-4.30*	-5.98	2.10

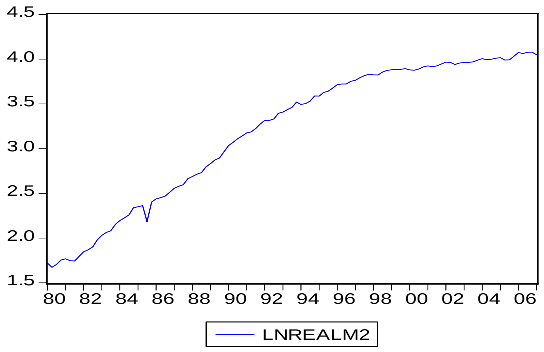
Note: 1. Note that * and ** indicate the significance level at 1% and 5%.

2. The critical value is presented in Table 3.15.

3.3.2 The Stationary of the log of real broad money aggregate (LnRealM2)

Figure 3.2 presents the log of real broad money demand (LnRealM2). The graph illustrates that the series LnRealM2 seems to be nonstationary with a positive slope over the sample period.

Figure 3.2 Plot of the log of real broad money aggregate (LnRealM2)



Mean	3.19
Median	3.46
Maximum	4.07
Minimum	1.67
Std. Dev.	0.78
Skewness	-0.57
Kurtosis	1.89
Jarque-Bera	11.62
Probability	0.002

The ADF statistics at level with intercept and trend up to five lags are insignificant for both short and longer data sets. This evidence clearly indicates that the series LnRealM2 with intercept and trend is nonstationary. However, the ADF statistic of LnRealM2 without time trend shows evidence of stationary as the test statistics are greater than the given critical value.

After first differencing, the results of both of the two data sets show that the null hypothesis of a unit root is rejected at 1% significance level for the lag of zero to the second lag length, while the lag length of the third to the fifth are not significant. For the data set from 1993-2007, the AIC statistic of LnRealM2 (2) is smallest (AIC is –5.58). In addition, the Ljung-Box Q-statistic result of LnRealM2 (2) shows that there is no evidence of autocorrelation (Ljung-Box Q-statistic is 0.24, not significant). Thus, the second lag length is selected for LnRealM2. In the case of the longer data sets, the first lag is selected, as the AIC appeared to be smallest and the Ljung-Box Q-Statistics is insignificant.

Table 3.3 The Results of the ADF test for LnRealM2 (1993Q1-2007Q1)

	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference		
Variables	No trend	With trend		AIC	
LnRealM2 (0)	-3.49**	-2.1	-7.33*	-5.28	
LnRealM2 (1)	-3.59*	-2.12	-5.43*	-5.55	0.011
LnRealM2 (2)	-3.99*	-2.23	-5.26*	-5.58	0.24
LnRealM2 (3)	-4.31*	-1.85	-2.00	-5.74	0.76
LnRealM2 (4)	-3.6*	-2.36	-1.78	-5.75	12.70**
LnRealM2 (5)	-4.15*	-3	-1.56	-5.72	12.77**

Note: 1. Note that * and ** indicate the significance level at 1% and 5%.

2. The critical value is presented in Table 3.14.

Table 3.4 The Results of ADF test for LnRealM2 (1980Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
LnRealM2 (0)	-2.83	0.18	-11.83*	-6.46	
LnRealM2(1)	**-3.79***	**0.41**	**-7.79***	**-6.62**	**0.07**
LnRealM2 (2)	-4.14*	0.64	-6.08*	-6.59	0.03
LnRealM2 (3)	-4.30*	0.92	-3.42	-6.69	12.78*
LnRealM2 (4)	-3.54	0.50	-2.50	-6.72	5.47
LnRealM2 (5)	-3.53	0.11	-2.32	-6.70	0.30

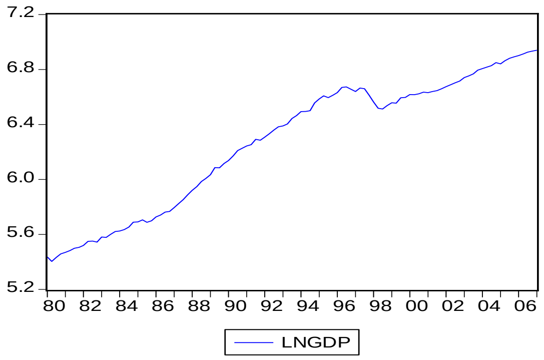
Note: 1. Note that * and ** indicate the significance level at 1% and 5%.

2. The critical value is presented in Table 3.15.

3.3.3 The Stationary of log GDP (LnGDP)

Figure 3.3 plots the series LnGDP over the sample period. It seems that the series is nonstationary with an evidence of trend break around the third quarter of 1997.

Figure 3.3 Plot of the log of LnGDP



Mean	6.27
Median	6.44
Maximum	6.94
Minimum	5.40
Std. Dev.	0.47
Skewness	-0.41
Kurtosis	1.71
Jarque-Bera	10.53
Probability	0.00

The ADF statistic for the shorter data set in Table 3.5 indicates that the series LnGDP with zero lag is nonstationary for both the test including and excluding trend, with the ADF statistic being -0.67 for the model with drift but no time trends, and the ADF statistic being -1.26 for the model including trend. Both statistics are smaller than the critical value. Moreover, the result of the ADF at level up to a lag of five strongly supports that the series LnGDP contains a unit root due to the null hypothesis of unit root not being rejected with any lag length order. The unit root for LnGDP at level for the longer data set in table 3.6 also suggests that LnGDP is not a stationary variable since the null hypothesis of a unit root is not rejected.

The first differencing of the ADF test for the series LnGDP in Table 3.5 shows that the null hypothesis of a unit root is rejected at 1% significance level for the lag of zero to the second and the fourth lag length. Given the smallest AIC criteria, the second lag length is most appropriate with the AIC equal to -8.15. However, the Ljung-Box Q-statistic indicates that the null hypothesis of no autocorrelation is rejected at 1% significance for every lag included up to the fifth lag. This means there is autocorrelation in the series LnGDP when lagged variables are included. Therefore, the lag length selected for LnGDP is the zero lag. The first differencing of the ADF for the LnGDP from 1980-2007 suggests that the hypothesis of a unit root is rejected at 1% significance. This confirms that the data LnGDP is I (1).

Table 3.5 The results of the ADF test for LnGDP (1993Q1-2007Q1)

	ADF test				
	ADF at level		ADF at		Ljung-Box
Variables	No trend	With trend	first difference	AIC	Q-Statistics
LnGDP (0)	**-0.67**	**-1.26**	**-4.84***	**-7.970**	
LnGDP (1)	-0.85	-1.83	-3.89*	-8.150	8.80*
LnGDP (2)	-0.58	-1.74	-3.58*	-8.200	13.453*
LnGDP (3)	-0.46	-1.63	-2.63***	-8.210	13.454*
LnGDP (4)	-0.37	-1.99	-3.62*	-8.172	14.99*
LnGDP (5)	-0.62	-2.54	-2.48	-8.174	17.21*

Note: 1. Note that *, **, and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.14.

Table 3.6 The results of the ADF test for LnGDP (1980Q1-2007Q1)

	ADF test				
	ADF at level		ADF at		Ljung-Box
Variables	No trend	With trend	first difference	AIC	Q-Statistics
LnGDP (0)	**-1.56**	**-2.18**	**-10.03**	**-0.41**	
LnGDP (1)	-1.55	-2.26	-7.87	-0.42	**1.55**
LnGDP (2)	-1.48	-2.28	-5.88	-0.44	10.70
LnGDP (3)	-1.51	-2.14	-5.78	-0.42	0.39
LnGDP (4)	-1.41	-1.83	-4.82	-0.39	0.006
LnGDP (5)	-1.45	-1.58	-4.86	-0.42	0.02

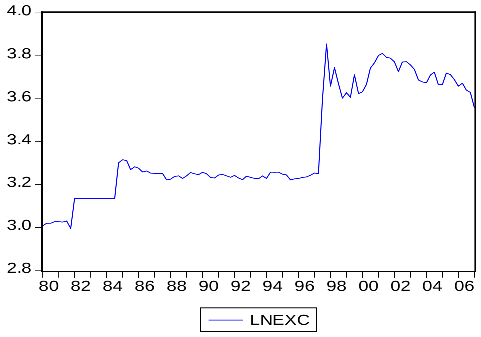
Note 1. Note that *, **, and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.15.

3.3.4 The Stationary of Log of Exchange Rate (LnEXC)

Figure 3.4 clearly presents that the log of exchange rate (LnEXC) looked stationary during the period 1985 to 1997 due to the fixed exchange rate system in Thailand. In addition, it looked like there was a structural change around 1997 quarter 3. This may be because of the change in the exchange rate system from a fixed exchange rate regime to a floating exchange rate in 1997.

Figure 3.4 Plot of the log of LnEXC



Mean	3.38
Median	3.25
Maximum	3.85
Minimum	2.99
Std. Dev.	0.25
Skewness	0.44
Kurtosis	1.68
Jarque-Bera	11.54
Probability	0.003

Although the plot above shows some stability in the series, the ADF statistics show that the series is nonstationary over the sample period because the null hypothesis of a unit root is not rejected at level, both with and without trend.

In the case of the data set from 1993Q1-2007Q1, the series LnEXC after first differencing is 1% significant for the zero to second lag length order, and 5% significant for the third and fourth lag. The null hypothesis of no autocorrelation is rejected at every lag length up to the fifth. This means there is an evidence of autocorrelation in the regression of the ADF test when lags are included. Therefore, the lag length selection for LnEXC is LnExc (0). However, the longer data set from 1980Q1-2007Q1 indicates that the ADF statistics after first differencing are 1% significant for most lags included except LnGDP(5). The Ljung-Box Q-statistic is significant for every lag included. Given a smallest AIC criteria, LnGDP (1) is selected.

Table 3.7 The Results of the ADF test for LnEXC (1993Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
LnEXC (0)	-1.45	-0.79	-5.13*	-5.69	
LnEXC (1)	-1.76	-1.47	-4.04*	-5.64	5.7**
LnEXC (2)	-1.79	-1.53	-4.91*	-5.7	6.38**
LnEXC (3)	-1.53	-0.69	-3.22**	-5.67	10.9**
LnEXC (4)	-1.68	-1.01	-3.23**	-5.62	11.02**
LnEXC (5)	-1.66	-0.75	-2.98*	-5.56	12.12**

Note: 1. Note that * and ** indicate the significance level at 1% and 5%.
2. The critical value is presented in Table 3.14

Table 3.8 The Results of the ADF test for LnEXC (1980Q1-2007Q1)

Variables	ADF test			AIC	Ljung-Box Q-Statistics
	ADF at level		ADF at first difference		
	No trend	With trend			
LnEXC (0)	-1.55	-2.18	-10.03*	-5.68	
LnEXC (1)	**-1.56**	**-2.26**	**-7.78***	**-5.66**	**1.24**
LnEXC (2)	-1.48	-2.01	-5.87*	-5.64	0.15
LnEXC (3)	-1.51	-2.14	-5.78*	-5.63	2.16
LnEXC (4)	-1.41	-1.83	-4.82*	-5.60	0.02
LnEXC (5))	-1.45	-1.72	-2.48	5.39	1.72

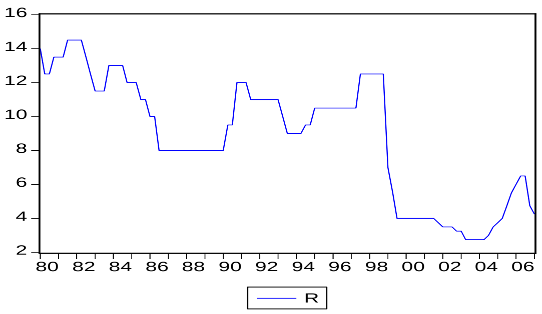
Note: 1. Note that * and ** indicate the significance level at 1% and 5%.

2. The critical value is presented in Table 3.15.

3.3.5 The Stationary of the Domestic interest rate (R)

The plot of the domestic interest (R) is presented in Figure 3.5. It seems that there is a break in the series.

Figure 3.5 Plot of the domestic interest rate



Mean	8.81
Median	9.50
Maximum	14.50
Minimum	2.75
Std. Dev.	3.57
Skewness	-0.31
Kurtosis	1.82
Jarque-Bera	8.11
Probability	0.017

It is not surprising that at level in the ADF test, the null hypothesis of a unit root is not rejected and the series is nonstationary for both short and longer data. The results of the first difference in Table 3.9 shows that the null hypotheses of a unit root are rejected at 1% significance for zero and the first lag length, 5% significance for the second and third lag length, and 10% significance for the fourth and fifth lag included. The null hypothesis of no serial correlation is rejected for every lag length. Given the smallest AIC criteria and no autocorrelation, the lag length selection for series R is zero. The results are confirmed by the first difference of the longer data set from 1980-2007 in Table 3.10. The ADF statistics at first difference are 1% significant. It can be said that the R is I(1).

Table 3.9 The results of the ADF test for R (1993Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
R (0)	-1.25	-1.36	-5.45*	-0.19	
R (1)	-1.34	-1.99	-3.76*	-0.16	4.95**
R (2)	-1.42	-2.55	-3.53**	-0.12	7.471**
R (3)	-1.38	-2.36	-3.22**	-0.06	7.474**
R (4)	-1.37	-2.34	-2.88***	-0.002	7.59**
R (5)	-1.39	-2.48	-3.52***	-0.05	7.77**

Note: 1. Note that *, ** and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.14.

Table 3.10 The results of the ADF test for R (1980Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
R (0)	-1.30	-1.36	-8.40*	-0.41	
R (1)	-1.33	-2.40	-5.23*	-0.43	3.91
R (2)	-1.62	-3.00	-5.11*	-0.44	1.84
R (3)	-1.71	-2.74	-4.91*	-0.42	0.73
R (4)	-1.55	-2.56	-4.56*	-0.39	0.19
R (5)	-1.45	-2.50	-4.91*	-0.42	3.64

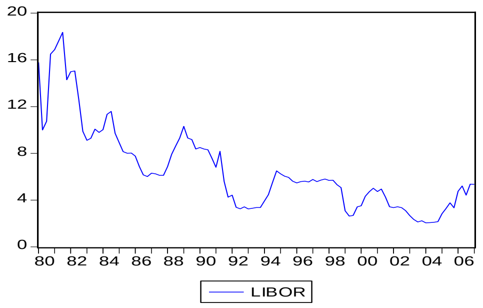
Note: 1. Note that *, ** and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.15.

3.3.6 The Stationary of LIBOR

Figure 3.6 clearly shows that the LIBOR is not stationary; the series looks fluctuated over the sample period. This evidence is supported by the ADF statistic at level; the null hypothesis of a unit root is not significant for both the data set from 1993Q1-2007Q1 and the data set from 1980Q1-2007Q1. It can be said that the series LIBOR is not stationary at any level.

Figure 3.6 Plot of LIBOR



Mean	6.61
Median	5.69
Maximum	18.35
Minimum	2.06
Std. Dev.	3.67
Skewness	1.25
Kurtosis	4.31
Jarque-Bera	36.34
Probability	0.000

However, after taking the first differencing, the variable appeared to be stationary with every lag length order, meaning the series LIBOR is integrated of order 1 (I(1)). The appropriate lag length is the lag of zero due to the smallest AIC and there is no evidence of autocorrelation.

Table 3.11 The results of the ADF test for LIBOR (1993Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
LIBOR (0)	**-4.42**	**-1.6**	**-5.73***	**-1.263**	
LIBOR (1)	-1.97	-2.19	-3.94*	-1.216	3.22
LIBOR (2)	-2.33	-2.55	-3.24**	-1.160	4.56***
LIBOR (3)	-2.03	-3.11	-3.26**	-1.132	5.12**
LIBOR (4)	-2.09	-2.76	-3.62*	-1.129	5.36**
LIBOR (5)	-1.57	-2.23	-3.44**	-1.132	8.13**

Note: 1. Note that *, ** and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.14.

Table 3.12 The results of the ADF test for LIBOR (1993Q1-2007Q1)

Variables	ADF test				Ljung-Box Q-Statistics
	ADF at level		ADF at first difference	AIC	
	No trend	With trend			
LIBOR (0)	**-2.62**	**-2.88**	**-10.66**	**0.03**	
LIBOR (1)	-1.67	-2.62	-8.79	-0.03	8.02
LIBOR (2)	-1.74	-2.44	-5.36	-0.34	11.57
LIBOR (3)	-3.34	-3.79	-6.36	-0.39	8.52
LIBOR (4)	-3.55	-3.41	-4.93	-0.37	0.37
LIBOR (5)	-3.71	-3.89	-4.16	-0.34	0.19

Note: 1. Note that *, ** and *** indicate the significance level at 1%, 5%, and 10%.

2. The critical value is presented in Table 3.15.

3.3.7 Summary of the ADF Unit Root Test

This section provides the summaries of the ADF test. As can be seen in Table 3.13, the results of the ADF, both data sets at level indicate that all variables appeared to be nonstationary when trend is included. The results without trend are also nonstationary except LnRealM2. However, the null hypothesis of a unit roots are rejected after the first differencing for all variables. Therefore, it can be said that all variables are integrated of orders one (I (1)) and these can be used in the next step of time series analyzing.

Table 3.13 Summary of the Result of the Unit root test.

Variables	ADF Test (1993Q1-2007Q1)			ADF Test (1980Q1-2007Q1)		
	At Level			At level		
	No trend	With trend	First different	No Trend	With trend	First different
LnRealM1	-1.15	-2.95	-9.65*(1)	-0.86	-3.26	-6.14*(3)
LnRealM2	-3.99*	-2.23	-5.26*(2)	-2.38	0.41	-7.79*(1)
LnGDP	-0.67	-1.26	-4.48*(0)	-0.67	-1.26	-4.84*(0)
LnEXC	-1.45	-0.7	-4.91*(2)	-1.55	-2.18	-5.6*(1)
R	-1.25	-1.36	-5.45*(0)	-1.30	-1.36	-8.40*(0)
LIBOR	-1.42	-1.60	-5.73*(0)	-2.62	-2.88	-10.66*(0)

Note: Note that *, ** and *** indicate the significance level at 1%, 5%, and 10%.

The numbers in parentheses indicates the optimum lag length of the ADF.

Table 3.14 The MacKinnon[3] Critical Value for the data set from 1993Q1-2007Q1

Number of lags	At Level				First difference	
	With trend		Without trend			
	1%	5%	1%	5%	1%	5%
0	-4.125	-3.489	-3.548	-2.913	-3.50	-2.914
1	-4.128	-3.490	-3.550	-2.914	-3.552	-2.915
2	-4.131	-3.492	-3.552	-2.915	-3.555	-2.916
3	-4.135	-3.494	-3.555	-2.916	-3.557	-2.917
4	-4.138	-3.495	-3.557	-2.917	-3.560	-2..918
5	-4.142	-3.497	-3.560	-2.918	-3.562	-2.919

[3] MacKinnon, 'Critical Values for Cointegration Tests', in Long-Run Economic Relationships, R.F. Engle and C.W.J. Granger, eds, London, Oxford, 1991, pp 267-276

Table 3.15 The MacKinnon Critical Value for the data set from 1980Q1-2007Q

Number of lags	At Level				First difference	
	With trend		Without trend			
	1%	5%	1%	5%	1%	5%
0	-3.491	-3.888	-4.12	-3.48	-3.495	-2.888
1	-3.492	-2.888	-4.12	-4.49	-3.492	-2.888
2	-3.492	-2.888	-4.13	-3.49	-3.493	-2.889
3	-3.493	-2.889	-4.13	-3.49	-3.493	-2.889
4	-3.493	-2.889	-4.08	-3.45	-3.494	-2.889
5	-3.494	-2.889	-4.04	-3.45	-3.494	-2.889

3.3.8 The result of the KPSS

The KPSS stationary test results are given in Table 3.16. The result of the KPSS level stationary shows that most of the variables appear to be significantly nonstationary in both the short and longer data set since the null hypothesis of stationary are rejected at 1% significance. In addition, the result of trend stationary is similar to level stationary in that the hypothesis of stationary is rejected at 1%. This clearly indicates that the all series are nonstationary in the tests, both with and without trend.

However, after the first differencing, most variables appeared to be stationary as the null hypothesis is not rejected at any significant level, except LnRealM2. The tests show that LnRealM2 is 1% significant after differencing. This evidence indicates that there are weak trend components inside the series LnRealM2 and LnP.

The results of the KPSS test confirm that all variables are I(1) and this can be processed in the next step.

Table 3.16 The results of the KPSS test (1993-2007)

Variables	KPSS Level Stationary					
	l = 0	l = 1	l = 2	l = 3	l = 4	l = 5
LnRealM1	5.02*	2.62*	1.8*	1.39*	1.14*	0.97*
LnRealM2	5.1*	2.64*	1.81*	1.39*	1.14*	0.97*
LnGDP	4.54*	2.37*	1.63*	1.27*	1.05*	0.9*
LnEXC	3.96*	2.03*	1.38*	1.07*	0.87*	0.75*
LnP	5.22*	2.69*	1.84*	1.42*	1.16*	0.99*
R	3.18*	1.96*	1.33*	1.02*	0.84*	0.72**
LIBOR	1.73*	0.9*	0.63**	0.5**	0.42	0.37
	KPSS Trend Stationary					
LnRealM1	0.57*	0.33*	0.25*	0.2**	0.16**	0.14
LnRealM2	1.21*	0.64*	0.44*	0.35*	0.29*	0.25*
LnGDP	0.75*	0.38*	0.26*	0.21**	0.17**	0.15**
LnEXC	0.93*	0.49*	0.34*	0.27*	0.23*	0.21**
LnP	1.09*	0.56*	0.38*	0.29*	0.24*	0.21**
R	0.54*	0.28*	0.19**	0.15**	0.13	0.11
LIBOR	0.39*	0.21**	0.15**	0.12	0.11	0.1
	KPSS test with first differencing					
LnRealM1	0.033	0.038	0.066	0.095	0.07	0.062
LnRealM2	0.8*	0.811*	0.849*	0.91*	0.811*	0.738**
LnGDP	0.25	0.18	0.15	0.13	0.12	0.11
LnEXC	0.26	0.205	0.181	0.187	0.194	0.205
LnP	0.78*	0.52**	0.43	0.38	0.34	0.32
R	0.152	0.119	0.101	0.094	0.091	0.089
LIBOR	0.18	0.15	0.13	0.12	0.115	0.117

Note:

Critical Value	***1%***	***5%***	***10%***
KPSS Level Stationary	*0.739*	*0.463*	*0.347*
KPSS Trend Stationary	*0.216*	*0.146*	*0.119*
KPSS with first differencing	*0.739*	*0.463*	*0.347*

Table 3.17 The results of the KPSS test (19980-2007)

Variables	KPSS Level Stationary					
	l = 0	l = 1	l = 2	l = 3	l = 4	l = 5
LnRealM1	10.56*	5.36*	3.62*	2.75*	2.22*	1.87*
LnRealM2	10.43*	5.28*	3.55*	2.69*	2.17*	1.82*
LnGDP	10.48*	5.30*	3.57*	2.70*	2.18*	1.83*
LnEXC	8.71*	4.44*	3.00*	2.28*	1.85*	1.56*
LnP	10.89*	5.53*	3.73*	2.82*	2.28*	1.87*
R	6.64*	3.39*	2.30*	1.76*	1.43*	1.22*
LIBOR	7.27*	3.78*	2.58*	1.98*	6.61*	1.38*
	KPSS Trend Stationary					
LnRealM1	0.21**	0.38*	0.27*	0.21*	0.18*	0.15**
LnRealM2	2.62*	1.33*	0.68*	0.55*	0.56*	0.47*
LnGDP	2.21*	1.11*	0.75*	0.56*	0.45*	0.38*
LnEXC	0.83*	0.44*	0.31*	0.24*	0.20*	0.17**
LnP	1.21*	0.61*	0.42*	0.32*	0.26*	0.22*
R	0.69*	0.35*	0.24*	0.19**	0.16**	0.14*
LIBOR	0.89*	0.48*	0.34*	0.23*	0.23*	0.20*
	KPSS test with first differencing					
LnRealM1	0.04	0.03	0.04	0.06	0.07	0.06
LnRealM2	1.03*	1.19*	1.26	1.31	1.14	1.01
LnGDP	0.57	0.44*	0.38	0.34	0.31	0.27
LnEXC	0.08	0.07	0.08	0.09	0.09	0.10
LnP	0.39	0.28	0.23	0.21	0.19	0.10
R	0.07	0.05	0.04	0.05	0.05	0.06
LIBOR	0.14	0.13	0.14	0.15	0.15	0.17

Note:

Critical Value	***1%***	***5%***	***10%***
KPSS Level Stationary	*0.739*	*0.463*	*0.347*
KPSS Trend Stationary	*0.216*	*0.146*	*0.119*
KPSS with first differencing	*0.739*	*0.463*	*0.347*

3.4 Testing for the Unit Root and Structural Break

3.4.1 Overview of the Concept of the Unit Root Test with Structural Break

This section overviews the concept of the unit root test with structural break. There are two procedures concerned in this thesis, Perron's 1997 approach and Zivot-Andrews' (1992) procedure.

3.4.1.1 Perron's 1997 approach to the Unit Root with Structural Break

Generally, an assumption of a standard ADF test is that there is no structural break during the sample period and the parameter is stable. This assumption might not correctly describe the integration property of data if there is a structural change in the time series. In some cases stationary time series may look like nonstationary when there is a structural break in the intercept and/or trend function. This may lead to the false conclusion that the null hypothesis of a unit root cannot be rejected and that the series contains a unit root, when in fact it does not.

A major criticism of the standard ADF test started with the study of Nelson and Plosser (1982) which showed that most macroeconomic and financial time series can be affected by a current shock. After that the issue of structural change on the level of macroeconomics and financial time series was of more concern to economists. One of the most popular pieces of literature about the unit root test in time series data is provided by Perron (1989). He claims that the standard ADF tests are biased towards the non-rejection of the null hypothesis of a unit root when there is a structural break during the sample period. Indeed, macroeconomic fluctuations are stationary if one allows for structural change to affect the time trend.

Perron (1989) created a formal procedure testing for the unit root which contained a structure break. This theory was based on the general ADF model with shift in mean and trend. He incorporated a dummy variable into the ADF test to allow for a single break in a slope and/or intercept of the trend function.

This structural break is allowed at a known break date T_b (1< T_b <T), where T_b is the time of the structural break. Perron proposed three possible models which will be considered when modelling the structural break. The first model is a crash model where the traditional ADF model is augmented by adding the dummy variable which presents shift on the intercept only. The second model called changing in growth allows for a change in slope of the trend function without any sudden change in the level at the time break. Another model is called the combine effect which allows for a change in both slope and intercept. Each of those three models contains a unit root with break under the null hypothesis. The alternative hypothesis is a broken trend stationary process which also incorporates the same dummy variables.

The hypothesis of three models by Perron (1989) can be written as:

<u>Null hypothesis</u>

Model 1: $$y_t = \mu + dD(Tb)_t + y_{t-1} + e_t \quad (3.15)$$

Model 2: $$y_t = \mu + y_{t-1} + (\mu_2 - \mu_1)DU_t + e_t \quad (3.16)$$

Model 3: $$y_t = \mu + y_{t-1}dD(Tb)_t + (\mu_2 - \mu_1)DU_t + e_t \quad (3.17)$$

where $D(Tb)_t = 1$ if $t = Tb + 1,$ and zero otherwise

$DU_t = 1$ if $t > Tb,$ and zero otherwise.

In addition, Perron (1989) also introduced three alternative hypothesis models; those three alternatives can be written as the following equation:

<u>Alternative hypothesis</u>

Model 1: $$y_t = \mu + \beta t + (\mu_2 - \mu_1)DU_t + e_t \quad (3.18)$$

Model 2: $$y_t = \mu + \beta t + (\beta_2 - \beta_1)DT_t + e_t \quad (3.19)$$

Model 3: $$y_t = \mu + \beta t + (\mu_2 - \mu_1)DU_t + (\beta_2 - \beta_1)DT + e_t \quad (3.20)$$

where $DT = t - Tb$ and $DT = t$ if $t > Tb$, and zero otherwise.

The first model is referred to as a crash model. Under the null hypothesis of a unit root, the model allows for an exogenous one time change at Tb in the level of a series, while the alternative of trend stationary allows for a one time change in intercept of trend function only. Model 2 permits an exogenous change in the rate of growth and it is referred to as the change growth model. Under the null hypothesis of a unit root, a drift parameter μ changes from μ1 to μ2 at the time breaks (Tb). The alternative hypothesis of Model 2 allows for a change in slope of the trend function without any sudden change in the level of the time break. The last model (Model 3) allows both exogenous change in rate of growth and time break.

Since Perron (1989) introduced a single point break into the regression model, many researchers have been more aware of structural change during the sample period. Perron and Vogelsang (1992) developed the Perron (1989) structural break approach by proposing two different classes of test statistics which allow for different forms of structural break, namely the Additive Outlines model (AO), and the Innovation Outlines model (IO). The AO model is more relevant for the series exhibiting a sudden break in the mean (the crash model), while the purpose of the IO model is to capture the changes in a more gradual manner over the sample period. After that, Perron (1994) extended the IO model by dividing the IO model into two versions, called the IO1 and IO2 models. While the IO1 version allows for gradual change in the intercept only, the IO2 version allows for gradual change in both intercept and the slope of trend function.

Those three models of a unit root test with structural break can be written as:

AO: $$y_t = \mu + \beta t + \gamma(DT) + \alpha y_{t-1} + \sum_{i=1}^{k} ci\Delta y_{t-1} + e_t \qquad (3.21)$$

IO1: $$y_t = \mu + \beta t + \theta(DU) + \delta D(T_b) + \alpha y_{t-1} + \sum_{i=1}^{k} ci\Delta y_{t-1} + e_t \qquad (3.22)$$

IO2 $$y_t = \mu + \beta t + \theta(DU) + \gamma(DT) + \delta D(T_b) + \alpha y_{t-1} + \sum_{i=1}^{k} ci\Delta y_{t-1} + e_t \qquad (3.23)$$

where T_b represents the break time,

DU denotes the intercept dummy, where DU = 1 if $t > T_b$ and zero otherwise.

DT is a slope dummy where DT = 1 if $t > T_b$ and zero otherwise.

$D(T_b)$ is a crash dummy where $D(T_b) = 1$ if $t > T_b + 1$ and zero otherwise.

The null hypothesis of a unit root can be rejected if the absolute value of the t-statistic for testing $\alpha = 1$ is greater than the critical value.

3.4.1.2 Zivot and Andrews' Model of the Unit Root with Structural Break

Perron's approach to the structural break is conditional on a known break point, where the choice of break point is based on prior observation of the series. The dummy variable is set at the point where structural break is believed to occur. This means Perron's procedure takes a break time as being exogenous. In addition, the pre-determined period for the dummy variable requires full information about the structural break point, which raised the risk associated with the wrong period selection. Therefore, this model could not be used when such breaks date are unknown.

To process the unit root test when the break date is unknown, Zivot and Andrews (1992) introduced another version based on Perron's (1989) original test, namely the ZA model. They improved Perron's approach by providing a structural break without pre-determining the break point time. While the structural break point in Perron's approach is exogenous data, the ZA model endogens the break point into the model through the estimation of a break point using a sequential method. Under the null hypothesis of the ZA approach, the series y_t is integrated without an exogenous structural break against the alternative hypothesis that the series is a trend stationary process with a one time break occurring at an unknown break point. The break point of the series is chosen as a minimum t-statistic on $\alpha = 1$ for a sequential test of the break point occurring at time $1<Tb<T$.

In practice, the hypothesis of the unit root in the ZA approach is tested by comparing the smallest t-value with a set of critical values which were estimated by Zivot and Andrews (1992). If the smallest t-value is greater than the critical value at a given significant level, the null hypothesis of the unit root is rejected and the series is stationary. In contrast, the series is nonstationary if the minimum t-statistic is smaller than the critical value. It should be noted that the critical values of the ZA approach are different from Perron's 1997 approach. As the ZA method is not conditional on prior selection of a break point, the critical value of ZA are greater than Perron's critical value. Consequently, the ZA model is more difficult to use to reject the null hypothesis of a unit root than Perron's 1997 approach.

In addition, Zivot and Andrews (1992) presented three equations in order to apply their testing procedure, called Model A, B and C. The Model A variables include an intercept (DU), where DU is a dummy variable which assumes the value of 1 when the break is present and zero before the break time, a linear time trend, the endogenous variable lagged one period, and a lag term of first difference of the endogenous variable. Model B allows a jump in the trend function. The dummy variable is called DT and consists of a new linear trend which is activated by the break. Model C contains elements from both models A and B and allows for a jump in the intercept and trend functions when a break occurrs. However, the most important part of the ZA model is the endogenous variable lagged one period (α).

The ZA model can be written in regression equations as:

Model A: $y_t = \mu + \beta t + \theta DU(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} cj \Delta y_{t-1} + e_t$ (3.24)

Model B: $y_t = \mu + \beta t + \gamma DT(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} cj \Delta y_{t-1} + e_t$ (3.25)

Model C: $y_t = \mu + \beta t + \theta DU(T_b) + \gamma DT(T_b) + \alpha y_{t-1} + \sum_{j=1}^{k} cj \Delta y_{t-1} + e_t$ (3.26)

where Tb is time break, DT is a dummy variable of a break in the trend occurring at the time break (Tb).DT =1 if t > t-Tb, and zero otherwise. DU denote a dummy variable capturing a shift in intercept, $DU = 1$ if t > Tb, and zero otherwise. The null hypothesis is rejected if the coefficient of α is statistically significant.

3.4.2 The Testing Procedure of the Unit Root with Structural Break

According to Perron's (1997) procedure, there are three models to test the unit root with structural break, AO, IO1 and IO2. Since there is no standard criteria to decide which model is the most relevant model for each series, this research follows Shrestha and Chowdhury's (2005) general-to-specific procedure. This procedure starts by running the Innovation Model 2 (IO2), which includes time trend (t) and time of structure break (DTb), and the model allows for the break in both intercept and trend. Then a check is made of the statistics of t and DTb. In case both t and DTb are not significant, then a check is made of the statistic of DU and DT. If all statistics are not significant, this implies that there is no statistically significant time trend and/or structural break in the time series.

In case the statistics of t and DTb are significant, then checks the statistic of DU and DT. If both DU and DT are significant, then selects this model (IO2) for that series. However, if only DU is significant, go to IO1 model which includes time trend (t) and time of structure break (Tb), and the model allows for the break in intercept only (DU). If only DT is significant, then check the Additive Outline model (AO). This model consists of time trend (t), time of structure break (Tb), and the break in slope only (DT).

It should be noted that there are two meanings of significance in this section. The first meaning is the case of t (α=1) where the series is significant and considered to be a stationary series if the absolute of the t-statistic for α=1 is greater than the absolute of the critical value at a given significance. Another significant meaning is in the case where the coefficients of t, DTb, DU and DT are close to zero and their t-statistics are significant, since the null hypothesis is that the value equals zero. However, there is no meaning if the coefficients are close to zero but their t-statistics are not significant. Similarly, if only the t-statistics are significant but the coefficients are not close zero. In other words, the conditions for t, D(Tb), DU and DT to be significant are that the coefficients are close zero and their t-statistics are significant at a given level at the same time.

3.4.3 Empirical Results of the Unit Root test with Structural Break: (Perron's 1997 approach)

This section reports the empirical results of the unit root test with structural break for each series. The results are generated by the RATS program based on Perron's 1997 procedure.

3.4.3.1.1 The Empirical Results of Perron's 1997 approach Model IO2

The result of Perron's 1997 model (IO2) is presented in Table 3.18. The result clearly shows that there are four variables that reject the null hypothesis of the unit root as the absolute value of the t-statistic for $\alpha = 1$ of those variables are greater than the critical value at a given level of significance. Series LnGDP and R are significant at 1 % level, LnEXC is 5% significant, and LnRealM2 is significant at 10% level.

Consider the statistic of t and DTb. There only the series LnGDP appeared to be significant in both the statistics of t and DTb. However, the statistic of DT is not significant due to the coefficient value not being close to zero (the coefficient equals 2.81). As a condition of model selection is that all statistics must be significant, model IO2 is not relevant for any series.

It is interesting that the statistic of time trend (t) is significant for all variables except LnEXC (t-statistic = 0.46) while the statistics of time break (DTb) are significant for only LnEXC, LnGDP, and R. In this case, we might have to apply either the AO and IO1 models or another alternative testing for structural break such as Zivot and Andrew's (1992) model to test the unit root with a structural break.

Table 3.18 The Results of the IO2 model (1993Q1-2007Q1)

Variables	Time break	k	β (t)	δ (DTb)	θ (DU)	γ (DT)	α	t(α=1)	Result
LnEXC	1997:1	3	0.001 (0.46)	-0.22 (-4.43)*	0.26 (5.38)*	-0.01 (-0.81)	0.56 (7.6)*	-5.93**	Reject
LnP	1997:1	3	0.002 (2.86)*	-0.01 (-1.19)	0.03 (2.76)*	-0.01 (-2.17)**	0.077 (13.2)*	-3.77	Not Reject
LnGDP	1997:2	3	0.003 (3.34)*	0.03 (2.62)*	-0.077 (-5.46)*	2.28 (0.02)	0.69 (14.1)*	6.24*	Reject
LnRealM1	2001:1	5	0.003 (2.23)**	0.06 (1.09)	-0.166 (-1.62)	0.007 (2.34)*	0.42 (2.99)*	-4.08	Not Reject
LnRealM2	1997:1	0	0.0163 (5.07)*	-0.01 (-0.96)	0.226 (4.91)*	-0.011 (-4.93)*	0.271 (2.0)**	-5.41***	Reject
R	1998:3	0	0.093 (4.99)*	4.51 (6.82)*	-3.223 (-6.54)*	-0.063 (-2.93)*	0.538 (11.2)*	-9.60*	Reject
LIBOR	2006:1	2	-0.015 (-.21)**	-2.07 (-1.90)	-45.23 (-20.2)*	0.816 (2.04)**	0.750 (-9.9)*	-3.30	Not Reject

Note: 1. The numbers inside parentheses are the t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.
3. The critical values of 1%, 5% and 10% are -6.32, -5.59, and -5.29.
4. The exogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1.

3.4.3.1.2 The Empirical Results of Perron's 1997 approach Model I01

Table 3.19 presents the results of Perron's 1997 IO1 model. The results indicate that out of seven series, there are three series can reject the null hypothesis of the unit root at 1%, as an absolute t-statistic for α=1 is greater than the critical value 1% (-5.92). These included LnEXC, LnGDP, and R. The table also clearly shows that the IO1 model could be selected for four series, LnEXC, LnGDP, LnRealM1, and LnRealM2 due to the statistic of time trend (t) and time break (DTb) appearing to be significant at 1%. Additionally, the statistic of DU (dummy variable capturing a shift in intercept) is significant for all four series.

Table 3.19 The Results of the IO1 model (1993Q1-2007Q1)

Variable	Time break	k	β (t)	δ (DTb)	θ (DU)	α	t(α=1)	Result
LnEXC	1997:1	3	-0.66 (-4.17)*	-0.22 (4.43)*	0.23 (6.87)*	0.55 (7.68)*	-6.04*	Reject
LnP	1997:1	3	7.32 (2.70)*	-0.01 (-0.53)	0.01 (1.94)	0.86 (20.12)*	-3.04	Not Reject
LnGDP	1997:2	3	0.003 (7.20)*	0.04 (2.71)*	-0.07 (-7.14)*	0.69 (15.07)*	-6.76*	Reject
LnRealM1	199-:4	5	0.01 (4.30)*	-0.19 (-3.74)*	-0.06 (-2.30)**	0.63 (8.03)*	-4.55	Not Reject
LnRealM2	1994:4	3	0.00 (2.64)*	-0.04 (-2.57)*	0.04 (3.79)*	0.73 (11.96)*	-4.37	Not Reject
R	1998:3	0	0.04 (4.94)*	4.32 (6.12)*	-4.08 (-9.66)*	0.59 (12.44)*	-8.56*	Reject
LIBOR	2005:3	1	-0.01 (-2.26)*	-1.11 (-2.12)**	0.85 (2.84)*	0.78 (11.96)*	-3.35	Not Reject

Note: 1. The numbers inside parentheses are t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.
3. The critical values of 1%, 5% and 10% are -5.92, -5.23, and -4.92.
4. The exogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1.

3.4.3.1.3 The Empirical Result of Perron's 1997 approach Model AO

The AO model of Perron's 1997 approach is presented in Table 3.20. The results show that under a null hypothesis of the unit root, only the time series LnRealM2 can be rejected and this series is found to be stationary, as an absolute t-statistic for α=1 equals 4.86, which is greater than the 5% critical value (-4.83). It can be concluded that under the AO model, all variables are nonstationary, except LnRealM2.

Another interesting point is that under the AO model, the coefficients of DT are statistically significant for all variables as the coefficients are close to zero, together with the t-value of all variables being strongly significant at 1% for all variables except R, which is significant at 5%. In addition, with the statistic of time trend (t), both coefficients and t-statistics are significant for all series. It can be said that Perron's 1997 approach model AO could be applied for all variables.

Table 3.20 The Results of the AO model (1993Q1-2007Q1)

Variable	Time break	K	β (t)	γ (DT)	α	t(α=1)	Result
LnEXC	2001:2	4	0.02 (15.16)*	-0.02 (-8.99)*	0.63 (6.04)*	-3.49	Not Rejected
LnP	1997:1	3	0.015 (22.52)*	-0.009 (11.35)*	0.844 (15.23)*	-2.80	Not Rejected
LnGDP	2001:2	5	0.004 (5.81)*	0.009 (5.52)*	0.789 (14.7)*	-3.92	Not Rejected
LnRealM1	2002:2	5	0.008 (6.39)*	0.011 (4.34)*	0.532 (4.20)*	-3.69	Not Rejected
LnRealM2	1997:1	4	0.022 (52.14)*	-0.016 (-28.75)*	-0.215 (-0.86)*	-4.864**	Reject
R	2006:1	2	-0.173 (-8.64)*	0.20 (2.18)**	0.828 (14.68)*	-3.033	Not Rejected
LIBOR	2005:4	2	-0.050 (-5.26)*	0.661 (3.92)*	0.750 (11.16)*	-3.71	Not Rejected

Note: 1. The numbers inside parentheses are t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.

3. The critical values of 1%, 5% and 10% are -5.45, -4.83, and -4.48.

4. The exogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1

3.4.3.1.4 The Model Selection of Perron's 1997 approach and

The model selection of Perron's 1997 approach is presented in Table 3.21. It clearly shows that Model IO2 is not suitable for any variable due to some of the statistics of t; Tb, DU and DT are not significant at any given level. Overall, the null hypothesis of the unit root can be rejected for LnEXC and LnGDP at 1% significant level and rejected at 5% significant for LnRealM2. It can be said that the series LnEXC, LnGDP and LnRealM2 are stationary when structural change is allowed, while the other variables are not stationary.

Table 3.21 Model Selection of Perron's 1997 Procedure (1993Q1-2007Q1)

Variable	Selected model	K	Time Break	t(α=1)	Result
LnEXC	IO1	3	1997:1	-6.04*	Rejected
LnP	AO	3	1997:1	-2.80	Not Rejected
LnGDP	IO1	3	1997:2	-6.76*	Rejected
LnRealM1	AO	5	2002:2	-3.69	Not Rejected
LnRealM2	AO	4	1997:1	-4.864**	Rejected
R	AO	2	2006:1	-3.033	Not Rejected
LIBOR	AO	2	2005:4	-3.71	Not Rejected

Note:
1. Note that * and ** denote statistical significance at 1% and 5%.
2. The critical values of the IO2 model at 1%, 5% and 10% are -5.57, -5.08, and -4.82.
3. The critical values of the AO model at 1%, 5% and 10% are -5.28, -4.65, and -4.38.

3.4.3.2 The Empirical Results of Perron's 1997 approach (1980Q1 2007Q1)

3.4.3.2.1 The Empirical Result of Perron's 1997 approach Model IO2 (1980Q1-2007Q1)

Table 3.22 presents the results of Perron's 1997 model (IO2), using the data set from 1980Q1 to 2007Q1. The results clearly show that there are four variables that reject the null hypothesis of the unit root as the absolute value of t-statistic for α = 1 of those variables is greater than the critical value at the given significant level. Series LnGDP is significant at 1%, LnEXC is 5% significant, and there is 10% significance for the series LnRealM2 and LIBOR.

As a condition of model selection for IO2 is that all statistics must be significant, model IO2 may be selected for the series LnEXC since all statistics are significant while others variables are not.

Table 3.22 The Results of the IO2 model (1980Q1-2007Q1)

Variables	Time break	k	β (t)	δ (DTb)	θ (DU)	γ (DT)	α	t(α=1)	Result
LnEXC	1997:1	5	0.007 (3.82)*	-1.16 (-4.29)*	32.28 (4.14)*	-0.016 (-4.13)*	2.38 (5.62)*	-5.59**	Reject
LnP	1994:4	4	0.00 (3.61)*	-0.01 (-1.23)	0.03 (3.07)*	0.00 (3.50)*	0.36 (3.50)*	-3.47	Not Reject
LnGDP	200.:1	5	0.01 (6.50)*	0.007 (0.48)	-8.31 (-1.33)	0.004 (1.33)	6.418 (6.39)	-6.39*	Reject
LnRealM1	1996:2	5	0.006 (4.49)*	0.05 (1.06)	-0.01 (-0.19)	-0.00 (-1.26)	0.02 (1.95)	-4.32	Not Reject
LnRealM2	2001:1	5	0.04 (5.14)*	-0.18 (-3.97)*	18.41 (0.87)	-0.00 (-0.87)	1.60 (5.58)*	-5.43***	Reject
R	1999:1	3	-0.11 (-2.86)*	-0.68 (-0.86)	900.48 (3.06)*	-0.44 (-3.06)	13.55 (3.96)*	-3.97	Not Reject
LIBOR	1989:1	5	-0.31 (-0.57)	4.61 (3.13)*	344.15 (3.93)*	-0.17 (-0.31)	26.03 (3.98)	-5.40***	Reject

Note: 1. The numbers inside parentheses are t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.

3. The critical values of 1%, 5% and 10% are -6.21, -5.55, and -5.25.

4. The Eexogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1.

3.4.3.2.2 The Empirical Results of Perron's 1997 approach Model IO1

Table 3.23 presents the results of Perron's 1997 IO1 model. The results indicate that out of seven series, there are three series that reject the null hypothesis of the unit root; LnGDP is 1% significant and there is 5% significance for series LnRealM2 and LIBOR.

The table also clearly shows that the IO1 model could be able selected for three series, including LnRealM2, R, and LIBOR due to the statistics of time trend (t) and time break (DTb) appearing to be significant at 1%. Additionally, the statistic of DU (dummy variable capturing a shift in intercept) is significant for all three series.

Table 3.23 The Results of the IO1 model (1980Q1-2007Q1)

Variable	Time Break	k	β (t)	δ (DTb)	θ (DU)	α	t(α=1)	Result
LnEXC	1997:2	5	0.02 (2.76)*	-0.12 (-2.92)	0.06 (1.96)	6.05 (4.12)	-4.03	Not rejected
LnP	2001:1	4	0.00 (3.29)*	0.01 (1.43)	0.01 (2.60)*	0.29 (3.28)*	-3.24	Not rejected
LnGDP	2000:1	5	0.01 (6.29)*	-0.01 (-0.61)	-0.02 (-2.93)	5.97 (6.20)*	-6.19	rejected
LnRealM1	1997:1	5	0.006 (4.28)*	0.03 (0.73)	-0.07 (-3.34)*	0.04 (0.75)	-4.22	Not rejected
LnRealM2	2001:1	5	0.04 (4.47)*	-0.15 (-5.05)*	-0.08** (-2.47)	1.65 (5.94)*	-5.76	rejected
R	2004:1	3	-0.11 (-3.58)*	1.61 (2.25)**	-1.93 (3.24)*	12.60 (3.94)*	-3.92	Not rejected
LIBOR	1989:1	5	-0.48 (-4.71)	4.60 (3.25)*	-2.54 (-2.54)	27.31 (5.44)	- 5.62***	rejected

Note: 1. The numbers inside parentheses are t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.

3. The critical values of 1%, 5% and 10% are -5.92, -5.23, and -4.92.

4. The exogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1.

3.4.3.2.3 The Empirical Results of Perron's 1997 approach Model AO

The AO model of Perron's 1997 approach is presented in Table 3.24. The results show that under the null hypothesis of the unit root, only time series LnGDP can be rejected and this series is found to be stationary, as an absolute t-statistic for α=1 equals 5.69, which is greater than the 1% critical value (-5.45). It can be concluded that under the AO model all variables are nonstationary, except LnGDP. Another interesting point is that under the AO model, the coefficients of DT are statistically significant for all variables as the t-value of all variables are strongly significant at 1% for all variables except LnRealM2. In addition, with the statistic of time trend (t), both the coefficient and the t-statistic are significant for all series. It can be said that Perron's 1997 approach model AO could be applied for all variables.

Table 3.24The Results of the AO model (1980Q1-2007Q1)

Variable	Time break	K	β (t)	γ (DT)	α	t(α=1)	Result
LnEXC	2000:1	0	-0.01 (10.480*	-0.01 -1.94)***	2.96 (16.6)*	-3.17	Not rejected
LnP	2002:4	4	0.01 (76.38)*	-0.01 (-6.26)*	3.74 (506.4)*	-2.68	Not rejected
LnGDP	1998:1	5	0.01 (30.98)*	-0.001 (-1.87)**	5.40 (1.09)	-5.69*	rejected
LnRealM1	1992:1	5	0.02 (27.16)*	-0.004 (-4.20)*	0.16 (6.48)*	-3.45	Not rejected
LnRealM2	1999:1	5	0.03 (17.84)*	-0.006 (-0.96)	1.57 (63.68)*	-4.19	Not rejected
R	2004:1	2	-0.11 (-4.70)*	-1.16 (-3.93)*	14.21 (38.24)*	-4.01	Not rejected
LIBOR	1983:1	1	-1.69 (-2.64)*	-1.27 (2.06)**	10.88 (4.97)*	-3.83	Not rejected

Note: 1. The numbers inside parentheses are t-ratios.

2. Note that *, ** and *** denote statistical significance at 1%, 5% and 10%.

3. The critical values of 1%, 5% and 10% are -5.45, -4.83, and -4.48.

4. The exogenous break point Tb is selected by minimizing the value of the t-statistic for testing α = 1

3.4.3.2.4 The Model Selection of Perron's 1997 approach

The model selection of Perron's 1997 approach is presented in Table 3.25. It is clearly shown that Model IO2 is suitable for the variable LnEXC due to all of statistics, including t, Tb, DU and DT being significant at any given level. Model AO is clearly selected for the series LnGDP, LnP, and LnRealM2. The IO1 model is selected for LnRealM1, R and LIBOR.

Overall, the null hypothesis of the unit root can be rejected for LnGDP at 1% significant level and rejected at 5% significant for LnRealM2 and LnEXC. It can be said that the series LnEXC, LnGDP and LnRealM2 are stationary when structural change is allowed, while other variables are not.

Table 3.25 Model Selection of Perron's 1997 Procedure (1980Q1-2007Q1)

Variable	Selected model	k	Time Break	t(α=1)	Result
LnEXC	IO2	0	1992:2	-5.59**	Rejected
LnP	AO	4	2002:4	-2.68	Not Rejected
LnGDP	AO	5	1998:1	-5.69*	Rejected
LnRealM1	AO	5	1992:1	-3.45	Not Rejected
LnRealM2	IO1	5	2001:1	-5.76**	Rejected
R	IO1	3	2004;1	-3.92	Not Rejected
LIBOR	IO1	5	1989:1	-5.62**	Rejected

Note: 1. Note that ** and ** denote statistical significance at 1% and 5%.*

3.4.4 Empirical Result of the Unit Root test with Structural Break: (Zivot and Andrews' approach)

The ZA procedure provides three possible models for testing the unit root in the presence of structural break and there is no standard test for selecting the appropriate model. This thesis follows the method of Chaudhuri and Wu (2003) which selected the model by estimating all three equations for each series and computing the t-statistic for $\alpha = 1$. Then the selection of the model is chosen from the strongest evidence against a random walk hypothesis (chosen from the most significant of the t-statistics in $\alpha = 1$). Table 3.26 presents the results of the unit root test with structural break based on Zivot and Andrews's procedure, using the data set from 1993Q1 to 2007Q1. Given the strongest of t-statistics, the results illustrate that Model A is selected for the series LnRealM1 and GDP, Model B is chosen for LnRealM2 and LIBOR, and Model C seems appropriate for the series LnP and R. There are three variables out of seven variables that reject the null hypothesis of the unit root. LnEXC, LnGDP, and R are 1% significance level, while the variable LIBOR is 5% significant.

It seems to be that the results of the unit root test with structural break based on Zivot and Andrews' procedure using the longer data sets in Table 3.27 is similar to the test for the shorter data set. As can be seen, the t-statistics of LnEXC, R, and LIBOR are significant, while the other variables are not.

Table 3.26 The Results of Zivot and Andrews' model (1993Q1-*2007Q1*)

Variable	Model	Tb	No. of Lag	T-Statistic	Critical Value 1%	Critical Value 5%	Result
LnEXC	A	1997:3	3	-6.01	-5.34	-4.8	Rejected
	B	2001:1	3	-3.07	-4.93	-4.42	Not rejected
	C	***1997:3***	***3***	***-6.1***	***-5.57***	***-5.08***	***Rejected***
LnP	A	2001:3	1	-2.69	-5.34	-4.8	Not rejected
	B	1997:4	1	-3.17	-4.93	-4.42	Not rejected
	C	***1997:3***	***1***	***-3.29***	***-5.57***	***-5.08***	***Not rejected***
LnGDP	***A***	***1997:4***	***5***	***-6.34***	***-5.34***	***-4.8***	***Rejected***
	B	2001:1	5	-4.6	-4.93	-4.42	Rejected
	C	1997:4	5	-6.21	-5.57	-5.08	Rejected
LnRealM1	***A***	***1997:2***	***5***	***-4.21***	***-5.34***	***-4.8***	***Not rejected***
	B	1998:2	5	-3.9	-4.93	-4.42	Not rejected
	C	1997:2	5	-4.08	-5.57	-5.08	Not rejected
LnRealM2	A	1995:2	3	-2.94	-5.34	-4.8	Not rejected
	B	***1996:2***	***3***	***-5.2***	***-4.93***	***-4.42***	***Not rejected***
	C	1997:2	3	-4.46	-5.57	-5.08	Not rejected
R	A	1999:1	2	-8.58	-5.34	-4.8	Rejected
	B	1999:2	2	-3.12	-4.93	-4.42	Not rejected
	C	***2003:1***	***2***	***-9.17***	***-5.57***	***-5.08***	***Rejected***
LIBOR	A	2005:1	3	-4.03	-5.34	-4.8	Not rejected
	B	***2004:4***	***3***	***-4.63***	***-4.93***	***-4.42***	***Rejected***
	C	2003:1.	3	-4.45	-5.57	-5.08	Not rejected

*Note: Note that * and ** denote statistical significance at 1% and 5%.*

Table 3.27The Results of Zivot and Andrews' model (1980Q1-2007Q1)

Variable	Model	Tb	No. of Lag	T-Statistic	Critical Value 1%	Critical Value 5%	Result
LnEXC	A	1997:3	0	-6.45	-5.34	-4.8	Rejected
	B	2003:1	0	-2.42	-4.93	-4.42	Not rejected
	C	***1997:3***	***0***	***-7.13***	***-5.57***	***-5.08***	***Rejected***
LnP	A	2003:2	2	-3.19	-5.34	-4.8	Not rejected
	B	2003:3	2	-4.22	-4.93	-4.42	Not rejected
	C	***2003:4***	***2***	***-4.23***	***-5.57***	***-5.08***	***Not rejected***
LnGDP	A	1997:3	5	-4.19	-5.34	-4.8	Not rejected
	B	1993:4	5	-3.69	-4.93	-4.42	Not rejected
	C	***1997:3***	***5***	***-4.68***	***-5.57***	***-5.08***	***Not rejected***
LnRealM1	A	1997:2	5	-4.18	-5.34	-4.8	Not rejected
	B	1997:3	5	-3.63	-4.93	-4.42	Not rejected
	C	***1996:4***	***5***	***-4.35***	***-5.57***	***-5.08***	***Not rejected***
LnRealM2	A	1985:4	4	-1.06	-5.34	-4.8	Not rejected
	B	***1995:1***	***4***	***-3.38***	***-4.93***	***-4.42***	***Not rejected***
	C	1994:4	4	-3.36	-5.57	-5.08	Not rejected
R	***A***	***1999:1***	***2***	***-5.04***	***-5.34***	***-4.8***	***Rejected***
	B	1993:3	2	-3.25	-4.93	-4.42	Not rejected
	C	1999:2	2	-4.93	-5.57	-5.08	Not rejected
LIBOR	***A***	***1984:4***	***3***	***-4.86***	***-5.34***	***-4.8***	***Rejected***
	B	1985:3	3	-4.49	-4.93	-4.42	Rejected
	C	1984:4	3	-4.58	-5.57	-5.08	Not rejected

*Note: that * and ** denote statistical significance at 1% and 5%.*

3.5 Conclusion

This chapter provides the brief concepts and the results of unit root testing. The chapter started by testing the unit root without the evidence of structural break by using a standard ADF and KPSS test. These results suggest that the null hypothesis of the unit root cannot be rejected in levels but can be rejected in the first difference for all variables. This implies that all variables are I(1) and are eligible for testing with the next step for both the short data set (1993Q1-2007Q1) and longer data set (1980Q1-2007Q1). However, as Thailand's financial crisis in 1997 may cause breaks in the data, the second part of the chapter retested the unit root with structural break by using Perron's approach. The results of the unit root with structural break show that the break date selected is 1997Q3 for the exchange rate and price level, 1997Q4 for GDP, 1997Q2 for LnRealM1, 1996Q2 for LnRealM2, 2003Q1 for domestic interest rates, and 2005Q1 for LIBOR. The null hypothesis of the unit root with structural break failed to reject most variables except LnEXC, R, and LIBOR. Overall, most of unit root tests suggested that the data are I(1). Although some of the breaking trend results suggest the possibility of trend stationary, we are going to assume (1) in the subsequent analysis chapters.

CHAPTER 4
THE COINTEGRATION AND ERROR CORRECTION MODEL: THE EMPIRICAL RESULTS OF MONEY DEMAND IN THAILAND

4.1 Introduction

The major objective of this chapter is to adopt the cointegration approach and the Vector Error Correction Model (VECM) to empirically test whether there exists a stable long-run and short-run equilibrium of the money demand function in Thailand. The chapter consists of three sections. The first section overviews the concept of cointegration and the concept of the Vector Error Correction approach. The second section is the empirical results of cointegration and the VECM for money demand in Thailand. There are two data sets used in the chapter, the full data set from 1980Q1-2007Q1 and the shorter data set from 1993Q1-2007Q1. The third section provides the comparison and policy implication of the chapter.

4.2 The Cointegration and Error Correction Model

4.2.1 The Cointegration concept

Generally, nonstationary time series data should not be used in regression models because it brings about the problem of spurious regression. However, there is an exception. For example, if y_t and x_t are nonstationary I(1) variables, then the difference or linear combination of them, such as $e_t = y_t - \beta_0 - \beta_1 x_t$ should be I(1) as well. However, in case $e_t = y_t - \beta_0 - \beta_1 x_t$ is stationary I(0), y_t and x_t are said to be cointegrated. This implies that y_t and x_t share similar stochastic trends and they will diverge too far from each other because their difference e_t is stationary. Therefore, the cointegrated y_t and x_t exhibit a long-run equilibrium relationship between y_t and x_t, which represents the short-run deviations from the long-run relationship. As a survey of Campbell and Perron (1991) found, a formal cointegration concept can be defined in a simple case of two time series y_t and x_t, where both are integrated of order one I(1). The two series can be said to have cointegration if there exists a parameter β_1 such that $e_t = y_t - \beta_0 - \beta_1 x_t$ is a stationary process.

In many cases of time series economic analysis, the regression equation may have to include more variables. Engle and Granger (1987) introduced the alternative concept of cointegration by considering a set of economic variables in the long-run equilibrium when:

$$\beta_1 x_{1t} + \beta_2 x_{2t} + \beta_3 x_{3t} + \ldots + \beta_n x_{nt} = 0$$

where β and x_t represent the vector $(\beta_1, \beta_2 \ldots \beta_n)$ and $(x_{1t}, x_{2t} \ldots x_{3t})$. The system is in long-run equilibrium when $\beta x_t = 0$. Then the equilibrium error (e_t) is that:

$$e_t = \beta x_t$$

Engle and Granger (1987) defined the cointegration concept as:

The components of the vector $x_t = (x_{1t}, x_{2t} \ldots x_{3t})$ are considered to be cointegrated of order d, *b* denoted by $x_t \sim \mathrm{CI(d, b)}$ if:

1. All components of x_t are integrated of order d.
2. There exists a vector $\beta = (\beta_1, \beta_2, \ldots, \beta_n)$ such that the linear combination $\beta x_t = \beta_1 x_{1t}, \beta_2 x_{2t}, \ldots, \beta_n x_{nt}$ $\beta' x_t$ is integrated of order (d-b) where b> 0.

It is interesting to note that although the original Engle and Granger’s definition of cointegration refers to the set of variables that are integrated in the same order, this does not imply that all integrated variables are cointegrated; a set of I (d) is usually not cointegrated. However, if two variables are integrated in a different order, they cannot be cointegrated. Another interesting aspect of the cointegration concept is that if x_t contains *n* nonstationary component, there may be as many as *n-1* linear independent cointegration vectors. For example, if x_t contains three variables, there can be at most two independent cointegration vectors. The number of cointegration vectors is called cointegration rank of x_t (Enders, 2004,p323)

4.2.2 Cointegration testing

Assume that two time series variables are believed to be cointegrated of order one and the researcher wants to test whether there exists the equilibrium relationship between the two. Engle and Granger (1987) proposed the process of cointegration testing which involves three steps:

Step 1: *Examine the variables for their order of integration*

A basic requirement of the cointegration test is that the variables must be integrated of same order. Thus, the first step of cointegration analysis is to pre-test each variable to determine their order of integration. The Augmented Dickey-Fuller tests can be applied in order to indicate the number of unit roots (if any) in each of the variables. There are three different possibilities that can happen in this step:

1. If the results show that both variables are stationary (I(0)), it is not necessary to proceed since a standard time series method applies to stationary variables. The classical regression analysis can be applied.
2. If the variables appeared to be integrated of different orders, then it can be concluded that the variables are not cointegrated.
3. In case both variables are integrated of the same order, then proceed to the second step of cointegration.

Step 2: *Cointegration testing*

In case the results of step 1 shows that x_t and y_t are integrated of the same order, usually where economic time series are I(1), then the second step is to estimate the long-run equilibrium relationship of Equation 4.1:

$$y_t = \beta_0 + \beta_1 x_t + e_t \qquad (4.1)$$

In case, y_t and x_t are cointegrated, then OLS regression yields a ‘super-consistent’ estimator of the cointegration parameter β_0 *and* β_1 (Ender, 2003).

To test where y_t and x_t are cointegrated, we can test whether the errors $e_t = y_t - \beta_1 - \beta_2 x_t$ are stationary as e_t series are the estimated value of the deviation from the long-run relationship. If this deviation appeared to be stationary, series y_t and x_t are cointegrated. However, if the e_t cannot be observed, we simply use the residual from the cointegrating regression instead of an observed equilibrium error. Therefore, the null hypothesis of absence of cointegration can be tested by performing a Dickey-Fuller test on the residual series to determine their order of integration. The form of residual auto regression is shown in Equation 4.2:

$$\Delta \hat{e}_t = \gamma \hat{e}_{t-1} + \varepsilon_t \qquad (4.2)$$

where $\hat{e}_t$ is residual from a regression equation and

γ is parameter.

The null hypothesis of no cointegration is that:

$$Ho: \gamma = 0 \ ,$$

$$Ha: \gamma < 0$$

If $\gamma = 0$, the null hypothesis of no cointegration is not rejected, the residual series contain a unit root test. Hence, we conclude that series y_t and x_t are not cointegrated. If $\gamma < 0$, the residual series does not contain a unit root test and we can reject a null hypothesis of no cointegration and the series y_t and x_t are cointegrated.

However, if the residual $\hat{e}_t$ in Equation 4.2 does not appear as the white noise, the ADF test can be used instead of Equation 4.2. Assume ε_t sequence in Equation 4.2 exhibits serial correlation. Estimate the autoregression:

$$\Delta\hat{e}_t = \gamma\hat{e}_{t-1} + \sum_{i=1}^{p} a_i \Delta\hat{e}_{t-1}\varepsilon_t \qquad (4.3)$$

If $-2 < \gamma < 0$, the residual series is stationary and the variables x_t and y_t are integrated.

It is noticed that the regression in both Equations 4.2 and 4.3 are estimated without intercept because the least square residuals ($\hat{e}_t$) have zero mean by construction (Stewart 2005,814)

Step 3: *Estimate the Error Correction Mechanism (ECM)*

It seems that cointegration concerns only long-run relationships between the set of variables. If the series y_t and x_t are integrated, it means variables have a long-term equilibrium relationship but it might have short-run fluctuation in the variables. Therefore, the third step is to estimate both the short-run and long-run affect of the time series model by estimating the error correction model.

If the result of step 2 shows that the variables are cointegrated, we can use the residuals from the equilibrium regression to estimate the error correction model and analyze the long-run and short-run effects.

If x_t and y_t are integrated, the error correction form is that:

$$\Delta y_t = a_1 + \sum_{i=0}^{n} \beta_i \Delta y_{t-i} + \sum_{j=0}^{m} \gamma_i \Delta x_{t-i} + \theta(y_t - \lambda x_t)_{t-1} + e_t \qquad (4.4)$$

Where the lagged terms of the Δx variable presents the short-run relationship, the β_0 coefficient indicates the current impact of Δx to Δy, whereas the long-run disequilibrium deviations are captured by the one period lagged error term of the cointegrating equation, with θ being the adjustment factor to equilibrium. The value of θ is between zero to one, while it is obvious that the closer to one the larger is the adjustment to equilibrium.

4.2.3 The Johansen methodology

Although the Engle-Granger cointegration approach is useful for testing the long-run equilibrium relationship between two variables and it seems to be easy to implement, there are a number of disadvantages of this approach. Firstly, the Engle-Granger method cannot be tested for a number of cointegrations when there are more than two variables. The second problem is that the method does not allow straightforward testing of a hypothesis regarding a cointegrating vector. The last problem is related to the estimation side of the Engle-Granger approach as the test approach relies on three steps (generating the error term and estimating the regression). Then, any error that is introduced in step one will carry on to the estimate regression equation in step two.

To avoid the problems of the Engle-Granger approach, Johansen (1988, 1991), Johansen and Juselius (1990) developed an alternative model for testing cointegration. The major aspect of this model is that it is allow for various restrictions on the cointegration vector as well as being based on the error correction of the VAR(p) model.

The Johansen multivariate cointegration approach is based on the *p* order vector autoregression (VAR) model. It can be generalized to allow for a higher-order autoregression process. Consider the equation:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \qquad (4.5)$$

Where $y_t = (y_1, y_{2,} ... y_{nt})$ is a (n-1) vector of I(1)

$\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, ..., \varepsilon_{nt})$ is assumed to be independent and identically distributed normal with zero mean and variance matrix is $\sum_t$

Subtracting y_{t-1} from both sides of Equation 4.5 we obtain:

$$\Delta y_t = (A_1 - \mathbf{I})y_{t-1} + A_2 y_{t-2} + A_3 y_{t-3} + \ldots + A_p y_{t-p} + \varepsilon_t \quad (4.6)$$

Adding and Subtracting $(A - I)\, y_{t-2}$ to the right-hand side of Equation 6.6 we obtain:

$$\Delta y_t = (A_1 - I)\Delta y_{t-1} + (A_2 + A_1 - I)y_{t-2} + A_3 y_{t-3} + \ldots + A_p y_{t-p} + \varepsilon_t \quad (4.7)$$

Next, adding and Subtracting $(A_2 + A_1 - I)y_{t-3}$ to the right-hand side we obtain:

$$\Delta y_t = (A_1 - \mathbf{I})\Delta y_{t-1} + (A_2 + A_1 - \mathbf{I})\Delta y_{t-2} + (A_3 + A_2 + A_1 - \mathbf{I})y_{t-3} + \ldots + A_p y_{t-p} + \varepsilon_t$$

Continuing in this process we obtain:

$$\Delta y_t \quad = \quad \sum_{i=1}^{p-1} \pi_i \Delta y_{t-i} + \pi_j y_{t-p} + \varepsilon_t \quad (4.8)$$

where $\pi_i \quad = \quad -\left[\mathbf{I} - \sum_{i=1}^{p} A_i\right]$, and

$$\pi_j \quad = \quad -\left[\mathbf{I} - \sum_{j=1}^{i} A_j\right]$$

The importance of Equation 4.8 is that the rank of matrix π represents the independent cointegrating vector. There are four interesting possible cases:

1) In case the rank (π) is zero, the matrix is null and Equation 4.8 is the usual VAR model in the first differences.
2) If the matrix appeared to be full rank (π = n), the vector process is stationary.
3) If the rank is equal one (π =1), there is a single cointegrating vector and πy_{t-p} is the error collection term.
4) For the case where 1< rank (π) < n, it can be said that there are multiple cointegrating vectors (Ender 2003, p. 352)

Johansen (1991) also proposed two likelihood ratio statistics to test the hypothesis of cointegration vectors, called trace statistic and maximal eigenvalue statistic. Those two equations can be expressed as:

$$\lambda_{trace}(r) \quad = \quad -T\sum_{i=r+1}^{n} \ln\left(1-\hat{\lambda}_i\right) \tag{4.9}$$

$$\lambda_{\max}(r,r+1) \quad = \quad -T\ln\left(1-\hat{\lambda}_{r+1}\right)$$

(4.10)

where $\hat{\lambda}_i$ is the estimated value of the characteristic roots obtained from the estimated π metric. T is the number of usable observations.

The aim of the trace statistic is to test the null hypothesis that the number of cointegrating vectors is less or equal r, $r \le r_0$ against the alternative hypothesis $r > r_0$ for $r_0 = (0,1,2,...,n)$, while the maximal eigenvalue statistic test is for the hypothesis that at least r cointegrating , $r = r_0$, against the alternative $r = r_0 + 1$.

In practice, there are four steps to illustrate the Johansen method:

Step 1: *Pre-test the order of integration of the variable.*

The most common test for choosing an appropriate lag length is to estimate a traditional VAR model including all variables in levels or non-differenced variables. This model can start with the longest length deemed reasonable, after that reducing down by re-estimating the model for one lag less until we zero lag. For example, if the test will be whether lags 2 through to 5 are important, the estimated equation will be:

$$y_t \; = \; A_0 + A_1 y_{t-1} + A_2 y_{t-2} + A_3 y_{t-3} + A_4 y_{t-4} + A_5 y_{t-5} + u_{1t} \tag{4.11}$$

$$y_t \; = \; A_0 + A_1 y_{t-1} + u_{2t} \tag{4.12}$$

where y_t is the $n \times 1$ vector

A_0 is the $n \times 1$ matrix of intercept term

A_i is the $n \times n$ matrix of coefficients

u_{1t} and u_{2t} are $n \times 1$ vector of (error terms).

In this step, we estimate the first system with the longest lags (five lags) of each equation and call variance/covariance matrix residuals $\sum_5$. Then we estimate the second equation by using one lag of each variable in each equation and we can call variance/covariance matrix residuals $\sum_1$. In this case, we can perform lag length order by using Sims' (1980) likelihood ratio statistic that is shown in Equation 4.13:

$$(T-c)(\log\left|\sum\nolimits_1\right| - \log\left|\sum\nolimits_5\right|) \tag{4.13}$$

where T is the number of observations,

c is the number of parameters in an unrestricted system, and

log $|\sum i|$ is a natural logarithm of the determinant of $\sum i$

To test this statistic, we can use the x^2 distribution with a degree of freedom equal to the number of coefficient restrictions. Since each A_i has n^2 coefficient, so constraining $A_2 = A_3 = A_4 = A_5 = 0$ entails $4n^2$ restriction (Enders, 2004,363). However, another alternative way to select lag length order for multivariate generalization is using AIC or SBC criteria.

Step 2: *Estimate the model and determine the rank of* π.

In this step, the OLS method seems to be not appropriate due to it being necessary to add cross-equation restrictions on the π matrix. Enders (2004) suggests that there are three alternative equation forms to estimate the model: (a) the model with all elements of A_0 is set equal to zero, (b) model with drift, or (c) model with a constant term in the cointegration vectors. Then, estimate the model by using the step one method.

Step 3: *Analyze the normalized cointegration vector and speed adjustment.*

There are three possible cases to test in this step.

1. To test that $\beta_0 = 0$ entails one restriction on one cointegrating vector, thus the likelihood ratio test contains a x^2 distribution with one degree of freedom. If the null hypothesis of $\beta_0 = 0$ is not rejected, then retest the

model by using the form of model in which there is neither a drift nor intercept in the cointegration vector.

2. To restrict the normalized cointegration vector, where $\beta_2 = -1$ and $\beta_3 = 1$ entails two restrictions in one cointegrating vector. In this case, the likelihood ratio test contains a x^2 distribution with two degrees of freedom.

3. The test that the joint restriction $\beta = (0,-1,,-1,1)$ entails three restrictions:

$$\beta_0 = 0, \beta_2 = -1, \text{ and } \beta_3 = 1.$$

Step 4: *Innovation accounting and test on the Error Correction Model*

4.2.4 The Vector Error Correction Model

A cointegration method is more concerned about the long-run equilibrium relationship between two variables but it is not concerned about the short-run relationship between the two variables. To capture the short-run dynamic between the two variables, Engle and Granger (1987) and Granger (1988) proposed an alternative method to describe the short-run dynamic relationship between variables, known as the Error Correction Model (ECM). The major idea of the ECM is that a proportion of disequilibrium from any change in one of these variables is related to change in past equilibrium error (Engle & Granger, 1987,p254). Since Granger introduced the concept of ECM, it became more popular among economists due to the ECM method being formulated in terms of first difference, which can eliminate trend from the equation. In addition, ECM can capture short-run and long-run equilibrium relationships of the set of variables.

A suggestion of Engle and Granger (1987) was that if the two time series y_t and x_t are cointegrated in the same order (both y_t and x_t are I (d)), any linear combination of the two series should be the same and the residual that obtains from the regression y_t on x_t should be I (d). Therefore, the simple way to derive the Error Correction Model is to show if y_t and x_t are linear functions of the latent integrated progress, the residual of y_t regressed on x_t should be stationary (Keele & De Boef 2004 ,p7).

Assume that both y_t and x_t are integrated order one (y_t and x_t are I (1)). Consider the long-run equilibrium relationship between y_t and x_t from Equation 4.14:

$$y_t = \alpha + \beta x_t + \varepsilon_t \qquad (4.14)$$

Equation 4.14 means that in the long-run equilibrium y_t is a function of x_t and the error terms ε_t :

To capture the short-run equilibrium between the two variables, Engle and Granger suggest the simple dynamic of short-run adjustment in Equation 4.15:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \qquad (4.15)$$

Rearrange Equation 4.15 by taking first difference we obtain:

$$\Delta y_t = \alpha_0 + (\alpha_1 - 1) y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \qquad (4.16)$$

Subtracting $\beta_0 x_{t-1}$ from the right-hand side of Equation 6.16 we obtain:

$$\Delta y_t = \alpha_0 + (\alpha_1 - 1) y_{t-1} + \beta_0 \Delta x_t + (\beta_0 - \beta_1) x_{t-1} + \varepsilon_t \qquad (4.17)$$

Add and subtract $(\alpha_1 - 1)x_{t-1}$ from the right-hand side:

$$\Delta y_t = \alpha_0 + \gamma (y_{t-1} - x_{t-1}) + \lambda_1 \Delta x_t + \lambda_2 x_{t-1} + \varepsilon_t \qquad (4.18)$$

where $\gamma = (\alpha_1 - 1)$, $\lambda_1 = \beta_0$, and $\lambda_2 = \beta_1 + \beta_0 + \alpha_1 - 1$

The γ or $(\alpha_1 - 1)$ in Equation 4.18 represents the speed at which y_t adjusts to any discrepancy between y_t and x_t in the previous period, while $(y_{1-1} - x_{t-1})$ is equal to zero when y_t and x_t are in equilibrium and it measures the extent to which the long-run relationship is not satisfied. The λ_1 represents the short-run relationship between the two variables. However, instead of explicitly including an error correction term in the form of $(y_{1-1} - x_{t-1})$, Keele and De Boef (2004) suggest the convenient model for estimating the error correction model is:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \eta 1 \Delta x_t + \eta_2 x_{t-1} + \varepsilon_t \tag{4.19}$$

where $\gamma = (\alpha_1 - 1)$, $\eta_1 = \lambda_1 = \beta_0$, and $\eta_2 = \beta_1 + \beta_0$

Equation 6.19 can be re-written in the form of an Error Correction Model as:

$$\Delta y_t = \alpha_0 + \gamma(y_{t-1} + \eta_2 x_{t-1}) + \eta_1 \Delta x_{t-1} + \varepsilon_t \tag{4.20}$$

4.2.5 The Vector Error Correction Model

The ECM presents the single error correction equation to capture the short-run relationship between the two variables but it cannot analyze the error correction of multiple equations. Engle and Granger (1987) offered the Vector Error Correction Model (VECM) to estimate multiple regressions. While the ECM is used to capture the short-run relationship when series y_t and x_t are cointegrated in the same order, the VECM is similar to the ECM but it considered all variables as endogenous variables and each variable in the model is determined by other variables. The VECM is actually the combination of the Vector Auto Regressive (VAR) and the Error Correction Model (ECM). In order to derive the VECM we need to start with the VAR model.

Consider the non-structural auto regressive VAR model in Equation 4.21:

$$y_t = \mu_0 + \sum_{i=1}^{k} \eta_i y_{t-1} + u_t \tag{4.21}$$

where y_t is a ρ x 1 vector of variables that include all variable as endogenous.

It is determined by k lags of all ρ variables in the system.

μ_0 is a ρ x 1 vector of constant term coefficient.

η_i is the ρ x ρ metrics of coefficients on the i lag of y_t

u_t is a ρ x 1 vector of the error term.

The VAR model can be generated by first differencing variables. If the first differenced variables are I (1), the VAR equation can be expressed as:

$$\Delta y_t = \mu_0 + \sum_{i=1}^{k} \eta_i \Delta y_{t-1} + u_t \tag{4.22}$$

According to Engle and Granger (1987), the Vector Error Correction Model (VECM) is simply restricted VAR which required accommodating with the Error Correction Model (ECM). Therefore, the VECM can be expressed as:

$$\Delta y_t = \mu_0 + \prod y_{t-1} + \sum_{i=1}^{\rho-1} \Gamma_i \Delta_i y_{t-i} + \varepsilon_t \tag{4.23}$$

Another alternative form of the VECM without constant suggested by Johansen can be written as:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{\rho-1} \Gamma_i \Delta_i y_{t-i} + \varepsilon_t \tag{4.24}$$

where $\varepsilon_t \sim N(0,\Omega), t = 1,2,...,T$, $\prod = \sum_{i=1}^{\rho} A_i - I$, and $\Gamma_i = \sum_{j=1+1}^{\rho} A_j$

It should be noted that at equilibrium the reduced form of Johansen's VECM can be written as $\Delta y_{t-1} = \prod y_{t-1}$. The term of $\sum_{i=1}^{\rho-1} \Gamma_i \Delta_i y_{t-i}$ would not exist in equilibrium; all $\Delta y_{t-.i}$ will be zero and setting the error term ε_t to their expected value of zero will leave $\prod y_{t-1} = 0$ (Brooks, 2002).

The VECM is also often presented in the form of a change in dependent variables being a function of the explanatory variables and the error correction term, as expressed in Equation 4.25:

$$\Delta y_t = \mu_0 + \sum_{i=1}^{\rho-1} \Gamma_i \Delta_i y_{t-i} + \delta ECT_{t-1} + \varepsilon_t \tag{4.25}$$

where ECT represents an Error Correction Term.

The ECT derives from the cointegration vectors and δ records the response of the dependent variable in each period t.

However, the initial relationship for y_t after the cointegrating vector has been normalized can be written as:

$$y_t = \eta_1 y_{t-1} + \eta_2 y_{t-2} + ... + \eta_i y_{t-i} \qquad (4.26)$$

The error correction term is that:

$$ECT_t = \ y_t + \eta_1 y_{t-1} + \eta_2 y_{t-2} + ... + \eta_i y_{t-i} \qquad (4.27)$$

4.3 The Empirical Results of Stability of Money Demand in Thailand

This section provides results of the stability of money demand function in Thailand. The section starts by providing the model of money demand functions. Then, the empirical results of money demand functions in Thailand are presented. Two data sets used for analyzing the money demand function. These are the data set from 1980Q–2007Q1 and the data set from 1993Q1–2007Q1. In both data sets, we will test both M1 and M2 money demand function in Thailand. In each test, we will start by testing a simple money demand function, where money demand is dependent on real income and domestic interest rates. After that, we will add the variable exchange rate and LIBOR in order to test the role of the exchange rate on money demand in Thailand.

4.3.1 Modeling of the money demand function in Thailand

The most general form of the money demand function is usually defined as money demand being dependent on real income and the opportunity cost of holding money that usually proxy by domestic interest rate and the money demand equation will be:

$$\left(\frac{M}{P}\right) = f\left[\left(\frac{Y}{P}\right), R\right] \qquad (4.28)$$

where $\left(\frac{M}{P}\right)$ is real money balance

$\left(\frac{Y}{P}\right)$ is real income

R is the domestic interest rate.

The estimation in this chapter will start by testing money demand in Thailand by using a simple model of the money demand function. The variables included in the simple model are real money holding (M1 or M2), real income (GDP), and domestic interest rates (R). The simple model estimate is written in equation as:

$$\mathrm{Re}\,alM_t = \alpha + \beta GDP_t + \delta R_t + \varepsilon_t \tag{4.29}$$

However, in an open economy, where the international trade and capital movement have greater importance in the economy, the external factors become major concerns in monetary analysis. As suggested by Bahmani-Oskooee and Techaratanachai (2001), the fluctuation in the exchange rate has resulted in a change in the money demand function. Since the depreciation of the domestic currency caused an increase in the domestic currency value of foreign assets, those who were holding foreign assets considerably increased their wealth and had higher demand on domestic currency (Arango & Nadiri, 1981). In this case, the domestic money demand should increase. However, in the case of currency substitution, the depreciation of domestic currency may also cause a decrease in money demand. When the exchange rate is expected to depreciate, the expected return from foreign assets will increase. This causes more demand on foreign currency and less demand on domestic currency and so domestic money demand may decline. To examine the relationship between money demand and the exchange rate fluctuation, the equation will add the exchange rate variable (EXC) into the simple model. In addition, in an open economy where the international trade and capital movement have greater importance in the economy, domestic investors can also choose to hold foreign assets. Therefore, the choices of holding assets for investors include domestic money, foreign money, domestic bonds and foreign bonds. For this reason, many economists take into account the foreign factors in the money demand function. For example, Bahmani-Oskooee (1991) claimed that the foreign sector has a significant affect on money aggregate in an open economy. This, together with the study of Sriram (1999), found that foreign assets can also be represented as an opportunity cost of holding money. Then, the foreign interest rate is included in the money demand function. Therefore, the second equation used to estimate the demand for money in the section is that:

$$\mathrm{Re}\,alM_t = \alpha + \beta GDP_t + \delta R_t + \phi LIBOR_t + \eta EXC_t + \varepsilon_t \qquad (4.30)$$

where $RealM_t$ represents real money demand. The variable $RealM_t$ is generated by (M_t/P_t), where M_t is money aggregate and P_t is the consumer price index. Two money aggregate variables are employed in this research–narrow money (M1) and broad money (M2). R is the domestic interest rate, proxied by discount interest rates, *Discount rate, which is the rate of interest, set by the central bank that member banks are charged when they borrow money through the central bank. It also can be referred to the interest on an annual basis deducted in advance on a loan*. The reason to use discount interest rates is that the Bank of Thailand usually applied the discount interest rate as a monetary instrument and sometimes it appears as an intermediate target in monetary policy. In addition, the Bank of Thailand can control the discount interest rate directly. P is referring to the price level represented by the consumer price index (1988=100). The real income variable is proxied by GDP or Gross Domestic Produce at the 1988 constant price. LIBOR is the London Interbank Offered Rates, which presents foreign interest rates. *The reason to use LOBOR as a proxy of foreign interest rate is that the LIBOR is the most famous barometer for short-term interest rates in the world. In addition, LIBOR is also the interest rate that the most credit-worthy banks around the world charge each other for loans* and EXC is the exchange rate (baht to US$).

The demand for money in this thesis is estimated by using two quarterly data sets, the full data set from 1980Q1-2007Q1 and the data set from 1993:1-

2007:1. The rationale for the use of two data sets is that there is limited quarterly GDP data in Thailand, as the official database provides consistent data from only 1993Q to 2007Q1. However, estimates of Thai GDP data by Abeysinghe & Gulasekaran (2004), which closely match official data are also available. Therefore, this thesis utilizes both data sets for testing the stability of the money demand function in order to compare the results between the short and longer data set. The chapter focuses on the estimation of both short-run and long-run relationship of money demand in Thailand, using both the narrow money demand (M1) function and the broad money demand (M2) function. The result of this estimation also allows the calculation of the so-called money overhang from the long-run money demand function and allow the test of whether this can help to predict inflation in Thailand

All variables are estimated in form of logarithms except R_t and $LIBOR_t$. Therefore, the equation estimated in this section is that:

$$Ln\,\mathrm{Re}\,alM_t = \alpha + \beta LnGDP_t + \delta R_t + \varepsilon_t$$

and

$$Ln\,\mathrm{Re}\,alM_t = \alpha + \beta LnGDP_t + \delta R_t + \phi LIBOR_t + \eta LnEXC_t + \varepsilon_t$$

Many studies applied the cointegration technique to examine the demand for money function in developed countries. For example, Hoffman and Rasche (1991) and Hafer and Jansen (1991) used cointegration to estimate demand for money in the US. Bahmani-Oskooee (2001) used this technique for Japan. Sriram (2002) also applied the same technique for money demand in Malaysia. They were followed by Bahmani-Oskooee and Rehman (2005) who used the same method to estimate the stability of money demand in Asian developing countries. Oomes and Ohnsorge (2005) applied this technique to Russia, and James (2005) to Indonesia.

To achieve the result of testing the relationship between the stability of the money demand function in Thailand, this thesis first applies the Augmented

Dickey-Fuller test (ADF) to test the stationary of each variable and establish the order of integration of variables used in model. Many economists claim that there might be cointegration in a set of two or more variables. Then, the second step is cointegration testing. The pair-wise cointegration is applied as a pre-test in this section in order to test whether there is pair-wise cointegrating between the real money demand (RealM1 or RealM2), and its determinants. After that, the multivariate cointegration approach and the Vector Error Correction Model are applied to examine the long-run and the short-run relationship of the money demand function in Thailand.

After testing the long-run and the short-run relationship of the money demand function, we will test whether the estimate of the money demand equation is helping forecast inflation at different lags. According to the study of Polleit and Gerdesmeier (2005), the money overhang can be defined as a difference between the actual money stock and the equilibrium stock of money. The money overhang in this thesis will follow the idea of Polleit and Gerdesmeier by using the long-run money demand equation to estimate the money overhang. Therefore, money overhang in this section is:

$$\text{OM} = \text{LnRealM1} - \text{LnRealM1}^{e} \qquad (4.31)$$

where LnRealM^{e} is money demand that is calculated from the long-run money demand function and LnRealM_t refers to actual money holdings. The money overhang for the simple model of money demand is:

$$OM = LnrealM_t - (\alpha + \beta LnGDP + \gamma R) \qquad (4.32)$$

The money overhang for the money demand function that includes the exchange rate and R can be calculated from:

$$OM = LnrealM_t - (\alpha + \beta LnGDP + \gamma R + \lambda LnEXC + \eta R) \qquad (4.33)$$

To analyze the relationship between inflation and money overhang, we start the estimation by testing the correlation of the current measure of money overhang with current inflation, one-quarter-ahead inflation, four-quarter-ahead inflation, and eight-quarter-ahead inflation. After that, the simple forecasting equation of inflation and money overhang will be tested in order to examine whether money overhang helps in forecasting inflation in Thailand.

4.3.2 The result of money demand function in Thailand (1980Q1 - 2007Q1)

4.3.2.1The result of the M1 Money demand function (a simple model)

A major objective of this section is to examine the long-run and the short-run relationship of the M1 money demand function in Thailand, using the longer data set from 1980Q1 to 2007Q1. The estimation in this chapter starts by testing the pair-wise cointegration as a pretest of multivariate cointegration for the M1 money demand function in Thailand. Then, the cointegration approach and the Vector Error Correction Model are applied. In each model, we will start by testing a simple model where money demand is dependent on real income and interest rates. Then, the variable exchange rate and LIBOR will be added to examine whether external factors have an affect on money demand in Thailand.

The pair-wise cointegration between M1 money demand (LnRealM1), real income (LnGDP) and interest rates (R) is estimated by using Saikkonen and Lutkepohl's approach with the JMulTi program. The number of lags in the table are selected by the smallest AIC criteria. There are three determinants in this section: the test with intercept and shift dummy that also allows time trend in the series; the test including intercept and trend but excluding the shift dummy; and the test with only intercept. Since there is evidence of a break date during the financial crisis iThailand during middle of 1997 to the beginning of 1999 and there is a degree of uncertainly about the break date in the series, therefore, we set the date of 1998Q2 as a sample shift dummy variable.

Table 4. 1 The pair-wise cointegration results for the M1 money demand function (1980:1 – 2007:1)

Variables		Deterministic	No. of lags	H0: r=r0	Test statistic	Critical Value 10%	5%	1%
LnRealM1 and	LnGDP	Trend, intercept, and shift dummy	5	ro=0	10.81	13.88	15.76	19.71
				ro=1	1.29	5.47	6.79	9.73
LnRealM1 and	R	Trend, intercept, and shift dummy	5	ro=0	14.77***	13.88	15.76	19.71
				ro=1	0.01	5.47	6.79	9.73
LnGDP and	R	Trend, intercept, and shift dummy	4	ro=0	12.80	13.88	15.76	19.71
				ro=1	0.38	5.47	6.79	9.73
LnRealM1 and	LnGDP	Trend, intercept	5	ro=0	14.21***	13.88	15.76	19.71
				ro=1	1.33	5.47	6.79	9.73
LnRealM1 and	R	Trend, intercept	5	ro=0	14.55***	13.88	15.76	19.71
				ro=1	0.34	5.47	6.79	9.73
LnGDP and	R	Trend, intercept	4	ro=0	16.72**	13.88	15.76	19.71
				ro=1	0.56	5.47	6.79	9.73
LnRealM1 and	LnGDP	Intercept	4	ro=0	5.84	10.47	12.26	16.10
				ro=1	2.34	2.98	4.13	6.93
LnRealM1 and	R	Intercept	1	ro=0	12.13***	10.47	12.26	16.10
				ro=1	0.45	2.98	4.13	6.93
LnGDP and	R	Intercept	4	ro=0	9.45	10.47	12.26	16.10
				ro=1	2.84	2.98	4.13	6.93

Variables: LnRealM1, LnGDP, R

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% levels of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.1 presents a pair-wise cointegration between LnRealM1, LnGDP, and R. In the case of the equation including the shift dummy and trend, there is evidence of pair-wise cointegration between M1 money demand and R, suggested by the test statistic of pair-wise cointegration being greater than 10% critical value. The test without the shift dummy variable but including trend states that M1 money demand and real income (LnRealM1 and LnGDP), and M1 money demand and interest rates (LnRealM1 and R) have pair-wise relationships of 10% significant level. The test with intercept but no trend and shift dummy variable also suggests that the null hypothesis of no pair-wise relationship between two variables is rejected at 10% significant for LnRealM1 and R, meaning that there is a pair-wise relationship between LnRealM1 and R at 10 % significance. However, given 5% significance, there is no pair-wise relationship between two variables.

Table 4.2 The cointegration results for M1 money demand (1980:1–2007:1)
Variables: LnRealM1, LnGDP, R

Variables	Deterministic	No of lags	H0: r=r0	Test statistic	Critical Value 10%	5%	1%
LnRealM1,LnGDP, and R	Trend, intercept, and shift dummy	4	ro=0	36.46*	26.07	28.5	33.5
			ro=1	6.23	13.88	15.76	19.71
			ro=2	0.04	5.47	6.79	9.73
LnRealM1,LnGDP, and R	Trend and intercept	1	ro=0	60.79*	26.07	28.5	33.5
			ro=1	23.46*	13.88	15.76	19.71
			ro=2	1.51	5.47	6.79	9.73
LnRealM1,LnGDP, and R	Intercept	3	ro=0	29.32*	21.76	24.2	29.1
			ro=1	6.57	10.47	12.26	16.1
			ro=2	2.13	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*
The number of lags is selected by the smallest AIC criteria.

Table 4.2 shows the multivariate cointegration of the M1 money demand function in Thailand using the simple model of money demand with the data set from 1980Q1-2007Q1. The results suggest that in the case where the shift dummy and time trend are included, the null hypothesis of $r_0 = 0$ is rejected at 1 % significant level, as the test statistic is 36.46, greater than 1% critical value. However, the null hypothesis of $r_0 = 1$ is not rejected at any given significant level, suggesting that there is a single cointegrating vector between LnRealM1, LnGDP, and R when shift dummy and trend are included. Similarly, the test with intercept but excluding time trend and the shift dummy variable rejects the null hypothesis of $r_0 = 1$ at 1% significance. However, the cointegration result of the model without dummy shift but allowing time trend in the series indicates that there are at least two combinations where all variables are cointegrated in the M1 money demand function in Thailand since the null hypothesis of r_0 =1 is rejected at 1% significant level. Therefore, it could be said that exits a stable long-run relationship among the M1 money demand, domestic income (GDP) and domestic interest rates (R) in the Thai economy.

A result of the cointegration above strongly suggests that there is a single cointegration vector among M1 money demand (LnRealM1), real income (GDP), and interest rates (R) when the test excludes trend and the shift dummy. It may not be necessary to include a shift dummy and time trend in the analysis. The next step will be to estimate the normalized cointegration vector by setting the coefficient on LnRealM1 at -1 and then the vector equation will represent the long-run money demand function in Thailand. In addition, the coefficient of each variable shows the elasticity of each variable on the M1 money demand in Thailand.

Table 4.3 presents the normalized cointegrating vector of the M1 money demand function in Thailand by using the data from 1980Q1 to 2007 Q1. The coefficient of both LnGDP and R are significant at 1% level, suggesting that real income and the interest rate has an affect on money holding in Thailand in the long run. The income elasticity of M1 money demand is 0.65, meaning that a 1% increase in real GDP in Thailand leads to a 0.65% increase in the M1 money demand in Thailand. The estimate of interest rate (R) elasticity is -0.06%, indicating that in the long run if domestic interest rates increase by 1%, M1 money demand will drop by 0.06%.

Table 4.3 The normalizing of the M1money demand function in Thailand (1980:1–2007:1)

LnRealM1	**LnGDP**	**R**	**C**
-1	0.65* [-5.66]	-0.06* [4.47]	2.06** [2.45]

Note: The numbers in parenthesis show the t-statistics.
Note that * and ** indicate 1% and 5% level of significance.

Table 4.4 shows the result of weak exogeneity of variables in the cointegration. The results show that LnRealM1 and GDP are 1% significant. This means that LnRealM1, and GDP are not a long-run weak exogeneity with respect to the cointegration vector. However, the variable R appeared to be a weak exogeneity as the test statistic is insignificant. Therefore, we can continue the VECM in the next step by using LnRealM1 and LnGDP as endogenous variables, and R as an exogenous variable.

Table 4.4 The test for Cointegration Restrictions for weak exogeneity (1980:1–2007:1)

Variable	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
		Restrictions: $\alpha(1,1)=0$		
LnRealM1	334.94	10.50	1.00	0.00
		Restrictions: $\alpha(2,1)=0$		
LnGDP	335.86	8.73	1.00	0.00
		Restrictions: $\alpha(3,1)=0$		
R	340.17	0.09	1.00	0.75

As the initial focus of this thesis was to test the stability of the money demand function in Thailand, we continue the test by analyzing the parameter stability of money demand. Hansen and Johansen (1999) proposed a formal test for parameter stability in the context of recursive estimation of the eigenvalue associated with the test for cointegration. In the context of a single cointegrating vector in the M1 money demand in Thailand, the largest eigenvalue, the one associated with the cointegration test suggesting a single cointegrating vector, can be estimated for the full sample and then recursively for sub-samples. The test is then based on the difference between the two eigenvalues, rejecting the null of stability if this difference exceeds some critical value. Limiting distributions for the test statistic have been calculated by Ploberger, Kramer and Kontrus (1989). Denoting that the eigenvalue associated with the full sample of data is λ_i^T and the eigenvalue estimated data used up to observation □ is λ_i^τ. Hansen and Johansen (1999) used the maximum value of the constructed test statistics over the recursive estimation range to carry out the test[4]. The tests

[4] Using their notation they calculate $\sup_{T_1 \le \tau \le T} \tau(\xi_i^{(\tau)})$ where $\xi_i^{(\tau)} = \log\left(\frac{\lambda_i^\tau}{1-\lambda_i^\tau}\right)$ and $\tau(\xi_i^{(\tau)}) = \frac{\tau}{T}\left|\left(\xi_i^{(\tau)} - \xi_i^{(T)}\right)/\hat{\sigma}_{ii}\right|$

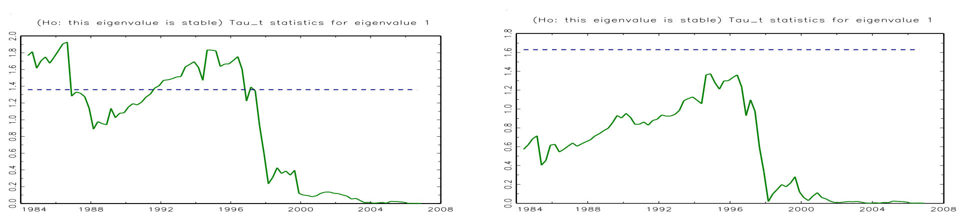
were carried out using JMulTi[5]. There are 2 options available for implementing the test. In calculating the recursive eigenvalues it is possible to either a) concentrate out the short-run parameters (assuming they are stable) using their full sample estimates or b) to estimate all parameters recursively. Option a) really allows us to focus on the parameters of the long-run part which is what we are interested in at the moment. However, given the instability of the late 90's we would be surprised if the short run dynamics had remained stable. As a result, we calculated the test statistic using both options, but we chose to use the tests based on option a) to carry our decision on the merit or otherwise of keeping the shift dummy in the cointegration analysis.

Figure 4.1 shows the results of the M1 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.2. Figure (A) on both figures show the recursive estimates of all parameters, while Figure (B) uses full sample estimates to concentrate out short-term parameters. As can be seen when full re-estimation of all parameters is carried out at each point in the recursion, the test statistic shows a sharp drop around 1998. However, when we concentrate out the short-run dynamics using the full sample estimates both models show no sign of instability. Based on the results, we focus in the final section on a VECM model where we estimate the cointegration excluding the shift dummy.

Figure 4.1 Recursive Tau statistic for the M1 money demand function without shift dummy

Figure (A): The recursive estimate of all parameters

Figure (B): Full sample estimates to concentrate out short-term parameters



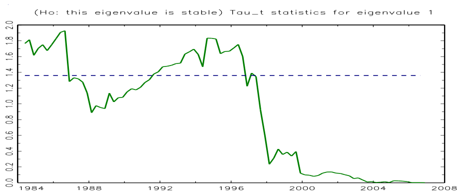
(Figure A) *(Figure B)*

[5] Lutkepohl and Kratzig (2004)

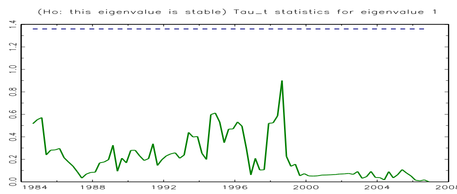
Figure 4.2 Recursive Tau statistic for the M1 money demand function including shift dummy

Figure (A): The recursively estimates of all parameters

Figure (B): Full sample estimates to concentrate out short-term parameters



(Figure A)



(Figure B)

Next, the Vector Error Correction Model (VECM) is adopted to capture the short-run relationship in money the demand function in Thailand. *Table 4.5* presents the result of the VECM for the M1 money demand in Thailand between 1980Q1-2007Q1. As can be seen, the coefficient on the error correction term in D(LnRealM1) and D(LnGDP) are 1% significant, meaning that M1 money demand and real income have adjusted to the long-run equilibrium relationship.

Taking D(LnRealM1) as dependent variables, the coefficient of ECT (-1) is -0.19. As error correction terms indicate the speed adjustment to the long-run equilibrium, it can be said that the disequilibrium of the M1 money demand function in Thailand will be corrected approximately 19% within a quarter. The coefficient in the second column presents the change of lag variable on the current change of the M1 money demand in Thailand. Only the coefficient of D(LnRealM1 (-1)) appeared to be insignificant while other variables are significant. The coefficient of D(LnRealM1(-2)) is -0.23, indicating that a 1% increase in M1 money demand in the last quarter caused a decrease of around 0.23% of the current M1 money demand. The coefficient of D(LNGDP (-1)) is 1, suggesting that if income of the prior quarter increased by 1%, M1 money demand in the current quarter is increased by 1%. The coefficient of R equals -0.01, meaning that a 1% decrease in interest rates in the quarter leads to an increase in the current M1 money demand of around 0.01%

.

Table 4.5 The result of the VECM for the M1 money demand (1980:1– 2007:1)

Error Correction:	D(LnRealM1)	D(LnGDP)
CointEq1	-0.191 [-5.38]	-0.034 [-2.83]
D(LnRealM1(-1))	-0.122 [-1.463]	0.054 [1.91]
D(LnRealM1(-2))	-0.232 [-2.84]	0.017 [0.62]
D(LnGDP(-1))	1.004 [3.38]	0.222 [2.21]
D(LnGDP(-2))	-0.954 [-3.36]	0.071 [0.74]
R	-0.011 [-4.72]	-0.001 [-1.83]

Taking only the significant variables and eliminating insignificant variables, the VECM equations for the M1 money demand in Thailand can be written as:

$$
\begin{array}{l}
Ln\,RealM1 = -0.19ECT_{t-1} - 0.23\Delta Ln\,RealM1_{t-2} + 1.00\Delta LnGDP_{t-1} - 0.98\Delta LnGDP_{t-2} - 0.01R \\
\qquad\qquad (-5.38) \qquad\qquad (-2.84) \qquad\qquad (3.38) \qquad\qquad (-3.36) \qquad\qquad (-4.72)
\end{array}
$$

R-squared = 0.39 F-statistic = 10.71 Akaike AIC = -3.13

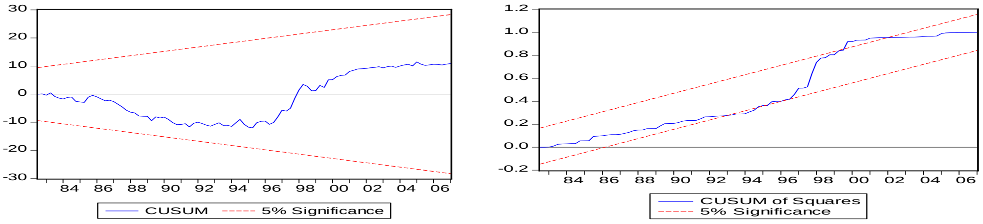
AR 1-4 test: F (4-96) = 1.83 (0.12) ARCH 1-4 test: F (5, 95) = 1.73 (0.13)

Hetero test: F (12, 93) = 1.88 (0.06) RESET test F (1, 99) = 17.36(0.00)

The stability of parameters in the simple M1 money demand function

To test a stability of the money demand function in this section, the CUSUM and CUSUMSQ proposed by Brown, Durbin, and Evans (1975) are employed. The test of CUSUM is based on the cumulative sum of recursive residuals, while CUSUMSQ is based on the squared recursive residuals. If the plot of CUSUM and/or CUSUMSQ stays within given significant levels, it can be said that the coefficient estimates are stable. As can be seen in Figure 4.3(A), the estimate of CUSUM seems to be stable over the sample periods as the demand equation stays within 5% critical. However, the CUSUMSQ in Figure 4.3(B) shows that there is an evidence of instability around Thailand's financial crisis period (1988-2001).

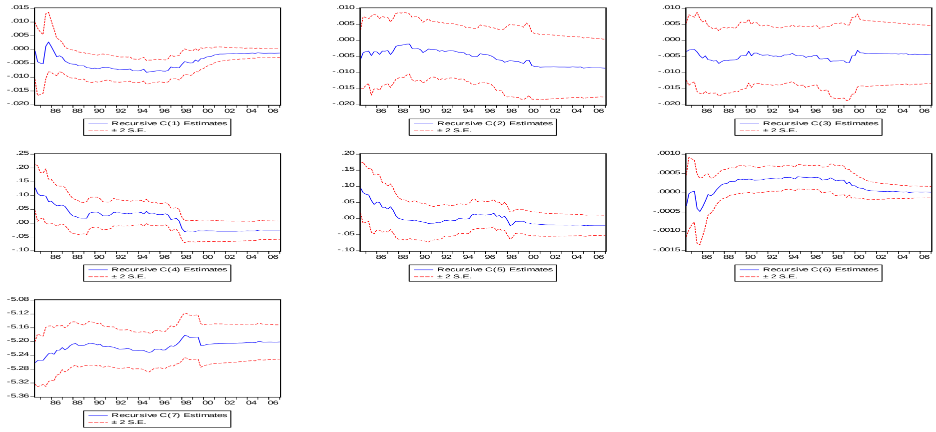
Figure 4.3 Plot of CUSUM and CUSUMSQ



(A) Plot of CUSUM *(B) Plot of CUSUMSQ*

The recursive coefficient is presented in Figure 4.4. It is not surprising that the results show the estimated coefficient seems to be constant after 1997.

Figure 4.4 Plot of the recursive coefficient



Money overhang and inflation

In this step, we will test whether the estimate of money demand equation is helping forecast inflation at different lags. The money overhang in this section is:

$$OM1 = LnrealM1 - (\alpha + \beta LnGDP + \gamma R)$$

where OM1 is money overhang calculated from the M1 long-run money demand function. To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead inflation is regressed on one to four–quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang).

The results of money overhang and inflation are that:

One-quarter-ahead inflation and money overhang

$$INF = 0.02 + 0.44 INF_{t-1} + 0.005 OM1_{t-1}$$
$$(0.31) \quad (4.24\ ) \quad (0.81)$$

R-squared = 0.18 Prob(F-statistic) = 0.00 DW = 1.81

AR test: F (12-92) = 0.59 (0.89) ARCH test: F (12, 82) = 0.60(0.83)

Hetero test: F (12, 93) = 2.40 (0.05) RESET test F (1, 99) = 0.34 (0.56)

Four-quarter-ahead inflation and money overhang

$$INF = 0.28 + 0.35 INF_{t-1} + 0.11 INF_{t-2} + 0.09 INF_{t-3} + 0.14 INF_{t-4} + 0.005 OM1_{t-1}$$
$$(0.33) \quad (3.03) \quad (0.96) \quad (0.80) \quad (1.54) \quad (0.87)$$

R-squared = 0.25 Prob(F-statistic) = 0.00 DW = 1.81

AR test: F (12-86) = 0.21 (0.99) ARCH test: F (12, 79) = 0.48 (0.91)

Hetero test: F (10, 93) = 6.13 (0.00) RESET test F (1, 97) = 0.85 (0.35)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.06 + 0.03 INF_{t-5} + 0.03 INF_{t-6} + 0.03 INF_{t-7} + 0.11 INF_{t-8} + 0.01 OM1_{t-5}$$
$$(1.99) \quad (0.19) \quad (0.24) \quad (0.25) \quad (0.88) \quad (1.79)$$

R-squared = 0.06 Prob(F-statistic) = 0.05 DW = 1.06

AR test: F (12-82) = 1.73 (0.08) ARCH test: F (12, 77) = 0.68 (0.72)

Hetero test: F (10, 89) = 0.44 (0.91) RESET test F (1, 93) =1.46 (0.22)

Overall, money overhang that is calculated from the M1 money demand function in this model might not help in forecasting one and four-quarter-ahead forecasts due to the coefficient of money overhang not being significant for the one and four-quarter-ahead forecasting. However, it might help in forecasting the eight-quarter-ahead inflation.

4.3.2.2 The result of the M1 money demand function (include LnEXC and LIBOR)

To estimate the cointegration between the M1 money demand (LnRealM1), real income (LnGDP), domestic interest rates (R), the exchange rate (EXC), and LIBOR, we start by testing pair-wise cointegration between the set of variables. Table 4.6(A) presents the pair-wise with shift dummy (sdum). The results suggest that the null hypothesis pair-wise cointegration rejects at 10% significant for LnRealM1 and R, and it is 1% significant for the pair-wise relationship between LnGDP and R, and between R and LnEXC. It can be said that there is a long-run relationship between real income and interest rates, and between the exchange rate and interest rates. The result of pair-wise cointegration including intercept and trend but excluding the shift dummy variable in Table 4.6(B) suggests that the LnRealM1 has a pair-wise relationship with LnGDP at 10% significance. In addition, there is a pair-wise relationship between LnGDP and R at 5% significant level. The test without the shift dummy and trend in Table 4.6(C) shows that there is pair-wise relationship between LnGDP and LnEXC at 10% significant level. However, given 5% significance, there is no pair-wise cointegrating with all variables included in the equations.

Table 4.6 The result of pair-wise cointegration of the M1 money demand in Thailand

4.6(A) Determinants: Trend, intercept, and shift dummy

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM1 and LnGDP	5	ro=0	10.81	*13.88*	*15.76*	*19.71*
		ro=1	1.29	*5.47*	*6.79*	*9.73*
LnRealM1 and R	5	ro=0	14.77***	*13.88*	*15.76*	*19.71*
		ro=1	0.00	*5.47*	*6.79*	*9.73*
LnRealM1 and LnEXC	1	ro=0	12.06	*13.88*	*15.76*	*19.71*
		ro=1	3.97	*5.47*	*6.79*	*9.73*
LnRealM1 and LIBOR	5	ro=0	9.12	*13.88*	*15.76*	*19.71*
		ro=1	0.00	*5.47*	*6.79*	*9.73*
LnGDP and R	4	ro=0	23.27*	*13.88*	*15.76*	*19.71*
		ro=1	0.63	*5.47*	*6.79*	*9.73*
LnGDP and LnEXC	4	ro=0	8.39	*13.88*	*15.76*	*19.71*
		ro=1	0.15	*5.47*	*6.79*	*9.73*
LnGDP and LIBOR	4	ro=0	8.96	*13.88*	*15.76*	*19.71*
		ro=1	0.13	*5.47*	*6.79*	*9.73*
R and LnEXC	5	ro=0	23.43*	*13.88*	*15.76*	*19.71*
		ro=1	2.74	*5.47*	*6.79*	*9.73*
R and LIBOR	4	ro=0	7.39	*13.88*	*15.76*	*19.71*
		ro=1	4.74	*5.47*	*6.79*	*9.73*
LnEXC LIBOR	1	ro=0	8.10	*13.88*	*15.76*	*19.71*
		ro=1	3.23	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.6(B) Determinants: Trend, intercept

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM1 and LnGDP	5	ro=0	14.21***	*13.88*	*15.76*	*19.71*
		ro=1	1.33	*5.47*	*6.79*	*9.73*
LnRealM1 and R	5	ro=0	10.35	*13.88*	*15.76*	*19.71*
		ro=1	0.67	*5.47*	*6.79*	*9.73*
LnRealM1 and LnEXC	1	ro=0	1.74	*13.88*	*15.76*	*19.71*
		ro=1	3.62	*5.47*	*6.79*	*9.73*
LnRealM1 and LIBOR	5	ro=0	10.65	*13.88*	*15.76*	*19.71*
		ro=1	0.67	*5.47*	*6.79*	*9.73*
LnGDP and R	3	ro=0	15.27**	*13.88*	*15.76*	*19.71*
		ro=1	0.43	*5.47*	*6.79*	*9.73*
LnGDP and LnEXC	5	ro=0	6.96	*13.88*	*15.76*	*19.71*
		ro=1	0.72	*5.47*	*6.79*	*9.73*
LnGDP and LIBOR	4	ro=0	8.48	*13.88*	*15.76*	*19.71*
		ro=1	0.36	*5.47*	*6.79*	*9.73*
R and LnEXC	4	ro=0	13.78	*13.88*	*15.76*	*19.71*
		ro=1	3.79	*5.47*	*6.79*	*9.73*
R and LIBOR	4	ro=0	7.60	*13.88*	*15.76*	*19.71*
		ro=1	3.68	*5.47*	*6.79*	*9.73*
LnEXC LIBOR	1	ro=0	6.74	*13.88*	*15.76*	*19.71*
		ro=1	3.89	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.6(C) Determinants: Intercept

Variables	No. of lags	H0: r=r0	Test statistic	*Critical Value*		
				10%	*5%*	*1%*
LnRealM1 and LnGDP	4	ro=0	5.84	*10.47*	*12.26*	*16.10*
		ro=1	2.34	*2.98*	*4.13*	*6.93*
LnRealM1 and R	1	ro=0	9.56	*10.47*	*12.26*	*16.10*
		ro=1	2.23	*2.98*	*4.13*	*6.93*
LnRealM1 and LnEXC	1	ro=0	8.32	*10.47*	*12.26*	*16.10*
		ro=1	2.23	*2.98*	*4.13*	*6.93*
LnRealM1 and LIBOR	4	ro=0	10.36	*10.47*	*12.26*	*16.10*
		ro=1	1.14	*2.98*	*4.13*	*6.93*
LnGDP and R	5	ro=0	9.45	*10.47*	*12.26*	*16.10*
		ro=1	2.84	*2.98*	*4.13*	*6.93*
LnGDP and LnEXC	5	ro=0	11.60***	*10.47*	*12.26*	*16.10*
		ro=1	2.94	*2.98*	*4.13*	*6.93*
LnGDP and LIBOR	5	ro=0	12.11	*10.47*	*12.26*	*16.10*
		ro=1	1.80	*2.98*	*4.13*	*6.93*
R and LnEXC	1	ro=0	10.37	*10.47*	*12.26*	*16.10*
		ro=1	0.01	*2.98*	*4.13*	*6.93*
R and LIBOR	5	ro=0	4.60	*10.47*	*12.26*	*16.10*
		ro=1	0.04	*2.98*	*4.13*	*6.93*
LnEXC LIBOR	1	ro=0	4.89	*10.47*	*12.26*	*16.10*
		ro=1	0.04	*2.98*	*4.13*	*6.93*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

The results for cointegration among LnRealM1, LnGDP, R, LnEXC, and LIBOR are presented in Table 4.7. The results of the model that included intercept, trend, and the shift dummy variable indicates that the null hypothesis of $r_0 = 1$ is rejected at 5% significance level, since the test statistic (50.26) is greater than 5% critical value (45.32). This indicates that there are two cointegrating equations in the long-run between LnRealM1, LnGDP, R, LnEXC, and LIBOR. However, the results from the model that included intercept and trend suggests that there is a single cointegration vector between five variables. This result is similar to the test with only intercept, as the result suggests that there is one combination of variables where all variables are integrated since the null hypothesis of r=0 is rejected at 1% significant level.

Table 4.7 Cointegration of the M1 money demand function *when LnEXC and LIBOR are included* (1980:1–2007:1)

Variables	Deterministic	No of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM1, LnGDP, LnEXC, R, LIBOR	Trend, intercept, and shift dummy	1	ro=0	88.21*	62.45	66.13	73.42
			ro=1	50.26**	*42.25*	*45.32*	*51.45*
			ro=2	18.79	*26.07*	*28.52*	*33.50*
			ro=3	3.64	*13.88*	*15.76*	*19.71*
			ro=4	0.69	*5.48*	*6.79*	*9.73*
LnRealM1, LnGDP, LnEXC, R, LIBOR	Trend and intercept	3	ro=0	88.72*	62.45	66.13	73.42
			ro=1	29.89	*42.25*	*45.32*	*51.45*
			ro=2	13.13	*26.07*	*28.52*	*33.50*
			ro=3	5.21	*13.88*	*15.76*	*19.71*
			ro=4	0.36	*5.48*	*6.79*	*9.73*
LnRealM1, LnGDP, LnEXC, R, LIBOR	Intercept	3	ro=0	96.37*	62.45	66.13	73.42
			ro=1	37.03	*42.25*	*45.32*	*51.45*
			ro=2	13.86	*26.07*	*28.52*	*33.50*
			ro=3	5.17	*13.88*	*15.76*	*19.71*
			ro=4	0.80	*5.48*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Overall, it can be said that there exists a single cointegration between the five variables in the M1 money demand when the equation excludes the shift dummy variable. Next, we will use the normalized cointegration vector by setting the coefficient of LnRealM1 as -1 and divide the other variables with -1. The equation presents the long run elasticity of each variable on the M1 money demand.

Table 4.8 presents the normalized cointegrating vector of the M1 money demand function in Thailand when the exchange rate (LnEXC) and LIBOR variables are included. The coefficient of LnGDP, R and EXC is significant at 1% while the coefficient of LIBOR is not, suggesting that real income, interest rates and the exchange rate have an affect on M1 money holding in Thailand in the long run while LIBOR has not. Income elasticity is 1.14, suggesting that an increase of 1% real income leads to an increase of 1.14% in M1 money demand. Interest rate elasticity for M1 money demand is -0.49, suggesting that M1 money holding will drop by 0.49% if domestic interest rates (R) increase by 1%. In case of the exchange rate elasticity, there is a negative coefficient of the exchange rate on M1 money holding. This implies there is a currency substitution in Thailand when the exchange rate is expected to depreciate. The expected return from foreign assets increases and this causes more demand on foreign currency and less demand on domestic currency, and so money demand declines.

Table 4.8 The normalizing of the M1 money demand function in Thailand when LnEXC and LIBOR are included (1980:1–2007:1)

LnRealM1	*LnGDP*	*R*	*LnEXC*	*LIBOR*	*C*
-1	*1.14*	*-0.49*	*6.97*	*0.02*	*-22.91*
	[-2.69]	*[8.40]*	*[7.62]*	*[-0.49]*	*[-5.80]*

Note : The number in parentheses shows the t-statistics.

The results of weak exogeneity of variables in the cointegration in Table 4.9 shows that only LnEXC is insignificant, indicating that the exchange rate (LnEXC) is a long-run weak exogeneity with respect to the cointegration vector. However, other variables are exogenous variables since they rejected the null hypothesis at 1% significant level. The vector error correction in the next step will be tested by using LnEXC as an exogenous variable while the others are endogenous.

Table 4.9 Weak exogenous test

Variable	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
Restrictions: [illegible]				
LnRealM1	322.76	7.83	1.00	0.01
Restrictions: [illegible]				
LnGDP	395.27	13.71	1.00	0.00
Restrictions: [illegible]				
R	396	12	1	0.00
Restrictions: [illegible]				
LnEXC	332.72	0.19	1.00	0.66
Restrictions: [illegible]				
LIBOR	331.4	3.1	1.0	0.01

Figure 4.5 shows the results of the M1 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.6. Figure (A) on both figures shows the recursive estimate of all parameters, while Figure (B) uses full sample estimates to concentrate out short-term parameters.

As can be seen, when the full sample of all parameters is carried out at each point in the recursion, the test statistic shows there is a sharp drop around 1998. However, the results show that there is no sign of instability when we concentrate out the short-run dynamics using the full sample estimates.

Figure 4.5 Recursive Tau statistics for the M1 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure (B): Full sample estimates to concentrate out short-term parameters

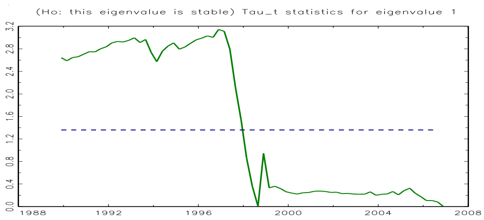
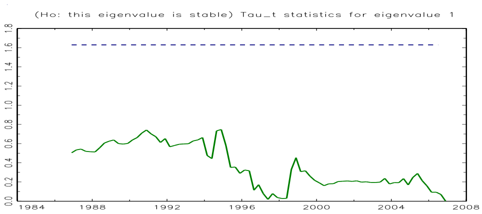


Figure (A)



(Figure(B)

Figure 4.6 Recursive Tau statistics for M1 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters

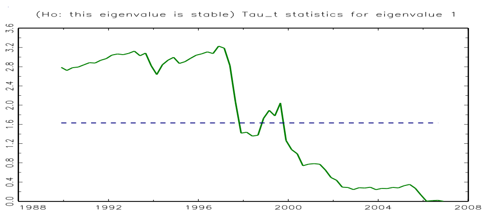
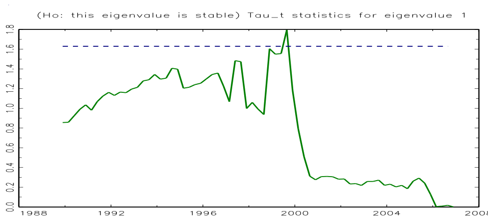


Figure (A)



Figure(B)

The Vector Error Correction Model (VECM) of M1 money demand is presented in Table 4.10. The coefficient on the error correction term in D(LmRealM1), D(LnGDP), D(R) and D(LIBOR) appear to be 1% significant. It can be concluded that all variables have adjusted to the long-run equilibrium relationship.

Taking D(LnRealM1) as dependent variables, the coefficient of ECT (-1) is 0.03, meaning that disequilibrium of the M1 money demand function in Thailand will be corrected by about 3% within a quarter. The coefficient of D(LnNRealM1(-1)) and D(LnRealM1(-2)) are significant at 1% and 5%. This implies that changes in M1 money demand in the past led to a change in current M1 money demand. The coefficient of D(LNGDP (-1)) is 0.9 (1% significant), suggesting that if income of the prior quarter increased by 1%, M1 money demand in the current quarter is increased by 0.92%. The coefficient of D(R(-2)) is -0.02, implying that M1 money demand will increase by 0.02% if the interest rate in last two quarters drops by 1%.

Table 4.10 The result of VECM for M1 money demand

Error Correction:	*D(LnRealM1)*	*D(LnGDP)*	*D(R)*	*D(LIBOR)*
CointEq1	*-0.03* *[-2.72371]*	*-0.01* *[-4.77070]*	*-0.51* *[-3.52451]*	*-0.50* *[-2.74967]*
D(LnRealM1(-1))	*-0.18* *[-1.92647]*	*0.04* *[1.28755]*	*0.36* *[0.24775]*	*0.76* *[0.42268]*
D(LnRealM1(-2))	*-0.24* *[-2.67236]*	*0.00* *[0.16210]*	*-0.86* *[-0.61206]*	*1.92* *[1.09388]*
D(LnGDP(-1))	*0.92* *[2.73999]*	*0.05* *[0.46423]*	*-4.29* *[-0.83287]*	*-7.01* *[-1.08296]*
D(LnGDP(-2))	*-1.16* *[-3.52108]*	*-0.10* *[-1.01972]*	*-7.92* *[-1.57804]*	*-11.93* *[-1.89340]*
D(R(-1))	*0.00* *[0.65415]*	*0.00* *[1.69870]*	*0.23* *[2.17317]*	*0.13* *[0.96502]*
D(R(-2))	*-0.02* *[-2.78153]*	*0.00* *[-2.05662]*	*0.25* *[2.42068]*	*0.15* *[1.16687]*
D(LIBOR(-1))	*0.00* *[-0.48184]*	*0.00* *[-0.00983]*	*0.05* *[0.58944]*	*0.10* *[0.92700]*
D(LIBOR(-2))	*0.00* *[-0.96548]*	*0.00* *[-0.56603]*	*-0.03* *[-0.40100]*	*-0.28* *[-2.79246]*
LnEXC	*-0.10* *[-2.61794]*	*-0.05* *[-4.57786]*	*-2.11* *[-3.57739]*	*-2.06* *[-2.77605]*

Taking only the significant variables and eliminating insignificant variables, the VECM equations for the M1 demand in Thailand in this can be written as:

$$
\begin{aligned}
Ln\,\mathrm{Re}\,alM1 = {} & -0.03ECT_{t-1} - 0.18\Delta Ln\,\mathrm{Re}\,alM1_{t-1} - 0.24\Delta Ln\,\mathrm{Re}\,alM1_{t-2} + 0.92\Delta LnGDP_{t-1} \\
& \quad (2.72) \qquad\qquad (-1.92) \qquad\qquad\qquad (-2.67) \qquad\qquad\qquad (2.73) \\
& -0.02\Delta(R_{t-2}) - 0.10LnEXC \\
& \quad (-2.78) \qquad\quad (-2.61)
\end{aligned}
$$

R-squared = 0.39 F-statistic = 6.88 Akaike AIC = -3.07

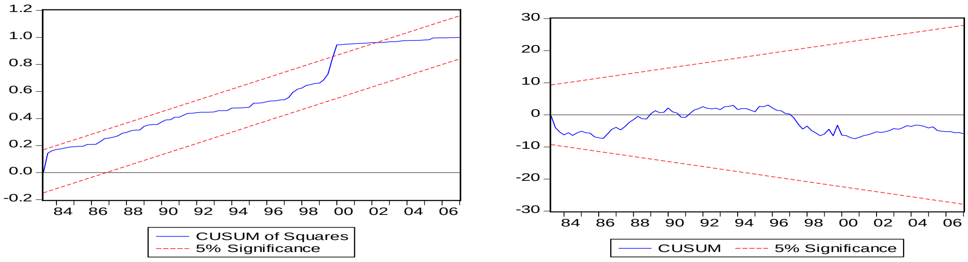
AR 1-4 test: F (12,80) = 1.26 (0.25) ARCH 1-4 test: F (12, 83) = 1.27 (0.24)

Hetero test: F (20, 84) = 1.88 (0.06) RESET test F (1, 99) = 4.86 (0.00)

The stability of parameters in the simple M1 money demand function

To test the stability of the money demand function in this section, the CUSUM and CUSUMSQ are employed. If the plot of CUSUM and/or CUSUMSQ stay within a given significant level, it can be said that the coefficient estimates are stable. As can be seen in Figure 4.7(A), the estimate of CUSUM appeared to be stable over the sample periods as the demand equation stayed within 5% critical. However, the CUSUMSQ in Figure 4.7(B) shows that there is an evidence of instability during 1999-2001.

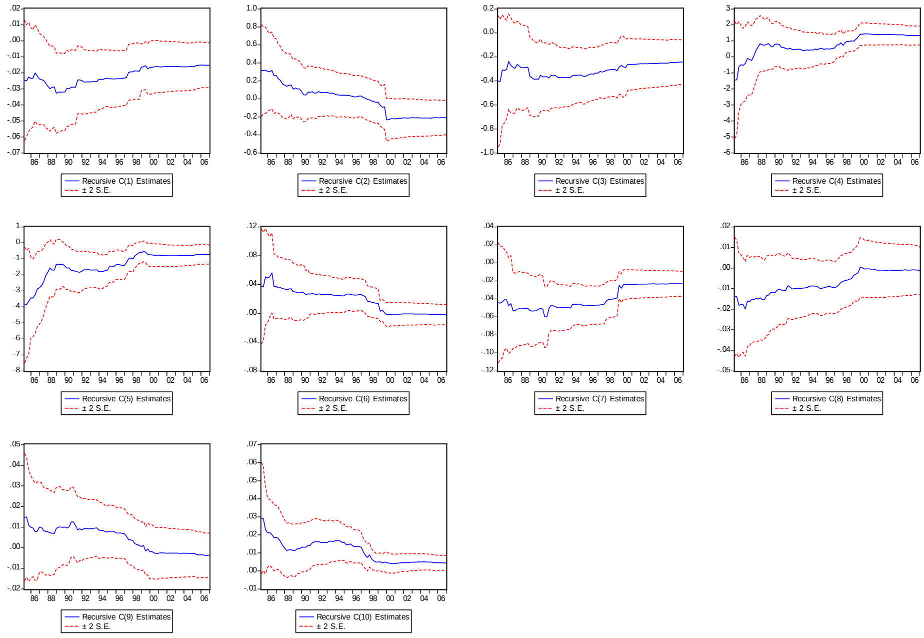
Figure 4.7 Plot of CUSUM and CUSUMSQ



(A) Plot of CUSUM *(B) Plot of CUSUMSQ*

The recursive coefficient is presented in Figure 4.8. It is not surprising that the results show the estimated coefficient seems to be constant after 1999.

Figure 4.8 Plot of recursive coefficient



Money overhang and inflation

In the next step, we will test whether the estimate of the money demand equation is helping forecast inflation at differing lags. As the variable LnEXC and LIBOR are added in this section, the money overhang in this model is:

$$OM1EX = LnrealM1 - (\alpha + \beta LnGDP + \gamma R + \eta LnEXc + \lambda LIBOR)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four-quarter- ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One-quarter-ahead inflation and money overhang

$$INF = 0.007 + 0.39INF_{t-1} + 0.0007OM1EX_{t-1}$$
$$(5.06) \quad (3.84) \quad (2.75)$$

R-squared = 0.23 Prob(F-statistic) = 0.00 DW = 1.81

AR test: F (12-92) = 0.37 (0.97) ARCH test: F (12, 82) = 0.50 (0.90)

Hetero test: F (5, 101) = 2.34 (0.05) RESET test F (1, 103) = 0.78 (0.37)

Four-quarter-ahead inflation and money overhang

$$INF = 0.04 + 0.33INF_{t-1} + 0.11INF_{t-2} + 0.06INF_{t-3} + 0.15INF_{t-4} + 0.005OM1EX_{t-1}$$
$$(2.48) \quad (2.98) \quad (0.93) \quad (0.56) \quad (1.36) \quad (0.79)$$

R-squared = 0.27 Prob(F-statistic) = 0.00 DW = 1.81

AR test: F (12-86) = 0.16 (0.99) ARCH test: F (12, 79) = 0.49 (0.91)

Hetero test: F (20, 83) = 4.59 (0.00) RESET test F (1, 97) = 2.70 (0.10)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.008 + 0.06INF_{t-5} + 0.02INF_{t-6} + 0.09INF_{t-7} + 0.09INF_{t-8} + 0.007OM1EX_{t-5}$$
$$(5.16) \quad (0.56) \quad (0.22) \quad (0.80) \quad (0.86) \quad (2.93)$$

R-squared = 0.11 Prob(F-statistic) = 0.04 DW = 1.33

AR test: F (12-82) = 1.27 (0.24) ARCH test: F (12, 75) = 0.76 (0.68)

Hetero test: F (10, 89) = 0.44 (0.91) RESET test F (1, 94) =1.15 (0.28)

Overall, money overhang that is calculated from the M1 money demand function that includes the variable exchange rate and LIBOR can help in forecasting the inflation rate in Thailand since the coefficient of money overhang appeared to be a positive sign as expected and it appeared to be significant. In addition, there is no evidence of serial correlation for those three forecasting equations.

4.3.2.3 The result of the M2 Money demand function: simple model testing

This section presents the empirical result of the stable long-run and short-run relationship of the M2 money demand function in Thailand using the longer data set from 1980Q1-2007Q1. The estimation is started by pair-wise cointegration. The result of pair-wise cointegration in Table 4.11 indicates that there is no pair-wise cointegration between LnRealM2, LnGDP and R for the test allowing time trend in the series, both including and excluding the shift dummy variable. However, there is an evidence of pair-wise cointegration between M2 money demand and real income for the test excluding trend and the shift dummy variable as suggested by the test statistic of pair-wise cointegration greater than 5% critical value.

Table 4.11 The pair-wise cointegration results for the M1 money demand function

Variables: LnRealM2, LnGDP, R

Variables	Determinants	No of lags	H0: r=r0	Test statistic	Critical Value 10%	5%	1%
LnRealM2 and LnGDP	Trend, intercept,	2	ro=0	2.75	13.88	15.76	19.71
	and shift dummy		ro=1	0.29	5.47	6.79	9.73
LnRealM2 and R	Trend, intercept,	3	ro=0	8.46	13.88	15.76	19.71
	and shift dummy		ro=1	1.08	5.47	6.79	9.73
LnGDP and R	Trend, intercept,	3	ro=0	13.19	13.88	15.76	19.71
	and shift dummy		ro=1	0.57	5.47	6.79	9.73
LnRealM2 and LnGDP	Trend, intercept	5	ro=0	5.57	13.88	15.76	19.71
			ro=1	0.49	5.47	6.79	9.73
LnRealM2 and R	Trend, intercept	5	ro=0	9.95	13.88	15.76	19.71
			ro=1	1.50	5.47	6.79	9.73
LnGDP and R	Trend, intercept	5	ro=0	11.39	13.88	15.76	19.71
			ro=1	0.58	5.47	6.79	9.73
LnRealM2 and LnGDP	Intercept	2	ro=0	14.63**	10.47	12.26	16.10
			ro=1	0.39	2.98	4.13	6.93
LnRealM2 and R	Intercept	5	ro=0	6.76	10.47	12.26	16.10
			ro=1	0.22	2.98	4.13	6.93
LnGDP and R	Intercept	5	ro=0	9.45	10.47	12.26	16.10
			ro=1	2.84	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

The result of multivariate cointegration for the M2 money demand function in Thailand is presented in Table 4.12 The results suggest that in the case where the shift dummy and time trend are included, the null hypothesis of $r_0 = 0$ is rejected at 1% significant level. This suggests that there is a single cointegrating vector between LnRealM1, LnGDP, and R. Similarly, the test with intercept but no trend and shift dummy also suggests that there is a single cointegrating vector in the M2 money demand function since it rejected the null hypothesis of $r_0 = 0$ at 1% significance. The cointegration result of the model with intercept and trend indicates that there is at least one combination where all variables are cointegrated in the M2 money demand function in Thailand since the null hypothesis of $r_0 = 0$ is rejected at 1% significant level. Overall, there exists a stable long-run relationship among M2 money demand, domestic income (GDP) and domestic interest rates (R) in the Thai economy.

Table 4.12 The cointegration results for M2 money demand (1980:1-2007:1)
LnRealM2, LnGDP, R

Variables	Determinants	No of lags	H0: r=r0	Test statistic	Critical Value 10%	5%	1%
LnRealM2,LnGDP and R	Trend, intercept, and shift dummy	4	ro=0	36.46*	26.07	28.5	33.5
			ro=1	6.23	13.88	15.76	19.71
			ro=2	0.04	5.47	6.79	9.73
LnRealM2,LnGDP and R	Trend and intercept	4	ro=0	60.79*	26.07	28.5	33.5
			ro=1	13.46	13.88	15.76	19.71
			ro=2	1.51	5.47	6.79	9.73
LnRealM2,LnGDP and R	Intercept	3	ro=0	29.32*	21.76	24.2	29.1
			ro=1	6.57	10.47	12.26	16.1
			ro=2	2.13	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Since the results of cointegration above strongly suggest that there is a single cointegration vector among M2 money demand, real income (GDP) and interest rates (R) when the test included trend, both with and without the shift dummy variable, then it may not be necessary to include a shift dummy in the normalized cointegration analysis in the next step. Table 4.13 presents the normalized cointegrating vector of the M2 money demand function in Thailand by using the data from 1980Q1-2007Q1. As can be seen, the coefficients of both LnGDP and R are strongly significant at a 1% level, suggesting that real income and interest rates affect the M2 money holding in Thailand in the long run. The income elasticity of M2 money demand is 3.26, meaning that a 1% increase in real GDP in Thailand leads to a 3.26% increase in the M2 money demand in Thailand. The domestic interest rate (R) elasticity is -0.12, indicate that in the long run if domestic interest rates increase by 1%, the M1 money demand will drop by around 0.12%.

Table 4.13 The Normalized cointegration for M2 money demand function (1980:1-2007:1)

LnrealM2	LnGDP	R	Trend	C
-1	3.265 [-11.20]	-0.127 [7.06]	0.039 [6.761]	14.011

Note: The number in parentheses show the t-statistic.

Table 4.14 shows the result of weak exogeneity of variables in the cointegration. The results show that LnRealM2 and R are 1% significant and LnGDP is 5% significant. It can be said that LnRealM2, R and GDP are not a long-run weak exogeneity with respect to the cointegration vector. Therefore, we can continue the VECM in the next step by using LnRealM2, LnGDP and R as endogenous.

Table 4.14 Test for Cointegration Restriction for weak exogeneity (1980:1-2007:1)

Variable No. of CE(s)	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
		Restrictions: [illegible]		
LnRealM2	398.3074	7.55231	1	0.01
		Restrictions: [illegible]		
LnGDP	399.61	4.96	1.00	0.03
		Restrictions: [illegible]		
R	392.93	18.31	1.00	0.00

NA indicates restriction not binding.
CE represents the cointegration equation.

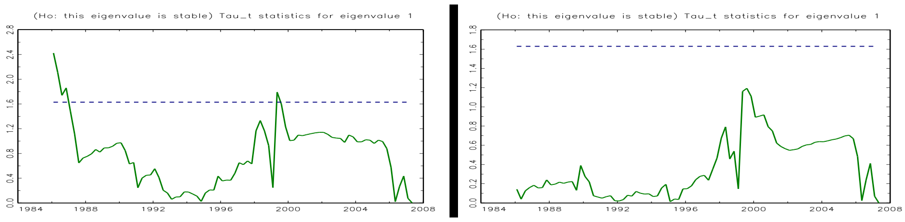
Next, we will test the stability of the M2 money demand function in Thailand by using a formal test for parameter stability in the context of recursive estimation of the eigenvalue associated with the test for cointegration. Figure 4.9 shows the results of the M2 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.10.

Figure(A) shows the recursive estimates of all parameters, while Figure(B) uses full sample estimates to concentrate out short-term parameters. As can be seen when full re-estimation of all parameters is carried out at each point in the recursion, the test statistic shows a sharp drop around 1998. However, when we concentrate out the short-run dynamics using the full sample estimates, both models show no sign of instability. Based on the results, we focus in the final section on a VECM model where we estimate the cointegration excluding the shift dummy; it appears to contribute neither to the cointegration result nor to the stability.

Figure 4.9 Recursive Tau statistics for the M2 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters

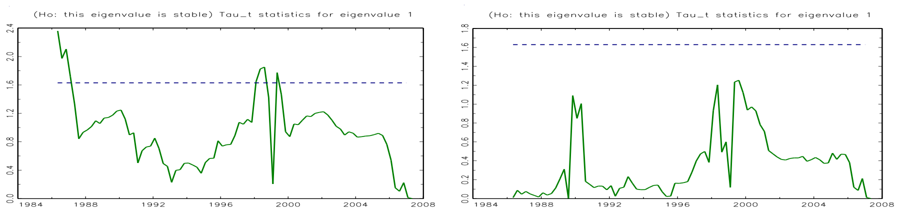


Figure(A) *Figure(B)*

Figure 4.10 Recursive Tau statistics for M2 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters



Figure(A) *Figure(B)*

To achieve the result of a short-run stable relationship in the M2 money demand function, the Vector Error Correction Model will be used in the next step. As can be seen in Table 4.15, the coefficient on the error correction term in

D(LnRealM2) and D(R) are 1% significant while 5% significant for D(LnGDP). It can be concluded that M2 money demand, real income, and interest rates have adjusted to the long-run equilibrium relationship rather than interest rates. Considering D(LnRealM2) as a dependent variable, the results found that the error correction term is 1% significant, suggested by the t-statistic being -3.60, greater than 1% critical value for the t-statistic (2.57). The coefficient of ECT (-1) for M2 money demand is -0.07, meaning that the disequilibrium of the M2 money demand function in Thailand will be corrected approximately 7% within a quarter. It interesting that changes of lag for LnRealM2 are insignificant for every lag included, suggesting that the changes of lag for LnRealM2 have no affect on current M2 money holding in the short run. However, the coefficient of D(LnGDP (-3)) is 5% significant with the positive coefficient. The variable ((Δ (R (-3)) is significant at a 5% level. This means that real income and domestic interest rates in the past have an affect on current M2 money demand.

Table 4. 15 The result of the VECM for M1 money demand

Error Correction:	D(LnRealM2)	D(LnGDP)	D(R)
CointEq1	-0.07 [-3.60]	-0.02 [-2.25]	-2.22 [-5.60]
D(LnRealM2(-1))	-0.15 [-1.50]	0.05 [1.15]	-1.36 [-0.67]
D(LnRealM2(-2))	-0.06 [-0.56]	0.03 [0.56]	-0.30 [-0.14]
D(LnRealM2(-3))	-0.02 [-0.24]	-0.03 [-0.67]	-2.48 [-1.23]
D(LnGDP(-1))	-0.28 [-1.11]	0.19 [1.69]	-9.39 [-1.89]
D(LnGDP(-2))	-0.24 [-0.98]	-0.04 [-0.37]	-13.30 [-2.70]
D(LnGDP(-3))	0.50 [-2.06]	-0.06 [-0.50]	-6.05 [-1.26]
D(R(-1))	0.00 [-0.34]	0.00 [0.34]	0.18 [2.05]
D(R(-2))	0.00 [0.13]	-0.01 [-3.22]	0.26 [2.94]
D(R(-3))	-0.01 [1.98]	0.00 [2.34]	-0.01 [-0.07]
C	0.04 [5.41]	0.01 [3.28]	0.44 [2.87]

Taking only the significant variables and eliminating insignificant variables, the VECM equations for M2 demand in Thailand can be written as:

$$Ln\,\mathrm{Re}\,alM1 = -0.07ECT_{t-1} + 0.50\Delta LnGDP_{t-3} - 0.01\Delta R_{t-3}$$
$$\qquad (-3.60) \qquad\qquad (-2.06) \qquad\qquad (1.98)$$

R-squared = 0.16 F-statistic = 1.80 Akaike AIC = -3.78

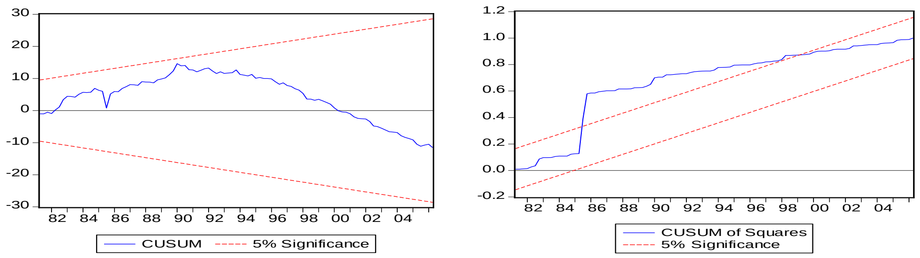
AR 1-4 test: F (24,70) = 1.24 (0.23) ARCH 1-20 test: F (20, 64) = 0.80(0.69)

Hetero test: F (20, 84) = 1.89 (0.06) RESET test F (1, 93) = 18.18 (0.00)

The stability of parameters in the simple M2 money demand function

This section presents the results of the stability of parameters for the M2 money demand function in Thailand by using the CUSUM and CUSUMSQ approach. As can be seen in Figure 4.11, the estimate of CUSUM seems to be stable over the sample periods as the demand equation stays within 5% critical. However, the CUSUMSQ shows that there is an evidence of instability around 1984-1998. The recursive residual also shows that the function is unstable around 1985.

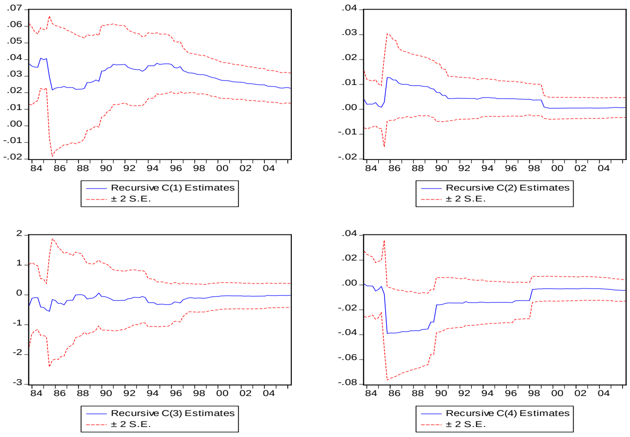
Figure 4.11 Plot of CUSUM and CUSUMSQ



(a) Plot of CUSUM *(B) Plot of CUSUMSQ*

Although CUSUMSQ and the recursive in the last section show the evidence of instability, in the recursive coefficient presented in Figure 4.12 the estimated coefficient seems to be stable after the financial crisis in 1998.

Figure 4.12 Plot of the recursive coefficient



Money overhang and inflation

In this section, we will examine whether the estimate of the M2 money demand equation in the previous section is helping forecast inflation at different lags. The equation of money overhang is:

$$OM2 = LnrealM2 - (\alpha + \beta LnGDP + \gamma R)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four–quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One-quarter-ahead inflation and money overhang

$$INF = 0.053 + 0.44 INF_{t-1} + 0.001 OM2_{t-1}$$
$$(2.24) \qquad (4.49) \qquad (2.01)$$

R-squared = 0.20 Prob (F-statistic) = 0.00 DW = 1.85

AR test: F (12,92) = 0.48 (0.91) ARCH test: F (12, 82) = 0.52 (0.87)

Hetero test: F (4, 102) = 3.17 (0.03) RESET test F (1, 103) = 0.91 (0.34)

Four-quarter-ahead inflation and money overhang

$$INF = 0.05 + 0.34INF_{t-1} + 0.11INF_{t-2} + 0.08INF_{t-3} + 0.18INF_{t-4} + 0.001OM2_{t-1}$$
(2.04) (3.10) (0.99) (0.68) (1.65) (0.79)

R-squared = 0.25 Prob(F-statistic) = 0.00 DW = 1.82

AR test: F (12-86) = 0.19 (0.99) ARCH test: F (12, 79) = 0.57 (0.85)

Hetero test: F (10, 93) = 5.26 (0.00) RESET test F (1, 97) = 3.17 (0.08)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.10 + 0.06INF_{t-5} + 0.06INF_{t-6} + 0.04INF_{t-7} + 0.16INF_{t-8} + 0.003OM2_{t-5}$$
(3.79) (0.48) (0.47) (0.33) (1.30) (3.54)

R-squared = 0.14 Prob(F-statistic) = 0.00 DW = 1.16

AR test: F (12-82) = 0.57 (0.11) ARCH test: F (12, 75) = 1.12 (0.33)

Hetero test: F (10, 89) = 1.60 (0.11) RESET test F (1, 93) =2.00 (0.16)

As can be seen in the equations above, the coefficient money overhang (OM2) is significant at 5% for the one-quarter-ahead model and it is 1% significant for the four-quarter-ahead and the eight-quarter-ahead models. In addition, the coefficient of MO2 for those three equations is a positive sign as expected, indicating that an increase in money overhang in the last quarter leads to an increase in the current inflation rate.

4.3.2.4 The result of the M2 money demand function (include LnEXC and LIBOR)

This section presents the results of the stable long-run relationship of the money demand function by using the money demand model that included the exchange rate (LnEXC) and LIBOR variables. The pair-wise cointegration tests for M2 money demand and each variable are presented in Table 4.16. Table(A) presents the pair-wise with shift dummy (sdum), constant, and trend. Table(B) reports the pair-wise without shift dummy (sdum) and the results allow for time trends in the series and constant, and Table(C) shows the pair-wise cointegration result with intercept only. The results of pair-wise cointegration including the shift dummy (sdum) suggest that the null hypothesis pair-wise cointegration is rejected at 1% significant for LnGDP and R, LnGDP and LIBOR, and R and LnEXC. The results of pair-wise cointegration when intercept and trend are included but excluding the shift dummy variable in Table 4.16(B) suggests that there is only a pair-wise relationship between domestic and international interest rates (R and LIBOR) since the test statistic is 5% significant. The test without the shift dummy and trend in Table 4.16(C) shows that there is a pair-wise cointegration between LnRealM2 andLnEXC, LnGDP and LIBOR, and R and LIBOR at 1% significance.

Table 4. 16The result of pair-wise cointegration of the M2 money demand in Thailand

4.16(A) Determinants: Trend, intercept, and shift dummy

Variables		**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
					10%	***5%***	***1%***
LnRealM2 and	LnGDP	4	ro=0	3.79	*13.88*	*15.76*	*19.71*
			ro=1	0.46	*5.47*	*6.79*	*9.73*
LnRealM2 and	R	4	ro=0	8.46	*13.88*	*15.76*	*19.71*
			ro=1	1.08	*5.47*	*6.79*	*9.73*
LnRealM2 and	LnEXC	4	ro=0	7.03	*13.88*	*15.76*	*19.71*
			ro=1	1.64	*5.47*	*6.79*	*9.73*
LnRealM2 and	LIBOR	4	ro=0	10.46	*13.88*	*15.76*	*19.71*
			ro=1	0.16	*5.47*	*6.79*	*9.73*
LnGDP and	R	4	ro=0	23.27*	*13.88*	*15.76*	*19.71*
			ro=1	0.63	*5.47*	*6.79*	*9.73*
LnGDP and	LnEXC	4	ro=0	8.39	*13.88*	*15.76*	*19.71*
			ro=1	0.15	*5.47*	*6.79*	*9.73*
LnGDP and	LIBOR	4	ro=0	23.27*	*13.88*	*15.76*	*19.71*
			ro=1	0.63	*5.47*	*6.79*	*9.73*
R and	LnEXC	4	ro=0	28.43*	*13.88*	*15.76*	*19.71*
			ro=1	3.32	*5.47*	*6.79*	*9.73*
R and	LIBOR	4	ro=0	7.39	*13.88*	*15.76*	*19.71*
			ro=1	4.74	*5.47*	*6.79*	*9.73*
LnEXC	LIBOR	1	ro=0	8.53	*13.88*	*15.76*	*19.71*
			ro=1	3.23	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

4.16(B) Determinants: Trend, intercept

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM2 and LnGDP	5	ro=0	5.57	*13.88*	*15.76*	*19.71*
		ro=1	0.49	*5.47*	*6.79*	*9.73*
LnRealM2 and R	5	ro=0	9.95	*13.88*	*15.76*	*19.71*
		ro=1	1.50	*5.47*	*6.79*	*9.73*
LnRealM2 and LnEXC	1	ro=0	8.05	*13.88*	*15.76*	*19.71*
		ro=1	0.22	*5.47*	*6.79*	*9.73*
LnRealM2 and LIBOR	4	ro=0	11.10	*13.88*	*15.76*	*19.71*
		ro=1	0.02	*5.47*	*6.79*	*9.73*
LnGDP and R	5	ro=0	11.39	*13.88*	*15.76*	*19.71*
		ro=1	5.58	*5.47*	*6.79*	*9.73*
LnGDP and LnEXC	5	ro=0	6.96	*13.88*	*15.76*	*19.71*
		ro=1	0.72	*5.47*	*6.79*	*9.73*
LnGDP and LIBOR	4	ro=0	8.48	*13.88*	*15.76*	*19.71*
		ro=1	0.36	*5.47*	*6.79*	*9.73*
R and LnEXC	4	ro=0	13.78	*13.88*	*15.76*	*19.71*
		ro=1	3.79	*5.47*	*6.79*	*9.73*
R and LIBOR	1	ro=0	17.25**	*13.88*	*15.76*	*19.71*
		ro=1	3.89	*5.47*	*6.79*	*9.73*
LnEXC LIBOR	1	ro=0	6.74	*13.88*	*15.76*	*19.71*
		ro=1	3.89	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.16(C) Determinants: Intercept

Variables	No. of lags	H0: r=r0	Test statistic	*Critical Value*		
				10%	*5%*	*1%*
LnRealM2 and LnGDP	2	ro=0	14.63**	*10.47*	*12.26*	*16.10*
		ro=1	0.39	*2.98*	*4.13*	*6.93*
LnRealM2 and R	5	ro=0	6.76	*10.47*	*12.26*	*16.10*
		ro=1	0.22	*2.98*	*4.13*	*6.93*
LnRealM2 and LnEXC	1	ro=0	20.57*	*10.47*	*12.26*	*16.10*
		ro=1	0.65	*2.98*	*4.13*	*6.93*
LnRealM2 and LIBOR	5	ro=0	15.71**	*10.47*	*12.26*	*16.10*
		ro=1	1.67	*2.98*	*4.13*	*6.93*
LnGDP and R	5	ro=0	9.45	*10.47*	*12.26*	*16.10*
		ro=1	2.84	*2.98*	*4.13*	*6.93*
LnGDP and LnEXC	5	ro=0	11.60***	*10.47*	*12.26*	*16.10*
		ro=1	2.94	*2.98*	*4.13*	*6.93*
LnGDP and LIBOR	4	ro=0	19.37*	*10.47*	*12.26*	*16.10*
		ro=1	2.23	*2.98*	*4.13*	*6.93*
R and LnEXC	4	ro=0	19.37*	*10.47*	*12.26*	*16.10*
		ro=1	2.23	*2.98*	*4.13*	*6.93*
R and LIBOR	3	ro=0	29.53*	*10.47*	*12.26*	*16.10*
		ro=1	4.36	*2.98*	*4.13*	*6.93*
LnEXC LIBOR	1	ro=0	4.89	*10.47*	*12.26*	*16.10*
		ro=1	0.04	*2.98*	*4.13*	*6.93*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

The results for cointegration among LnRealM2, LnGDP, R, LnEXC, and LIBOR are presented in Table 4.17. The results of the model that included intercept, trend, and the shift dummy variable indicate that the null hypothesis of $r_0 = 1$ is rejected at 10% significant level, since the test statistic is greater than a 10% critical value. This indicates that there are two cointegrating equations in the long run between five variables. However, the results of the model that included intercept and trend suggest that there is a single cointegration vector between five variables as the null hypothesis of $r_0 = 0$ is rejected at 1% significant. The test with only intercept also shows that there are two cointegrating vectors in the model.

Table 4.17 Cointegration of the M1 money demand function

Variables	Deterministic	No of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM2, LnGDP, LnExc, R, LIBOR	Trend, intercept, and shift dummy	1	ro=0	90.51*	62.45	66.13	73.42
			ro=1	42.67***	*42.25*	*45.32*	*51.45*
			ro=2	16.09	*26.07*	*28.52*	*33.50*
			ro=3	4.41	*13.88*	*15.76*	*19.71*
			ro=4	0.61	*5.48*	*6.79*	*9.73*
LnRealM2, LnGDP LnExc, R, LIBOR	Trend and intercept	5	ro=0	90.67*	62.45	66.13	73.42
			ro=1	37.54	*42.25*	*45.32*	*51.45*
			ro=2	26.34	*26.07*	*28.52*	*33.50*
			ro=3	5.44	*13.88*	*15.76*	*19.71*
			ro=4	0.06	*5.48*	*6.79*	*9.73*
LnRealM2, LnGDP LnExc, R, LIBOR	Intercept	5	ro=0	102.71*	62.45	66.13	73.42
			ro=1	47.08**	*42.25*	*45.32*	*51.45*
			ro=2	24.67	*26.07*	*28.52*	*33.50*
			ro=3	9.96	*13.88*	*15.76*	*19.71*
			ro=4	3.39	*5.48*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.18 presents the normalized cointegrating vector of the M2 money demand function in Thailand when the exchange rate (LnExc) and LIBOR variables are included. It should be noted that the coefficient of all variables is significant at 1%, suggesting that real income, interest rates, exchange rates, and LIBOR have an affect on M2 money holding in Thailand. Income elasticity is 2.27%, suggesting that an increase ofs 1% in real income led to an increase of 2.27% in M2 money demand. Interest rate elasticity for M2 money demand appeared as -0.06, suggesting that M2 money holding will drop by 0.06% if domestic interest rates (R) increase by 1%. In the case of exchange rate elasticity, there are negative coefficients of the exchange rate in M2 money holdings. This implied that there is a currency substitution in Thailand when the exchange rate is expected to depreciate. The expected return from foreign assets will increase and it causes more demand on foreign currency and less demand on domestic currency; then domestic money demand may decline. LIBOR has a negative relationship with M2 money holding in Thailand, meaning that a decrease in LIBOR leads to an increase in M2 money holding in Thailand.

Table 4.18 The normalized M1 money demand function in Thailand when LnEXC and LIBOR are included

LnRealM2	LnGDP	R	LnEXC	LIBOR	Trend	C
-1	2.27	-0.06	-2.23	-0.02	0.02	17.92
	[-13.07]	[-6.48]	[-11.49]	[3.38]	[5.62]	

Note: The numbers in parentheses show the t-statistics.

The results of weak exogeneity of variables in the cointegration in Table 4.19 show that only LnRealM2 and LnGDP are significant at 5%. This indicates that M2 money holding (LnRealM2) and real income (LnGDP) is not a long-run weak exogeneity with respect to the cointegration vector. However, other variables are weakly exogenous variables since they do not reject the null hypothesis at any significant level. The vector error correction in the next step will be tested by using LnRealM2 and LnGDP as an endogenous variable while others are exogenous.

Table 4.19 Weak Exogenous

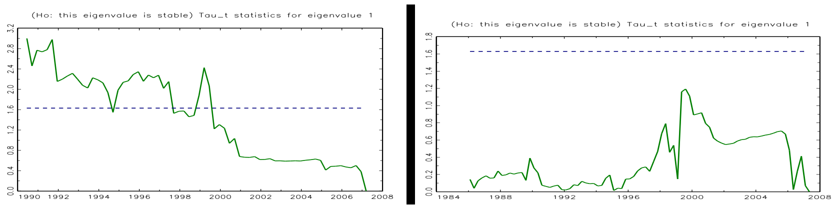
Variable No. of CE(s)	Restricted Log-likelihood	LR Statistic	Degrees of Freedom	Probability
	Restrictions:			
LnRealM2	521.7	3.8	1.0	0.05
	Restrictions:			
LnGDP	521.3	4.52	1.00	0.03
	Restrictions:			
R	522.7	1.8	1.0	0.17
	Restrictions:			
LnEXC	519.3	8.6	1.0	0.3
	Restrictions:			
LIBOR	514.25	18.68	1.00	0.15

Next, we will adopt a recursive estimation in order to analyze the parameter stability of the money demand function. There are two recursive tests in this section. The first option is to concentrate out the short-run parameters (assuming they are stable) using their full sample estimates and the second option is to estimate all parameters recursively. Figure 4.13 shows the results of the M2 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.14. Figure(A) on both figures show the recursive estimates of all parameters, while Figure(B) uses full sample estimates to concentrate out short-term parameters. As can be seen, when the full sample of all parameters is carried out at each point in the recursion, the test statistic shows there is a sharp drop around 1998. However, when we concentrate out the short-run dynamics using the full sample estimates, the results show that there is no sign of instability.

Figure 4.13 Recursive Tau statistics for the M2 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters

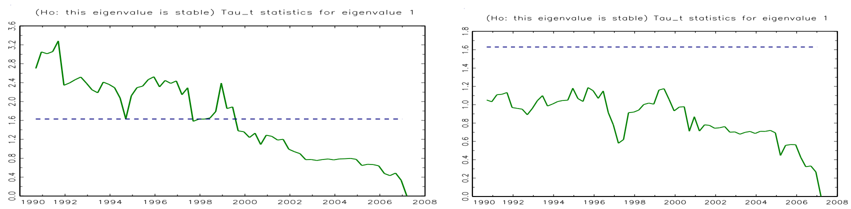


Figure(A) *Figure(B)*

Figure 4.14 Recursive Tau statistics for the M1 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters



Figure(A) *Figure(B)*

The Vector Error Correction Model (VECM) of the M2 money demand is presented in Table 4.20. The coefficient of the error correction term in D(LnRealM1), and D(LnGDP) are 1% significant. It can be concluded that all variables have adjusted to the long-run equilibrium relationship rather than interest rates. Taking D(LnRealM2) as dependent variables, the coefficient of ECT (-1) for M2 money demand is -0.11, suggesting that the disequilibrium of the M2 money demand function in Thailand will be corrected approximately 11% within a quarter.

Table 4.20 The result of the Error Correction Model

Error Correction:	D(LnRealM2)	D(LnGDP)
CointEq1	-0.115 [-2.50359]	0.037 [1.78567]
D(LnRealM2(-1))	-0.239 [-2.30261]	0.045 [0.96803]
D(LnRealM2(-2))	-0.173 [-1.58670]	0.012 [0.24789]
D(LnRealM2(-3))	-0.113 [-1.05122]	-0.017 [-0.36112]
D(LnRealM2(-4))	0.217 [2.15518]	-0.002 [-0.04585]
D(LnGDP(-1))	-0.205 [-0.88239]	0.008 [0.07860]
D(LnGDP(-2))	-0.127 [-0.54339]	-0.024 [-0.22774]
D(LnGDP(-3))	-0.495 [-2.22744]	-0.203 [-2.02509]
D(LnGDP(-4))	-0.022 [-0.10923]	0.032 [0.35844]
C	0.095 [0.64020]	0.405 [6.07495]
R	-0.004 [-1.69572]	-0.004 [-3.45966]
LIBOR	-0.002 [-1.40936]	0.001 [1.42557]
LnEXC	0.000 [-0.00300]	-0.106 [-5.47718]

Taking only the significant variables and eliminating insignificant variables, the VECM equations for the M2 money demand in Thailand can be written as:

$$\underset{}{Ln\,RealM2} = \underset{(2.50)}{-0.01ECT_{t-1}} \underset{(-2.30)}{- 0.23\Delta Ln\,RealM2_{t-1}} \underset{(2.15)}{+ 0.24\Delta Ln\,RealM2_{t-4}} \underset{(-2.22)}{+ 0.49\Delta LnGDP_{t-3}}$$

$$\underset{(-1.69)}{-0.004R}$$

R-squared = 0.31 F-statistic = 3.53 Akaike AIC = -3.98

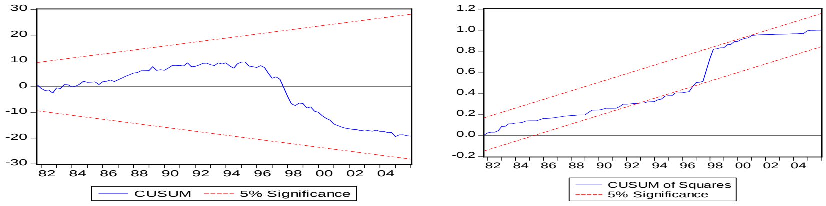
AR 1-4 test: F (12,79) = 1.48 (0.14) ARCH 1-20 test: F (4, 95) = 0.98(0.42)

Hetero test: F (24, 79) = 0.75 (0.78) RESET test F (1, 90) = 16.83 (0.00)

The stability of parameters in the M2 money demand function

To test the stability of money demand function in this section, the CUSUM and CUSUMSQ proposed by Brown et al. (1975) is employed. If the plot of CUSUM and/or/and CUSUMSQ stays within a given significant level, it can be said that the coefficient estimates are stable. As can be seen, the estimates of CUSUM are stable over the sample periods as the demand equation stays within 5% critical. However, the CUSUMSQ shows that there is evidence of instability during 1992-1997.

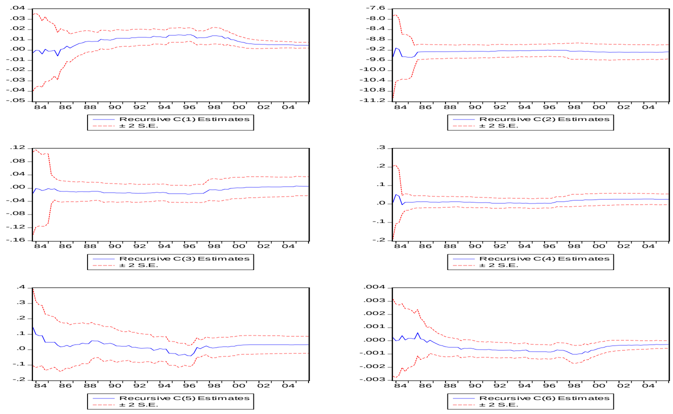
Figure 4.15 Plot of CUSUM and CUSUMSQ



(A) Plot of CUSUM *(B) Plot of CUSUMSQ*

The recursive coefficient is presented in Figure 4.16. It is not surprising that the results show the estimated coefficient seems to be constant after 1998.

Figure 4.16 Plot of recursive coefficient



Money overhang and inflation

In this step, we will test whether the estimate of money demand equation is helping forecast inflation at differing lags. The money overhang in this model is:

$$OM2EX = LnrealM2 - (\alpha + \beta LnGDP + \gamma R + \eta LnEXc + \lambda LIBOR)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four-quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One -quarter-ahead inflation and money overhang

$$INF = -0.02 + 0.44 INF_{t-1} + 0.004 OM2EX_{t-1}$$
$$(-1.88) \quad (4.44) \quad (2.26)$$

R-squared = 0.21 Prob(F-statistic) = 0.00 DW = 1.86

AR test: F (12,92) = 0.58 (0.85) ARCH test: F (12, 82) = 0.61 (0.82)

Hetero test: F (4, 102) = 2.33 (0.06) RESET test F (1, 103) = 0.94 (0.33)

Four-quarter-ahead inflation and money overhang

$$INF = -0.02 + 0.35 INF_{t-1} + 0.12 INF_{t-2} + 0.08 INF_{t-3} + 0.19 INF_{t-4} + 0.003 OM2EX_{t-1}$$
$$(-1.70) \quad (3.12) \quad (1.01) \quad (0.71) \quad (1.73) \quad (1.90)$$

R-squared = 0.27 Prob(F-statistic) = 0.00 DW = 1.83

AR test: F (12-86) = 0.21 (0.99) ARCH test: F (12, 79) = 0.61 (0.82)

Hetero test: F (10, 93) = 5.22 (0.00) RESET test F (1, 97) = 2.90 (0.09)

Eight -quarter-ahead inflation and money overhang

$$INF = -0.05 + 0.07 INF_{t-5} + 0.07 INF_{t-6} + 0.05 INF_{t-7} + 0.19 INF_{t-8} + 0.007 OM2EX_{t-5}$$
$$(-3.13) \quad (0.53) \quad (0.53) \quad (0.40) \quad (1.46) \quad (3.56)$$

R-squared = 0.14 Prob(F-statistic) = 0.00 DW = 1.17

AR test: F (12-82) = 1.56 (0.09) ARCH test: F (12, 75) = 1.09 (0.36)

Hetero test: F (10, 89) = 1.72 (0.09) RESET test F (1, 93) =5.89 (0.02)

4.3.3 The result of money demand function in Thailand (1993Q1 - 2007Q1)

4.3.3.1 The result of the M1 Money demand function: simple model testing

Table 4.21 shows a pair-wise cointegration for the M1 money demand function. There are three determinants of the tests: the test with intercept, shift dummy, and time trend in the series; the test including intercept and trend; and the test with only intercept. The test including the shift dummy and time trend indicates that there is an evidence of pair-wise cointegration between M1 money demand and domestic interest rates (LnRealM1 and R), suggested by the test statistic being 1% significant. The test with intercept and trend shows that M1 money holding and interest rates (LnRealM1 and R) have a pair-wise relationship at 1% significance. However, the test with only intercept suggests that a null hypothesis of no pair-wise relationship between two variables is not rejected at any given significant level.

Table 4.21 The pair-wise cointegration results for the M1 money demand function

Variables	Deterministic	No of lags	H0 r=r0	Test statistic	*Critical Value* 10%	5%	1%
LnRealM1 and LnGDP	Trend, intercept, and shift dummy	2	ro=0	11.29	13.88	15.76	19.71
			ro=1	3.10	5.47	6.79	9.73
LnRealM1 and R	Trend, intercept, and shift dummy	5	ro=0	24.58*	13.88	15.76	19.71
			ro=1	0.39	5.47	6.79	9.73
LnGDP and R	Trend, intercept, and shift dummy	4	ro=0	9.64	13.88	15.76	19.71
			ro=1	1.39	5.47	6.79	9.73
LnRealM1 and LnGDP	Trend, intercept	2	ro=0	12.56	13.88	15.76	19.71
			ro=1	3.28	5.47	6.79	9.73
LnRealM1 and R	Trend, intercept	5	ro=0	23.49*	13.88	15.76	19.71
			ro=1	9.53	5.47	6.79	9.73
LnGDP and R	Trend, intercept	4	ro=0	8.66	13.88	15.76	19.71
			ro=1	0.41	5.47	6.79	9.73
LnRealM1 and LnGDP	Intercept	2	ro=0	4.66	10.47	12.26	16.10
			ro=1	0.00	2.98	4.13	6.93
LnRealM1 and R	Intercept	1	ro=0	10.53	10.47	12.26	16.10
			ro=1	0.08	2.98	4.13	6.93
LnGDP and R	Intercept	5	ro=0	7.11	10.47	12.26	16.10
			ro=1	2.31	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.22 shows the multivariate cointegration of the M1 money demand function in Thailand. The estimate of demand function is tested both with and without dummy shift variables. The results of the M1 money demand function in Thailand suggest that the hypothesis of r_0 =1 is rejected at 10% significant level when the shift dummy and time trend are included in the equation, as the test statistic is 14.98 while 10% critical value is 13.88. However, the null hypothesis of r_0 =2 is not rejected at any given significant level, suggesting that there are two cointegrating vectors between LnRealM1, LnGDP and R in the M1 money demand function when the trend and the shift dummy are included. The cointegration results of the model without dummy shift but allowing time trend in the series indicates that the null hypothesis r=0 is strongly rejected at 1% significant, as the test statistic (37.13) is greater than 1% critical value (33.5). Similarly, the test with intercept but excluding time trend and the shift dummy variable is rejected as the null hypothesis of r=0 is at 5% significant level (the test statistic is 28.33 while 5% critical value is 24.16). Therefore, it may be concluded that there is at least one combination where all variables are cointegrated in the M1 money demand function in Thailand when the tests exclude the shift dummy variable.

Table 4.22 The cointegration results for M1 money demand
LnRealM1, LnGDP, R

Variables	Determinants	No of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	***5%***	***1%***
LnRealM1, LnGDP and R	Trend, Intercept,and shift dummy	5	ro=0	35.57*	26.07	*28.5*	*33.5*
			ro=1	14.98***	13.88	15.76	19.71
			ro=2	3.34	5.47	6.79	9.73
LnRealM1, LnGDP and R	Trend and intercept	3	ro=0	37.13*	26.07	*28.5*	*33.5*
			ro=1	13.25	13.88	15.76	19.71
			ro=2	0.01	5.47	6.79	9.73
LnRealM1, LnGDP and R	Intercept	3	ro=0	28.33**	21.76	*24.2*	*29.1*
			ro=1	9.79	10.47	12.26	16.1
			ro=2	0.13	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

As the results of the cointegration approach above strongly suggest, there is a single cointegration vector LnRrealM1, GDP, and R when the test excluded trend and the shift dummy. Hence, it may not be necessary to include a shift dummy and time trend in the next analysis.

Table 4.23 presents the normalized cointegration vector of the stable M1 money demand function. The table suggests that both GDP and R have a long-run relationship with the M1 money demand in Thailand, suggested by the t-statistics being significant at 1%. The income elasticity has a positive relationship with M1 money demand in Thailand. The estimation of interest elasticity for M1 money demand appeared to be a negative sign. The coefficient of R is -0.02, implying that a 1% increase in domestic interest rates caused a 0.02% decrease in M1 money demand.

Table 4.23 The normalized M1 money demand function in Thailand

LnR realM1	LnGDP	R	C
-1	1.40* [-16.13]	-0.02* [7.15]	7.61*

Note: The numbers in parentheses show the t-statistics.
Note that * indicates 1% level of significance.

Table 4.24 shows the result of weak exogeneity of variables in the cointegration. The results show that LnRealM1 and R are 10% significant, but 5% significance for LnGDP. It can be said that LnRealM1, GDP and R are not a long-run weak exogeneity with respect to the cointegration vector. Therefore, we can continue the VECM in the next step by using those three variables as endogenous variables.

Table 4.24 Test for Cointegration Restriction for weak exogeneity

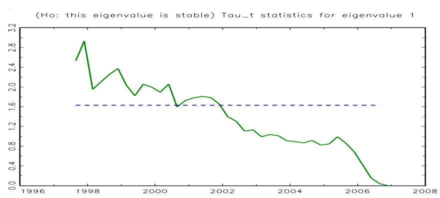
Variables	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
	Restrictions: $\alpha(1,1)=0$			
LnRealM1	186.2433	3.083018	1	0.07
	Restrictions: $\alpha(2,1)=0$			
LnGDP	162.06	4.86	1.00	0.03
	Restrictions: $\alpha(3,1)=0$			
R	183.54	2.98	1.00	0.08

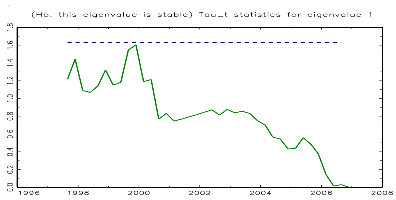
Figure 4.17 shows the results of the M1 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.18 Figure(A) shows the recursive estimates of all parameters, while Figure(B) uses full sample estimates to concentrate out short-term parameters. As can be seen, when full re-estimation of all parameters is carried out at each point in the recursion the test statistics show a sharp drop around 1998. However, when we concentrate out the short-run dynamics using the full sample estimates, both models show no sign of instability. Based on the results, we focus in the final section on a VECM model where we estimate the cointegration excluding the shift dummy; it appears to contribute neither to the cointegration result nor to the stability.

Figure 4.17 Recursive Tau statistics for the M1 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters



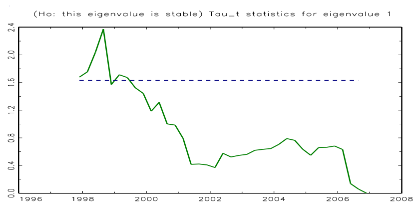


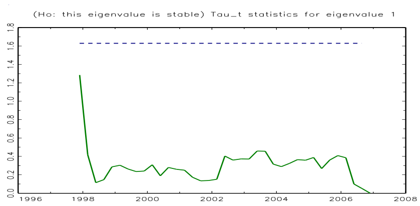
Figure(A) *Figure(B)*

Figure 4.18 Recursive Tau statistics for the M1 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters





Figure(A) *Figure(B)*

To capture the short-run relationship for the M1 money demand function in the simple model in Thailand, the Vector Error Correction Model (VECM) is applied in the next step. Table 4.25 presents the results of the VECM for the M1 money demand function, using a simple model with the data set from 1993Q1 to 2007Q1. The results show that the coefficient on the error correction term in D(LnRealM1) and D(R) are 5% significant, and 1% significant for D(LnGDP). This implies that M1 money demand, real income, and R have adjusted to the long-run equilibrium. Taking D(LnRealM1) as dependent variables, the results found that the error correction term is 5% significant. As error correction terms indicate the speed adjustment to the long-run equilibrium and the coefficient of ECT (-1) is -0.32, this means that the disequilibrium of the M1 money demand function in Thailand will be corrected approximately 32% within a quarter. The coefficient in the second column presents the change of lag variable on current change of the M1 money demand in Thailand. There, only the coefficient of D(LnGDP(-1)) appeared to be significant at 1% level, while the others' coefficients are insignificant.

Table 4.25 The results of the VECM for M1 money demand

Error Correction:	D(LnREALealM1)	D(LnGDP)	D(R)
CointEq1	-0.326 [-2.05361]	0.167 [2.61754]	-6.820 [-1.87577]
D(LnRealM1(-1))	-0.254 [-1.51989]	-0.030 [-0.44745]	6.268 [1.63999]
D(LnRealM1(-2))	-0.135 [-1.02666]	-0.051 [-0.95645]	3.670 [1.21643]
D(LnGDP(-1))	1.129 [3.29647]	0.537 [3.90865]	-5.057 [-0.64588]
D(LnGDP(-2))	-0.465 [-1.37219]	-0.021 [-0.15087]	-5.668 [-0.73085]
D(R(-1))	-0.004 [-0.59276]	-0.001 [-0.47565]	0.349 [2.25944]
D(R(-2))	-0.010 [-1.35017]	-0.009 [-3.15327]	0.288 [1.78254]
C	0.012 [1.82293]	0.004 [1.73168]	-0.066 [-0.45475]

Taking only the significant variables and eliminating insignificant variables, the VECM equations for the M1 money demand in Thailand can be written as:

$$Ln\,\mathrm{Re}\,alM1 = -0.32ECT \;\; +1.12\Delta LnGDP_{t-1}$$
$$(-2.05) \qquad\qquad (3.29)$$

R-squared = 0.45 F-statistic = 5.49 Akaike AIC = -3.48

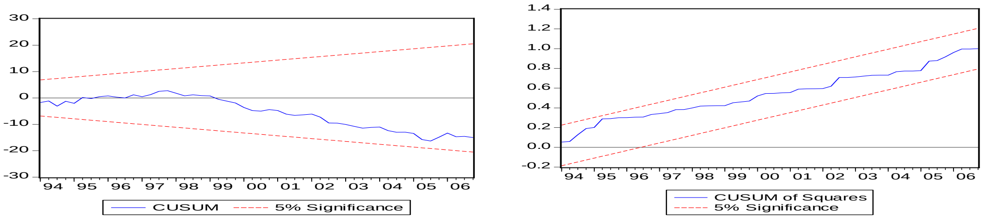
AR 1-4 test: F (4,42) = 1.29 (0.28) ARCH test: F (4, 45) = 0.54(0.70)

Hetero test: F (14,39) = 0.75 (0.78) RESET test F (1, 45) = 0.89 (0.34)

The stability of parameters in the simple M1 money demand function

This section presents the result of the stability of parameters for the M1 money demand function in Thailand by using the CUSUM and CUSUMSQ approach. If the plot of CUSUM and/or CUSUMSQ stays within a given significant level, this means that the coefficient estimates are stable. As can be seen in Figure 4.19, the estimates of CUSUM and CUSUMSQ seem to be stable over the sample periods, as the demand equation stays within 5% critical.

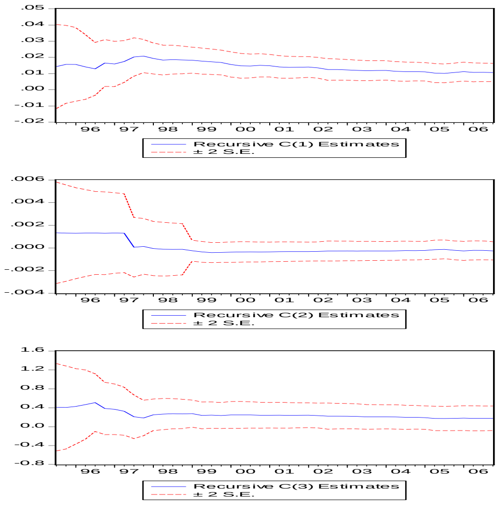
Figure 4.19 Plot of CUSUM and CUSUMSQ



(A) Plot of CUSUM *(B) Plot of CUSUM SQ*

The recursive coefficient is presented in Figure 4.20. It is not surprising that the results show the estimated coefficient seems to be stable after the financial crisis

Figure 4.20 Plot of recursive coefficient



Money overhang and inflation

In this section, we will examine whether the estimate of the M1 money demand equation in the previous section is helping forecast inflation at differing lags. The equation of money overhang is that:

$$OM1 = LnrealM1 - (\alpha + \beta LnGDP + \gamma R)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four-quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are following equations.

One-quarter-ahead inflation and money overhang

$$\underset{(2.35)}{INF = 0.18} + \underset{(5.08)}{0.53INF_{t-1}} + \underset{(2.30)}{0.01OM1_{t-1}}$$

R-squared = 0.37 Prob (F-statistic) = 0.00 DW = 1.67

AR test: F (4,49) = 1.05 (0.39) ARCH test: F (4, 47) = 0.63 (0.64)

Hetero test: F (3,52) =0.86 (0.46) RESET test F (1,52) = 0.03 (0.85)

Four-quarter-ahead inflation and money overhang

$$INF = \underset{(1.73)}{0.15} + \underset{(4.87)}{0.68INF_{t-1}} + \underset{(1.17)}{0.20INF_{t-2}} + \underset{(0.28)}{0.04INF_{t-3}} + \underset{(0.68)}{0.09INF_{t-4}} + \underset{(1.79)}{0.01OM2_{t-1}}$$

R-squared = 0.42 Prob(F-statistic) = 0.00 DW = 1.99

AR test: F (4,43) = 0.31 (0.86) ARCH test: F (4,44) = 0.23 (0.91)

Hetero test: F (9,43) = 0.53 (0.83) RESET test F (1,46) = 0.90 (0.34)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.34 + 0.01INF_{t-5} + 0.10INF_{t-6} + 0.07INF_{t-7} + 0.25INF_{t-8} + 0.02OM2_{t-5}$$

(3.60) (0.07) (0.55) (0.38) (1.75) (3.53)

R-squared = 0.25 Prob(F-statistic) = 0.02 DW = 1.91

AR test: F (12,31) = 2.02 (0.06) ARCH test: F (4, 40) = 1.98 (0.11)

Hetero test: F (19, 29) = 1.93 (0.06) RESET test F (1, 42) =0.80 (0.37)

Overall, the coefficient of money overhang appeared to be significant for one, four, and eight-quarter-ahead. We can say that money overhang estimated from the M1 money demand function can help in forecasting the inflation rate in Thailand.

4.3.3.2 The result of the M1 Money demand function: simple model including LnEXC and LIBOR

The pair-wise cointegration tests for M1 money demand and each variable are presented in Table 4.26. Table(A) presents the pair-wise with shift dummy (sdum), which include a constant in the cointegrating vector and allowed for trends in the series. Table(B) reports the pair-wise without shift dummy (sdum) and the results allow for time trends in the series and constant, and Table(C) shows the pair-wise cointegration result with intercept only.

The results of pair-wise cointegration when the shift dummy (sdum) is included suggest that the null hypothesis pair-wise cointegration is rejected at 1% significant for LnRealM1 and R, and 5% significant for LnGDP and R. It can be said that there is a long-run relationship between real M1 money holding and interest rates, and between real income and interest rates. The results of pair-wise cointegration when intercept and trend are included, but excluding the shift dummy variable, in Table 4.26(B) suggests that the LnRealM1 has a pair-wise relationship with R at 1% significant. However, the test without the shift dummy and trend in Table 4.26(C) shows that there is no pair-wise cointegrating with all variables included in the equations at any given significance.

Table 4.26 The results of bivariate (pair-wise) cointegration of M1 money demand

4.26(A) Determinants: Trend, intercept, and shift dummy

Variables		No. of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM1 and	LnGDP	2	ro=0	5.46	*13.88*	*15.76*	*19.71*
			ro=1	0.02	*5.47*	*6.79*	*9.73*
LnRealM1 and	R	5	ro=0	24.58*	*13.88*	*15.76*	*19.71*
			ro=1	0.39	*5.47*	*6.79*	*9.73*
LnRealM1 and	LnEXC	1	ro=0	6.37	*13.88*	*15.76*	*19.71*
			ro=1	2.18	*5.47*	*6.79*	*9.73*
LnRealM1 and	LIBOR	2	ro=0	9.61	*13.88*	*15.76*	*19.71*
			ro=1	2.02	*5.47*	*6.79*	*9.73*
LnGDP and	R	3	ro=0	16.42**	*13.88*	*15.76*	*19.71*
			ro=1	2.28	*5.47*	*6.79*	*9.73*
LnGDP and	LnEXC	2	ro=0	4.19	*13.88*	*15.76*	*19.71*
			ro=1	1.73	*5.47*	*6.79*	*9.73*
LnGDP and	LIBOR	2	ro=0	12.49	*13.88*	*15.76*	*19.71*
			ro=1	1.15	*5.47*	*6.79*	*9.73*
R and	LnEXC	2	ro=0	8.18	*13.88*	*15.76*	*19.71*
			ro=1	3.14	*5.47*	*6.79*	*9.73*
R and	LIBOR	1	ro=0	5.03	*13.88*	*15.76*	*19.71*
			ro=1	2.38	*5.47*	*6.79*	*9.73*
LnEXC	LIBOR	1	ro=0	5.47	*13.88*	*15.76*	*19.71*
			ro=1	1.04	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.26(B) Determinants: Trend, intercept

Variables		No. of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM1 and	LnGDP	2	ro=0	13.27	*13.88*	*15.76*	*19.71*
			ro=1	3.75	*5.47*	*6.79*	*9.73*
LnRealM1 and	R	5	ro=0	27.21*	*13.88*	*15.76*	*19.71*
			ro=1	0.26	*5.47*	*6.79*	*9.73*
LnRealM1 and	LnEXC	1	ro=0	5.91	*13.88*	*15.76*	*19.71*
			ro=1	1.93	*5.47*	*6.79*	*9.73*
LnRealM1 and	LIBOR	1	ro=0	12.20	*13.88*	*15.76*	*19.71*
			ro=1	2.43	*5.47*	*6.79*	*9.73*
LnGDP and	R	2	ro=0	15.29***	*13.88*	*15.76*	*19.71*
			ro=1	0.32	*5.47*	*6.79*	*9.73*
LnGDP and	LnEXC	2	ro=0	5.65	*13.88*	*15.76*	*19.71*
			ro=1	1.37	*5.47*	*6.79*	*9.73*
LnGDP and	LIBOR	2	ro=0	13.03	*13.88*	*15.76*	*19.71*
			ro=1	0.07	*5.47*	*6.79*	*9.73*
R and	LnEXC	4	ro=0	7.89	*13.88*	*15.76*	*19.71*
			ro=1	1.01	*5.47*	*6.79*	*9.73*
R and	LIBOR	1	ro=0	9.61	*13.88*	*15.76*	*19.71*
			ro=1	1.26	*5.47*	*6.79*	*9.73*
LnEXC	LIBOR		ro=0	5.92	*13.88*	*15.76*	*19.71*
			ro=1	0.80	*5.47*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Table 4.26(C) Determinants: Intercept

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM1 and LnGDP	2	ro=0	6.59	*10.47*	*12.26*	*16.10*
		ro=1	0.43	*2.98*	*4.13*	*6.93*
LnRealM1 and R	1	ro=0	10.33	*10.47*	*12.26*	*16.10*
		ro=1	0.08	*2.98*	*4.13*	*6.93*
LnRealM1 and LnEXC	1	ro=0	4.46	*10.47*	*12.26*	*16.10*
		ro=1	0.07	*2.98*	*4.13*	*6.93*
LnRealM1 and LIBOR	1	ro=0	4.02	*10.47*	*12.26*	*16.10*
		ro=1	0.07	*2.98*	*4.13*	*6.93*
LnGDP and R	5	ro=0	7.11	*10.47*	*12.26*	*16.10*
		ro=1	2.31	*2.98*	*4.13*	*6.93*
LnGDP and LnEXC	2	ro=0	5.16	*10.47*	*12.26*	*16.10*
		ro=1	2.36	*2.98*	*4.13*	*6.93*
LnGDP and LIBOR	4	ro=0	5.16	*10.47*	*12.26*	*16.10*
		ro=1	2.36	*2.98*	*4.13*	*6.93*
R and LnEXC	2	ro=0	9.20	*10.47*	*12.26*	*16.10*
		ro=1	0.00	*2.98*	*4.13*	*6.93*
R and LIBOR	4	ro=0	3.58	*10.47*	*12.26*	*16.10*
		ro=1	0.05	*2.98*	*4.13*	*6.93*
LnEXC LIBOR	1	ro=0	2.42	*10.47*	*12.26*	*16.10*
		ro=1	1.10	*2.98*	*4.13*	*6.93*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

The result for cointegration among LnRealM1, LnGDP, R, LnEXC, and LIBOR is presented in Table 4.27. The results of the model that included intercept, trend, and the shift dummy variable indicate that the null hypothesis of $r_0 = 2$ is rejected at 1% significant level, since the test statistic (36.99) is greater than 1% critical value (33.50). This indicates that there are three cointegrating equations in the long run between LnRealM1, LnGDP, R, LnEXC, and LIBOR. However, the results from the model with intercept and trend suggest that there is a single cointegration vector between the five variables, suggested by the test statistic of $r_0 = 0$ being rejected at 1% significance. This result is similar to the test with only intercept that also suggests that there is one combination of variables where all variables are integrated.

Table 4.27 Cointegration of the M1 money demand function

Variables	Deterministic	No of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM1, LnGDP LnExc, R, LIBOR	Trend, intercept, and shift dummy	5	ro=0	90.98*	62.45	66.13	73.42
			ro=1	66.51*	*42.25*	*45.32*	*51.45*
			ro=2	36.99*	*26.07*	*28.52*	*33.50*
			ro=3	10.94	*13.88*	*15.76*	*19.71*
			ro=4	3.39	*5.48*	*6.79*	*9.73*
LnRealM1, LnGDP LnExc, R, LIBOR	Trend and intercept	1	ro=0	96.26*	62.45	66.13	73.42
			ro=1	38.92	*42.25*	*45.32*	*51.45*
			ro=2	15.04	*26.07*	*28.52*	*33.50*
			ro=3	2.91	*13.88*	*15.76*	*19.71*
			ro=4	1.39	*5.48*	*6.79*	*9.73*
LnRealM1, LnGDP LnExc, R, LIBOR	Intercept	2	ro=0	75.84*	62.45	66.13	73.42
			ro=1	33.83	*42.25*	*45.32*	*51.45*
			ro=2	11.33	*26.07*	*28.52*	*33.50*
			ro=3	4.80	*13.88*	*15.76*	*19.71*
			ro=4	0.80	*5.48*	*6.79*	*9.73*

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*

The number of lags is selected by the smallest AIC criteria.

Overall, it would be reasonable to assume the existence of a single cointegration between the five variables in the M1 money demand when the equation is excluding the shift dummy variable. Therefore, the next step of the analysis will be the normalized cointegration vector by setting the coefficient of LnRealM1 as -1 and dividing the other variables with -1. The estimation of normalized cointegration will be performed without the dummy shift variable and time trend.

Table 4.28 presents the normalized cointegrating vector of the M1 money demand function in Thailand when the exchange rate variable and LIBOR are included. The coefficient of all variables is significant at 1% significant level, suggesting that real income, interest rates, the exchange rate, and LIBOR have an affect on M1 money holding in Thailand in the long run. The income elasticity is 1.42, meaning that 1% increase in real income leads to 1.42% increase in M1 money holding in Thailand. The coefficient of R and LIBOR are -0.01 and -0.03; both are negative signs. This implies that M1 money holding will drop by 0.01% and approximately 0.03% if domestic interest rates (R) and

LIBOR increase by 1%. In case of exchange rate elasticity, there are positive coefficients on the exchange rate in M1 money holding. This implies that depreciation in the Thai baht leads to public expectation of further depreciation, and a demand for more foreign currency. Therefore, the demand for domestic holding money is decreased.

Table 4.28 Normalized Cointegration

LnRealM1	LnGDP	R	LnEXC	LIBOR	C
-1	1.42	-0.01	0.09	-0.03	-7.96
	[-36.93]	[3.17]	[-2.85]	[6.00]	[29.19]

Note: The numbers in parentheses show the t-statistics.

Table 4.29 shows the result of weak exogeneity of variables in the cointegration. The results show that LnEXC, R, and LIBOR are insignificant, indicating that LnEXC, R, and LIBOR are weakly exogenous variables. However, LnRealM1 and LnGDP are not weakly exogenous since the test statistic can be rejected at 1% significant level. Therefore, the short-run relationship of the M1 money demand function in the next step can be modelled by using LnRealM1 and LnGDP as endogenous variables and the others as exogenous variables.

Table 4.28 Weak Exogenous

Variable	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
		Restrictions: $\alpha(1,1) = 0$		
LnRealM1	233.72	7.79	1.00	0.01
		Restrictions: $\alpha(2,1) = 0$		
LnGDP	233.8	7.7	1.0	0.0
		Restrictions: $\alpha(.3,1) = 0$		
R	237.45	0.35	1.00	0.55
		Restrictions: $\alpha(4,1) = 0$		
LnEXC	236.24	2.76	1.00	0.10
		Restrictions: $\alpha(5,1) = 0$		
LIBOR	237.01	1.21	1.00	0.27

The results of the Vector Error Correction Model for the M1 money demand function in Table 4.30 suggests that the error terms of D(LnRealM1) is 1% significant while they are 10% significant for D(LnGDP). This suggests that the M1 money holding and real income have adjusted to long-run equilibrium.

Taking D(LnRealM1) as dependent variables, the coefficient of ECT (-1) is -0.38, meaning that the disequilibrium of the M1 money demand function in Thailand will be corrected approximately 38% within a quarter. The coefficient of D(LnRealM1(-1)) and D(LnGDP(-1) is significant at 10% level. The coefficient of R is 1% significant level while others' coefficients are insignificant. This implied that a change in M1 money demand in one quarter and the change in GDP in a quarter prior, interest rates have an affect on the current M1 money demand in the short run while the exchange rate and LIBOR do not. The coefficient of D(LnRealM1(-1)) is -0.21, indicating that a 1% increase in M1 money demand in the last quarter caused a decrease of around 0.21% of the current M1 money demand. The coefficient of D(LnGDP (-1)) equals 0.65, suggesting that if income in the prior quarter increased 1%, M1 money demand in the current quarter is increased by 0.65%. Similarly, the coefficient of R equals -0.008, indicating that money demand will increase by 0.008% if real interest rates rise by 1%.

Table 4.29 The results of the vector error correction for the M1 money demand function

Error Correction:	D(LnRealM1)	D(LnGDP)
CointEq1	-0.387 [-3.07534]	0.080 [1.65373]
D(LnRealM1(-1))	-0.215 [-1.66717]	0.035 [0.71746]
D(LnGDP(-1))	0.659 [1.83620]	0.146 [1.06560]
C	0.166 [1.05224]	0.205 [3.40126]
R	-0.008 [-2.26918]	-0.002 [-1.20212]
LnEXC	-0.017 [-0.42622]	-0.052 [-3.48412]
LIBOR	-0.009 [-1.41082]	0.000 [-0.05035]

The equation for the M1 money demand in Thailand estimated by ECM can be written by eliminating insignificant lag from the system. Thus, the equation will be:

$$Ln\,RealM1 = -0.38ECT \;\; -0.21\Delta Ln\,RealM1_{t-1} + 0.65\Delta LNGDP_{t-1} - 0.008R$$
$$(-3.07) \qquad\qquad (-1.66) \qquad\qquad (1.83) \qquad (-2.26)$$

R-squared = 0.39 F-statistic = 5.25 Akaike AIC = -3.44

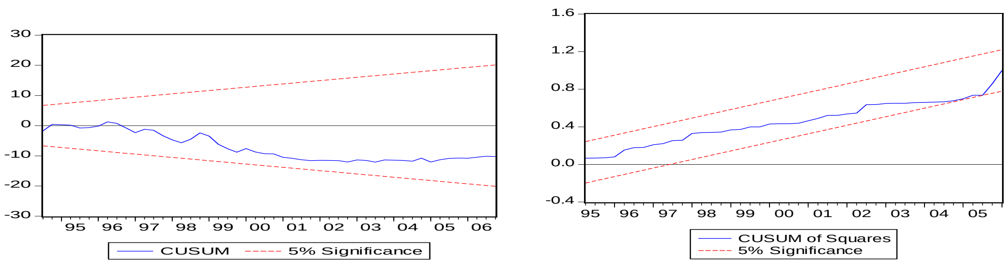
AR 1-4 test: F (4,44) = 1.58 (0.19) ARCH test: F (4, 46) = 0.68(0.60)

Hetero test: F (12,42) = 1.84 (0.07) RESET test F (1, 45) = 1.61 (0.20)

The stability of parameters in the simple M1 money demand function

To test the stability of the money demand function, the CUSUM and CUSUMSQ proposed by Brown et al. (1975) are employed. If the plot of CUSUM and/or CUSUMSQ stays within a given significant level, this means that the coefficient estimates are stable. As can be seen in Figure 4.21, the estimate of CUSUM and CUSUMSQ seems stable over the sample periods as the demand equation stays within 5% critical.

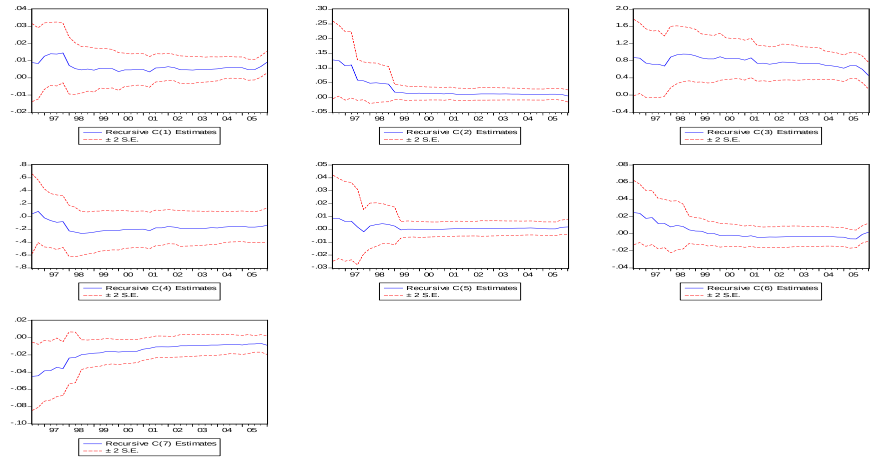
Figure 4.21 Plot of CUSUM and CUSUMSQ



(a) Plot of CUSUM ***(B) Plot of CUSUMSQ***

The recursive coefficient presented in Figure 4.22 shows that the estimated coefficients seem to be constant after 1999.

Figure 4.22 Recursive coefficient



Money overhang and inflation

In the next step, we will test whether the estimate of money demand equation is helping forecast inflation at differing lags. As the variable LnEXC and LIBOR are added in this section, the money overhang in this model is:

$$OM1EX = LnrealM1 - (\alpha + \beta LnGDP + \gamma R + \eta LnEXc + \lambda LIBOR)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four–quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One-quarter-ahead inflation and money overhang

$$INF = 0.53 INF_{t-1} + 0.0005 OM1EX_{t-1}$$
$$(4.49) \qquad\qquad (2.86)$$

R-squared = 0.30 Prob(F-statistic) = 0.00 DW = 1.58

AR test: F (4,50) = 0.44 (0.77) ARCH test: F (4,47) = 0.18 (0.94)

Hetero test: F (4,51) = 0.75 (0.55) RESET test F (1, 53) = 1.22(0.27)

Four-quarter-ahead inflation and money overhang

$$INF = 0.71INF_{t-1} + 0.21INF_{t-2} + 0.04INF_{t-3} + 0.04INF_{t-4} + 0.005OM1EX_{t-1}$$

(4.97) (1.24) (0.26) (0.35) (2.33)

R-squared = 0.38 Prob(F-statistic) = 0.00 DW = 1.99

AR test: F (4,44) = 0.08 (0.98) ARCH test: F (4,44) = 0.07 (0.98)

Hetero test: F (10,42) = 0.69 (0.72) RESET test F (1, 47) = 0.06(0.80)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.07INF_{t-5} + 0.07INF_{t-6} + 0.07INF_{t-7} + 0.15INF_{t-8} + 0.009OM1EX_{t-5}$$

(0.41) (0.32) (0.34) (0.95) (3.27)

R-squared = 0.02 Prob(F-statistic) = 0.04 DW = 0.73

AR test: F (12,32) = 1.92 (0.06) ARCH test: F (4, 40) = 1.23 (0.31)

Hetero test: F (10, 38) = 1.91 (0.07) RESET test F (1, 43) =0.81 (0.37)

Overall, money overhang can help in forecasting the inflation rate, especially for the four-quarter–ahead model. However, it might not help in the eight-quarter-ahead forecasting model, since there is an evidence of serial correlation in the model.

4.3.3.3 The Results of the M2 Money Demand Function: simple model

This section presents the empirical results of the stability of the M2 money demand function in Thailand by using the simple model with a data set from 1993Q1 to 2007Q1. The pair-wise cointegration results for the M2 money demand function in Table 4.31 suggest that in the case where the test with intercept, trend, and shift dummy are included, the null hypothesis of no pair-wise cointegration between LnGDP and R is rejected at 5% significant level, while other pair-wise are insignificant. Similarly, the test with intercept and trend but without the shift dummy shows there is evidence of a pair-wise cointegrating between LnGDP and R since the test statistic is significant at 10%. However, the null hypothesis of no pair-wise relationship between two variables when the test includes only intercept is not rejected at any given significant level.

Table 4.30 The pair-wise cointegration results for the M2 money demand function

Variables	Deterministic	No. of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	***5%***	***1%***
LnRealM2 and LnGDP	Trend, intercept, and shift dummy	2	ro=0 ro=1	9.58 1.36	13.88 5.47	15.76 6.79	19.71 9.73
LnRealM2 and R	Trend, intercept, and shift dummy	1	ro=0 ro=1	5.43 0.83	13.88 5.47	15.76 6.79	19.71 9.73
LnGDP and R	Trend, intercept, and shift dummy	3	ro=0 ro=1	16.42** 2.28	13.88 5.47	15.76 6.79	19.71 9.73
LnRealM2 and LnGDP	Trend, intercept	2	ro=0 ro=1	10.57 0.96	13.88 5.47	15.76 6.79	19.71 9.73
LnRealM2 and R	Trend, intercept	1	ro=0 ro=1	4.73 2.00	13.88 5.47	15.76 6.79	19.71 9.73
LnGDP and R	Trend, intercept	4	ro=0 ro=1	15.29*** 0.32	13.88 5.47	15.76 6.79	19.71 9.73
LnRealM2 and LnGDP	Intercept	4	ro=0 ro=1	6.48 1.17	10.47 2.98	12.26 4.13	16.10 6.93
LnRealM2 and R	Intercept	5	ro=0 ro=1	7.40 0.23	10.47 2.98	12.26 4.13	16.10 6.93
LnGDP and R	Intercept	5	ro=0 ro=1	7.11 2.31	10.47 2.98	12.26 4.13	16.10 6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*
The number of lags is selected by the smallest AIC criteria.

Table 4.32 presents the result of the cointegration test for the M2 money demand function in Thailand. The results suggest that there is a single cointegrating vector among LnRealM2, LnGDP and R suggested by the test statistic being 10% significant for the model with trend and the shift dummy variable, and it is 1% significant for the model without the shift dummy variable since the test statistic is greater than 1% significant. Therefore, it could be said that there exists a stable long-run relationship among M2 money demand, domestic income (GDP) and domestic interest rates (R) in the Thai economy.

Table 4. 31 The cointegration results for M1 money demand

Variables	Deterministic	No of lags	H0 r=r0	Test statistic	*Critical Value*		
					10%	***5%***	***1%***
LnRealM2, LnGDP and R	Trend, intercept, and shift dummy	1	ro=0	27.24***	26.07	*28.5*	*33.5*
			ro=1	6.47	13.88	15.76	19.71
			ro=2	0.01	5.47	6.79	9.73
LnRealM2, LnGDP and R	Trend and intercept	4	ro=0	52.42*	26.07	*28.5*	*33.5*
			ro=1	5.17	13.88	15.76	19.71
			ro=2	0.64	5.47	6.79	9.73
LnRealM2, LnGDP and R	Intercept	4	ro=0	50.42*	21.76	*24.2*	*29.1*
			ro=1	7.93	10.47	12.26	16.1
			ro=2	2.32	2.98	4.13	6.93

*Note: Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.*
The number of lags is selected by the smallest AIC criteria.

Table 4.33 presents the normalized cointegration of the M2 money demand function. The table suggests that both GDP and R have a long-run relationship with M2 money demands in Thailand, suggested by the t-statistics being significant at 1%. The income elasticity is 0.75, meaning that an increase of 1% in real income brings up 0.75% in M2 money demand in Thailand. The coefficient of R is -0.03, suggesting that a 1% increase in domestic interest rates leads to a 0.03% drop in M2 money holding in Thailand.

Table 4.32 Normalized cointegration

LnRealM2	LnGDP	R	C
-1	0.75*	-0.03*	-1.10*
	[-9.71]	[9.75]	[2.00]

Note: The numbers in parentheses show the t-statistics.
Note that * indicates 1% level of significance.

Table 4.34 shows the result of a weak exogeneity test. The results show that LnRealM2 and LnGDP are 5% significant, while R is significant at 10%. This indicates that all variables are not long-run weakly exogenous with respect to the cointegration vector.

Table 4.33 Test for Cointegration Restriction for weak exogeneity

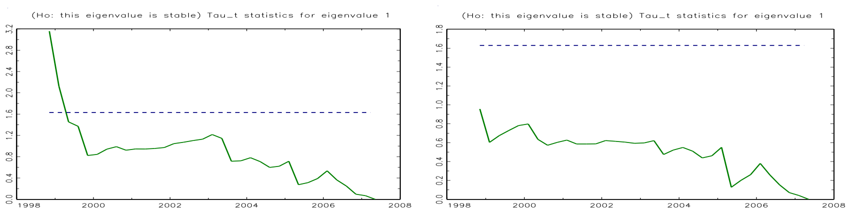
Variable	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
	Restrictions: $\alpha(1,1) = 0$			
LnRealM2	184.80	0.47	1.00	0.04
	Restrictions: $\alpha(2,1) = 0$			
LnGDP	182.96	4.14	1.00	0.04
	Restrictions: $\alpha(3,1) = 0$			
R	183.54	2.98	1.00	0.08

Figure 4.23 shows the results of the M2 money demand function without a shift dummy and the estimates including the shift dummy are in Figure 4.24. Figure(A) on both figures show the recursive estimates of all parameters, while Figure(B) uses full sample estimates to concentrate out short-term parameters. As can be seen when full re-estimation of all parameters is carried out at each point in the recursion, the test statistic shows a sharp drop around 1998. However, when we concentrate out the short-run dynamics using the full sample estimates, both models show no sign of instability.

Figure 4.23 Recursive Tau statistics for M1 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters

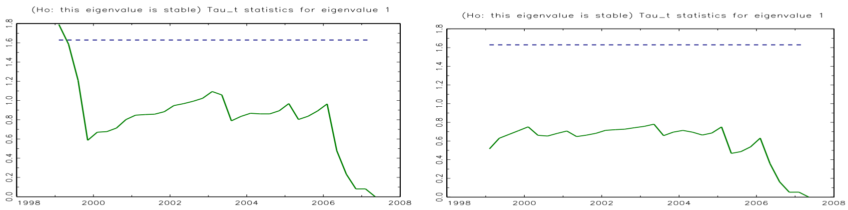


Figure(A) *Figure(B)*

Figure 4.24 Recursive Tau statistics for M1 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short- term parameters



Figure(A) *Figure(B)*

The result of the error correction term for the M2 money demand function is presented in Table 4.35. The error correction term of LnRealM2 is 5% significant and 1% significant for the error correction term of LnGDP and R. It can be said that all variables included in this model have adjusted into long-run equilibrium. Consider D(LnRealM2) as a dependent variable. The results show that the coefficient of error term is -0.80, suggesting that the equilibrium of the M2 money demand function will be corrected around 8% in a quarter. The coefficient of D(LnRealM2 (1)), D(LnRealM2 (2)), and D(LnRealM2 (3)) are 1% significant, and D(LnGDP (1)) is 5% significant. These means that M2 money holding in the past and GDP in the last quarter affect current M2 money holding while the interest rate has no relationship with M2 money holding in the short run.

Table 4.34 The results of the VECM for M2 money demand.

Error Correction:	D(LRM2)	D(LnGDP)	D(R)
ECT(-1)	-0.080** [-2.047]	-0.133* [-3.823]	-9.719* [-4.923]
D(LnRealM2(-1))	-0.346* [-2.904]	0.301 [0.016]	14.787* [2.434]
D(LnRealM2(-2))	-0.420* [-3.435]	0.108 [0.927]	10.163 [1.573]
D(LnRealM2(-3))	-0.350* [-3.053]	-0.046 [-0.441]	10.394 [1.800]
D(LnGDP(-1))	0.334** [2.381]	0.275 [1.925]	-26.501 [-3.348]
D(LnGDP(-2))	-0.193 [-1.385]	-0.181 [-1.276]	-24.179 [-3.074]
D(LnGDP(-3))	0.018 [0.900]	-0.431 [-2.916]	-8.390 [-1.022]
D(R(-1))	0.002 [0.685]	-0.001 [-0.412]	0.094 [0.786]
D(R(-2))	-0.001 [-0.223]	-0.009 [-3.918]	0.071 [0.568]
D(R(-3))	0.003 [0.382]	0.003 [1.173]	-0.192 [-1.495]
C	0.012* [2.874]	0.010 [3.254]	0.060 [0.355]

Note: The t-statistics are in parentheses.
Note that *, **, and *** indicate 1%, 5%, and 10% level of significance.

Taking only significant variables, the short-run M2 money demand function is:

$$
\begin{aligned}
Ln\,RealM2 = &-0.08ECT_{t-1} - 0.34\Delta Ln\,RealM2_{t-1} - 0.42\Delta Ln\,RealM2_{t-2} - 0.35\Delta Ln\,RealM2_{t-3} \\
&\quad(-2.04) \qquad\qquad (-2.09) \qquad\qquad (-3.43) \qquad\qquad (-3.05) \\
&+ 0.33\Delta LnGDP_{t-1} + 0.012 \\
&\quad(2.38) \qquad\qquad (2.87)
\end{aligned}
$$

R-squared = 0.16 F-statistic = 2.82 Akaike AIC = -4.94

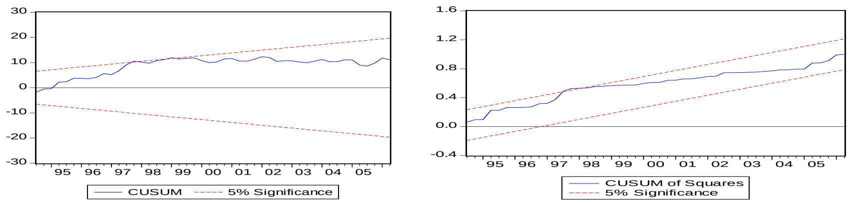
AR 1-4 test: F (4,44) = 1.58 (0.19) ARCH test: F (4, 46) = 0.68(0.60)

Hetero test: F (12,42) = 1.84 (0.07) RESET test F (1, 45) = 1.61 (0.20)

The stability of parameters in the simple M2 money demand function

This section presents the result of the stability of parameter for the M2 money demand function in Thailand by using the CUSUM and CUSUMSQ approach. If the plot of CUSUM and/or CUSUMSQ stays within a given significant level, it can be said that the coefficient estimates are stable. In addition, this section also performs the recursive residual and the recursive coefficient to confirm the result of the stability of parameters. As can be seen in Figure 4.25, the estimate of CUSUM seems to be stable over the sample periods as the demand equation stays within 5% critical. However, the CUSUMSQ shows that there is evidence of instability around 1997-1998.

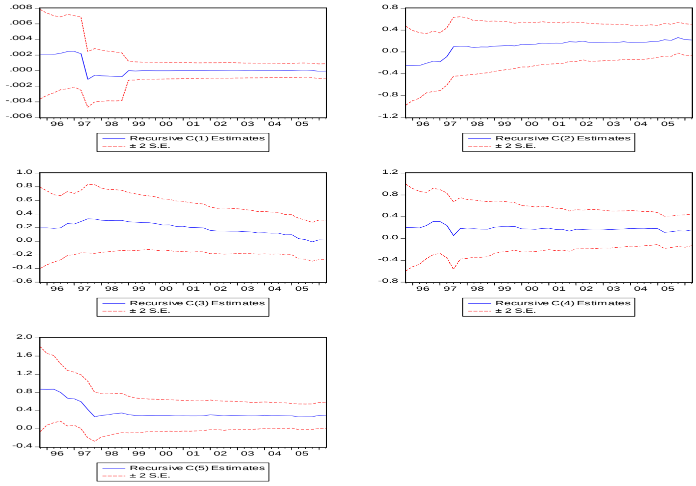
Figure 4.25 Plot of CUSUM and CUCUMSQ



(A) Plot of CUSUM *(B) Plot of CUSUMSQ*

The recursive coefficient is presented in Figure 4.26. It is not surprising that the results show the estimated coefficient seems to be stable after the financial crisis in 1997.

Figure 4. 26 Plot of recursive coefficient



Money overhang and inflation

In this section, we will examine whether the estimate of the M2 money demand equation in the previous section is helping forecast inflation at differing lags. The equation of money overhang is:

$$OM2 = LnrealM2 - (\alpha + \beta LnGDP + \gamma R)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four-quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One-quarter-ahead inflation and money overhang

$$INF = 0.001 + 0.54 INF_{t-1} + 0.01 OM2_{t-1}$$
$$(0.66) \qquad (5.11) \qquad (2.05)$$

R-squared = 0.36 Prob(F-statistic) = 0.00 DW = 1.65

AR test: F (2,51) = 0.74 (0.47) ARCH test: F (4,47) = 0.60 (0.74)

Hetero test: F (4, 51) = 0.49 (0.74) RESET test F (1, 52) = 0.00 (0.98)

Four-quarter-ahead inflation and money overhang

$$INF = 0.0006 + 0.69INF_{t-1} + 0.20INF_{t-2} + 0.05INF_{t-3} + 0.10INF_{t-4} + 0.02OM2_{t-1}$$
$$(0.27) \quad (4.96) \qquad (1.17) \qquad (0.34) \qquad (0.78) \qquad (1.97)$$

R-squared = 0.43 Prob(F-statistic) = 0.00 DW = 2.03

AR test: F (2,45) = 0.09 (0.91) ARCH test: F (4, 44) = 0.44 (0.77)

Hetero test: F (10,42) = 0.42 (0.92) RESET test F (1, 46) = 0.01 (0.89)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.004 + 0.11INF_{t-5} + 0.02INF_{t-6} + 0.01INF_{t-7} + 0.09INF_{t-8} + 0.01OM2_{t-5}$$
$$(1.96) \quad (0.53) \qquad (0.08) \qquad (0.08) \qquad (0.53) \qquad (1.77)$$

R-squared = 0.10 Prob(F-statistic) = 0.42 DW = 0.80

AR test: F (16,27) = 1.60 (0.13) ARCH test: F (4, 40) = 1.95 (0.12)

Hetero test: F (10,38) = 1.14 (0.35) RESET test F (1, 42) =0.78 (0.38)

As can be seen, money over hang can help in forecasting the inflation rate, especially for the one and four-quarter-ahead models, since the F-statistic of both models is strongly significant at 1% and the coefficient of OM2 is significant. However, it might not help in the eight-quarter-ahead forecasting model since the F-statistic is strongly insignificant.

4.3.3.4 The results of the M2 Money demand function: simple model testing including LnEXC and LIBOR 1993:1-2007:1

The pair-wise cointegration tests the for M2 money demand and each variable are presented in Table 4.36. Table(A) presents the pair-wise cointegration with shift dummy (sdum), including a constant in the cointegrating vector and allowing for trends in the series. Table(B) reports the pair-wise cointegration without shift dummy (sdum) and the results allow for time trends in the series and constant, and Table(C) shows the pair-wise cointegration result with intercept only.

The results of pair-wise cointegration when the shift dummy (sdum) is included suggest that there is only a pair-wise relationship between LnGDP and R, as the null hypothesis pair-wise cointegration is rejected at 5% significance. It can be said that there is a long-run relationship between real income and interest rates. The results of pair-wise cointegration when intercept and trend are included, but excluding the shift dummy variable, in Table 4.36(B) suggest that the LnGDP has a pair-wise relationship with R at 5% significance. However, the test without the shift dummy and trend in Table 4.36(C) shows that LnRealM2 has a pair-wise relationship with LIBOR at 10% significance. However, given 5% significance, there is no pair-wise cointegration with all the variables included in the equations.

Table 4.35 The result of bivariate (pair-wise) cointegration of M2 money demand in Thailand

4.36(A) Determinants: Trend, intercept, and shift dummy

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM2 and LnGDP	2	ro=0	9.58	*13.88*	*15.76*	*19.71*
		ro=1	1.36	*5.47*	*6.79*	*9.73*
LnRealM2 and R	1	ro=0	5.43	*13.88*	*15.76*	*19.71*
		ro=1	0.83	*5.47*	*6.79*	*9.73*
LnRealM2 and LnEXC	1	ro=0	9.88	*13.88*	*15.76*	*19.71*
		ro=1	0.69	*5.47*	*6.79*	*9.73*
LnRealM2 and LIBOR	1	ro=0	9.10	*13.88*	*15.76*	*19.71*
		ro=1	3.96	*5.47*	*6.79*	*9.73*
LnGDP and R	3	ro=0	16.42**	*13.88*	*15.76*	*19.71*
		ro=1	2.28	*5.47*	*6.79*	*9.73*
LnGDP and LnEXC	2	ro=0	4.19	*13.88*	*15.76*	*19.71*
		ro=1	1.73	*5.47*	*6.79*	*9.73*
LnGDP and LIBOR	2	ro=0	12.49	*13.88*	*15.76*	*19.71*
		ro=1	1.15	*5.47*	*6.79*	*9.73*
R and LnEXC	2	ro=0	8.18	*13.88*	*15.76*	*19.71*
		ro=1	3.14	*5.47*	*6.79*	*9.73*
R and LIBOR	1	ro=0	5.03	*13.88*	*15.76*	*19.71*
		ro=1	2.38	*5.47*	*6.79*	*9.73*
LnEXC LIBOR	1	ro=0	5.47	*13.88*	*15.76*	*19.71*
		ro=1	1.04	*5.47*	*6.79*	*9.73*

4.36 (B) Determinants: Trend, intercept

Variables		No. of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM2 and	LnGDP	1	ro=0	10.57	*13.88*	*15.76*	*19.71*
			ro=1	0.96	*5.47*	*6.79*	*9.73*
LnRealM2 and	R	1	ro=0	4.73	*13.88*	*15.76*	*19.71*
			ro=1	2.50	*5.47*	*6.79*	*9.73*
LnRealM2 and	LnEXC	1	ro=0	9.98	*13.88*	*15.76*	*19.71*
			ro=1	1.32	*5.47*	*6.79*	*9.73*
LnRealM2 and	LIBOR	5	ro=0	11.29	*13.88*	*15.76*	*19.71*
			ro=1	0.19	*5.47*	*6.79*	*9.73*
LnGDP and	R	2	ro=0	15.29**	*13.88*	*15.76*	*19.71*
			ro=1	0.32	*5.47*	*6.79*	*9.73*
LnGDP and	LnEXC	2	ro=0	5.65	*13.88*	*15.76*	*19.71*
			ro=1	1.37	*5.47*	*6.79*	*9.73*
LnGDP and	LIBOR	2	ro=0	13.03	*13.88*	*15.76*	*19.71*
			ro=1	0.07	*5.47*	*6.79*	*9.73*
R and	LnEXC	4	ro=0	7.89	*13.88*	*15.76*	*19.71*
			ro=1	1.01	*5.47*	*6.79*	*9.73*
R and	LIBOR	1	ro=0	9.61	*13.88*	*15.76*	*19.71*
			ro=1	1.26	*5.47*	*6.79*	*9.73*
LnEXC	LIBOR		ro=0	5.92	*13.88*	*15.76*	*19.71*
			ro=1	0.80	*5.47*	*6.79*	*9.73*

Table 4.36 (C) Determinants: Intercept

Variables	**No. of lags**	**H0: r=r0**	**Test statistic**	***Critical Value***		
				10%	***5%***	***1%***
LnRealM2 and LnGDP	4	ro=0	10.38	*10.47*	*12.26*	*16.10*
		ro=1	0.27	*2.98*	*4.13*	*6.93*
LnRealM2 and R	5	ro=0	7.40	*10.47*	*12.26*	*16.10*
		ro=1	0.23	*2.98*	*4.13*	*6.93*
LnRealM2 and LnEXC	2	ro=0	10.24	*10.47*	*12.26*	*16.10*
		ro=1	0.56	*2.98*	*4.13*	*6.93*
LnRealM2 and LIBOR	5	ro=0	10.51	*10.47*	*12.26*	*16.10*
		ro=1	0.84	*2.98*	*4.13*	*6.93*
LnGDP and R	5	ro=0	7.11	*10.47*	*12.26*	*16.10*
		ro=1	2.31	*2.98*	*4.13*	*6.93*
LnGDP and LnEXC	2	ro=0	5.16	*10.47*	*12.26*	*16.10*
		ro=1	2.36	*2.98*	*4.13*	*6.93*
LnGDP and LIBOR	4	ro=0	5.16	*10.47*	*12.26*	*16.10*
		ro=1	2.36	*2.98*	*4.13*	*6.93*
R and LnEXC	2	ro=0	9.20	*10.47*	*12.26*	*16.10*
		ro=1	0.00	*2.98*	*4.13*	*6.93*
R and LIBOR	4	ro=0	3.58	*10.47*	*12.26*	*16.10*
		ro=1	0.05	*2.98*	*4.13*	*6.93*
LnEXC LIBOR	1	ro=0	2.42	*10.47*	*12.26*	*16.10*
		ro=1	1.10	*2.98*	*4.13*	*6.93*

Table 4.37 presents the result of cointegration between LnRealM2, LnGDP, R, LnEXC, and LIBOR. The results of the model that included intercept, trend, and the shift dummy variable indicate that the null hypothesis of $r_0 = 0$ is rejected at 5% significant level, since the test statistic (66.30) is greater than 5% critical value (66.13). This indicates that there is one cointegrating equation in the long-run between LnRealM2, LnGDP, R, LnEXC, and LIBOR. The results from the model that excluded the shift dummy but included intercept and trend also suggest that there is a single cointegration vector between LnRealM1, LnGDP, R, LnEXC, and LIBOR since the null hypothesis of $r_0 = 0$ is rejected at 1% significant but it is not rejected for the hypothesis of $r_0 = 1$.

Table 4.36 Cointegration of the M1 money demand function

Variables	Deterministic	No of lags	H0: r=r0	Test statistic	*Critical Value*		
					10%	*5%*	*1%*
LnRealM2, LnGDP, LnExc, R, LIBOR	Trend, intercept, and shift dummy	1	ro=0	66.30*	62.45	66.13	73.42
			ro=1	25.71	*42.25*	*45.32*	*51.45*
			ro=2	13.26	*26.07*	*28.52*	*33.50*
			ro=3	6.36	*13.88*	*15.76*	*19.71*
			ro=4	0.81	*5.48*	*6.79*	*9.73*
LnRealM2, LnGDP, LnExc, R, LIBOR	Trend and intercept	3	ro=0	86.82*	62.45	66.13	73.42
			ro=1	42.01	*42.25*	*45.32*	*51.45*
			ro=2	22.24	*26.07*	*28.52*	*33.50*
			ro=3	11.26	*13.88*	*15.76*	*19.71*
			ro=4	0.17	*5.48*	*6.79*	*9.73*
LnRealM2, LnGDP, LnExc, R, LIBOR	Intercept	3	ro=0	73.93*	62.45	66.13	73.42
			ro=1	35.73	*42.25*	*45.32*	*51.45*
			ro=2	61.20	*26.07*	*28.52*	*33.50*
			ro=3	7.73	*13.88*	*15.76*	*19.71*
			ro=4	2.05	*5.48*	*6.79*	*9.73*

The normalized cointegration vector of the stable money demand function for the M2 money demand in Table 4.38 is performed by setting the estimated coefficient on the M2 money demand to equal -1 and dividing each cointegrating vector by the negative of the relevant money coefficient. It is interesting to note that the coefficient of LnGDP and R appeared to be 1% significant, while other variables are not. This means that the real income and interest rates have a strong relationship with the M2 money demand in the long-run while LIBOR and the exchange rate do not. The coefficient of LnGDP is 0.79, suggesting that M2 money holding will increase by approximately 0.79% if real income in Thailand rose by 1%. The estimates of domestic interest rate (R) elasticity is -0.02, indicating that a decrease of 1% in interest rates in Thailand caused a 0.02% increase in M2 money demand in Thailand.

Table 4.37 Normalized cointegration

Lnreal M2	LnGDP	R	LnEXC	LIBOR	C
-1	0.79	-0.02	-0.06	-0.001	1.00
	[-7.42]	[3.80]	[-0.66]	[-0.08]	[1.26]

Note: The numbers in parentheses show the t-statistics.

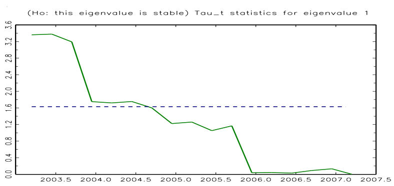
This section will test the stability of the M2 money demand function in Thailand by using a formal test for parameter stability in the context of recursive estimation of the eigenvalue associated with the test for cointegration. There are two options available for implementing the test. In calculation of the recursive eigenvalues it is possible to either, a) concentrate out the short-run parameters (assuming they are stable) using their full sample estimates or b) to estimate all parameters recursively.

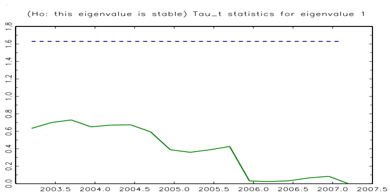
Figure 4.27 shows the results of the M2 money demand function without a shift dummy and the estimates including the shift dummy are presented in Figure 4.28. Figure(A) on both figures shows the recursive estimates of all parameters, while Figure(B) uses full sample estimates to concentrate out short-term parameters. As can be seen when full re-estimation of all parameters is carried out at each point in the recursion, the test statistic shows a sharp drop around 2004 and 2006. However, when we concentrate out the short-run dynamics using the full sample estimates both models show no sign of instability.

Figure 4.27 Recursive Tau statistics for M2 money demand function without a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters



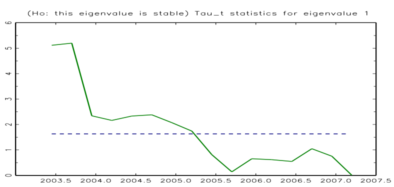


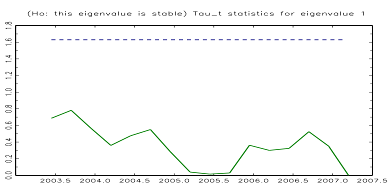
Figure(A) *Figure(B)*

Figure 4.28 Recursive Tau statistics for M2 money demand function including a shift dummy

Figure(A): The recursive estimates of all parameters

Figure(B): Full sample estimates to concentrate out short-term parameters





Figure(A) *Figure(B)*

The result of the weak exogeneity test in Table 4.39 shows that LnRealM2 and LnGDP is 5% significant, and R and LIBOR are 1% significant. Therefore, we can analyse the vector error correction by using all variables as endogenous variables.

Table 4.38 Weak Exogenous

Variable	Restricted Log-likehood	LR Statistic	Degrees of Freedom	Probability
Restrictions: $\alpha(1,1) = 0$				
LnRealM2	286.23	3.93	1.00	0.04
Restrictions: $\alpha(2,1) =$				
LnGDP	2869.47	3.44	1.00	0.05
Restrictions: $\alpha(.3,1) = 0$				
R	288.59	7.19	1.0	0.00
Restrictions: $\alpha(4,1) = 0$				
LnEXC	288.12	0.14	1.00	0.07
Restrictions: $\alpha(5,1) = 0$				
LIBOR	284.88	6.62	1.00	0.01

Table 4.40 presents the results of the VECM for M2 money demand. Taking D(LnRealM2) as dependent variables, the results found that the error correction term is 5% significant. As an error correction term indicates the speed adjustment to the long-run equilibrium and the coefficient of ECT (-1) is -0.002, this means that the disequilibrium of the M2 money demand function in Thailand will be corrected approximately 2% within a quarter.

The coefficient in the second column presents the change of lag variable on the current change of the M2 money demand in Thailand. The coefficient of D(LnRealM2(-4)), D(LnGDP(-4)), D(LIBOR(-1)) and D(LIBOR(-2)) are significant at 5% level, and D(R(-1)) is 10% significant. The coefficient of income in the last four quarters is 0.34, suggesting that a 1% increase in income from the last four quarters caused a 0.34 % increase in current M2 money demand. The coefficient of interest rates in the prior quarter is -0.01, suggesting that an increase of 1% in domestic interest rates in the last quarter leads to a decrease in M2 money holding in the current quarter by 0.01%. The exchange rate (EXC) has not affected M2 money demand in Thailand in the short run since the coefficient of the lag of LnEXC is not significant at any given significant level.

Table 4.39 The results of the VECM

Error Correction:	D(LnRealM2)	D(LnGDP)	D(R)	D(LnEXC)	D(LIBOR)
CointEq1	-0.002 [1.97213]	-0.003 [2.68390]	-0.26 [-7.22402]	-0.01 [-1.61061]	-0.11 [-3.04301]
D(LnRealM2(-1))	0.11 [0.78619]	0.08 [0.64555]	6.59 [1.61582]	0.72 [1.13795]	7.26 [1.78535]
D(LnRealM2(-2))	-0.07 [-0.48533]	0.05 [0.42096]	-6.04 [-1.54326]	0.59 [0.97044]	-0.93 [-0.23763]
D(LnRealM2(-3))	-0.13 [-0.91074]	-0.28 [-2.31853]	1.86 [0.47384]	0.92 [1.51231]	-2.15 [-0.54670]
D(LnRealM2(-4))	0.28 [2.10565]	0.03 [0.23702]	-1.54 [-0.40783]	0.32 [0.54098]	5.65 [1.49419]
D(LnGDP(-1))	0.12 [0.58407]	0.21 [1.19931]	19.98 [3.50332]	1.05 [1.19023]	-1.02 [-0.17883]
D(LnGDP(-2))	0.01 [0.03083]	0.08 [0.47251]	-9.23 [-1.68052]	-1.79 [-2.11205]	-2.71 [-0.49453]
D(LnGDP(-3))	0.05 [0.32651]	0.06 [0.45189]	6.07 [1.36576]	-0.79 [-1.15464]	12.43 [2.80199]
D(LnGDP(-4))	0.34 [2.05663]	0.33 [2.26425]	3.43 [0.73387]	0.09 [0.12859]	-7.32 [-1.56707]
D(R(-1))	0.01 [1.68084]	0.00 [-0.22334]	0.16 [1.69762]	0.02 [1.12937]	-0.01 [-0.09830]
D(R(-2))	0.00 [-0.89787]	-0.01 [-1.95687]	-0.23 [-2.27744]	-0.04 [-2.38504]	-0.13 [-1.25269]
D(R(-3))	0.00 [-0.13789]	0.00 [0.55907]	0.20 [1.69849]	0.04 [2.02462]	-0.16 [-1.30537]
D(R(-4))	0.00 [0.86863]	0.00 [1.08837]	-0.14 [-1.14620]	-0.05 [-2.42566]	-0.02 [-0.13481]
D(LnEXC(-1))	-0.01 [-0.16139]	-0.11 [-2.85972]	5.63 [4.50517]	0.50 [2.62243]	1.22 [0.97850]
D(LnEXC(-2))	-0.05 [-1.15138]	-0.10 [-2.53397]	7.40 [5.87270]	-0.19 [-0.96069]	1.66 [1.31785]
D(LnEXC(-3))	-0.04 [-1.01574]	-0.14 [-3.67417]	4.71 [3.79724]	0.24 [1.25743]	1.94 [1.56638]
D(LnEXC(-4))	0.01 [0.27445]	-0.01 [-0.25825]	10.97 [8.93942]	-0.14 [-0.74812]	3.18 [2.59415]
D(LIBOR(-1))	-0.01 [-1.95297]	0.00 [0.85686]	0.00 [0.00888]	-0.03 [-0.99808]	0.12 [0.69892]
D(LIBOR(-2))	0.01 [2.12797]	0.01 [1.36536]	0.29 [1.69317]	0.00 [-0.08901]	0.21 [1.26220]
D(LIBOR(-3))	0.00 [0.40111]	0.00 [0.00550]	-0.64 [-3.52408]	0.02 [0.56426]	0.15 [0.83380]
D(LIBOR(-4))	0.00 [0.19432]	0.00 [-0.60559]	0.33 [1.77085]	0.00 [0.04444]	-0.14 [-0.76846]

The estimate of the error correction model of the M2 money demand function is:

$$Ln\,RealM2 = -0.002ECT_{t-1} - 0.28\Delta Ln\,RealM2_{t-4} + 0.34\Delta LnGDP_{t-4} - 0.01\Delta R_{t-1}$$
$$(1.97) \qquad (2.10) \qquad (-2.05) \qquad (0.01)$$
$$- 0.01\Delta LIBOR_{t-1} + 0.01\Delta LIBOR_{t-2}$$
$$(1.95) \qquad (2.12)$$

R-squared = 0.51 F-statistic = 1.62 Akaike AIC = -5.14

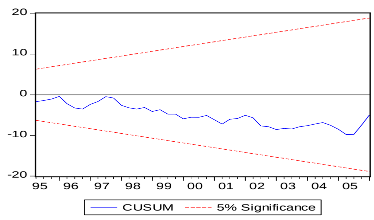
AR 1-4 test: F (4,44) = 1.58 (0.19) ARCH test: F (4, 46) = 0.68(0.60)

Hetero test: F (12,42) = 1.84 (0.07) RESET test F (1, 45)

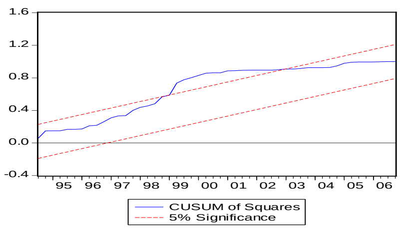
The stability of parameters in the simple M2 money demand function

To test a stability of money demand function, the CUSUM and CUSUMSQ proposed by Brown et al. (1975) is employed. If the plot of CUSUM and/or CUSUMSQ stays within a given significant level, it can be said that the coefficient estimates are stable. As seen in Figure 4.29, the estimate of CUSUM seems to be stable over the sample periods as the demand equation stays within 5% critical. However, the CUSUMSQ show there is evidence of instability around 1998-2002.

Figure 4.29 Plot of CUSUM and CUSUMSQ



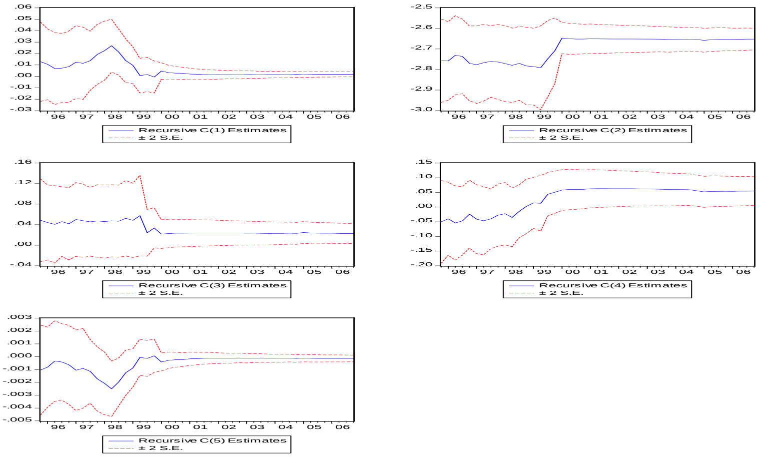
(A) Plot of CUSUM



(B) Plot of CUSUMSQ

The recursive coefficient is presented in Figure 4.30. It is not surprising that the results show the estimated coefficient seems to be unstable during 1996-1999. However, the coefficient became constant after 1999.

Figure 4.30 ***Plot of the Residual Recursive***



Money overhang and inflation

In the next step, we will test whether the estimate of money demand equation is helping forecast inflation at differing lags. The money overhang in this model is:

$$OM2EX = LnrealM2 - (\alpha + \beta LnGDP + \gamma R + \eta LnEXc + \lambda LIBOR)$$

To analyze the relationship between inflation and money overhang, we estimated the forecasting equation for one-quarter-ahead (inflation is regressed on one-quarter-ahead and money overhang), four-quarter-ahead (inflation is regressed on one to four-quarter-ahead and money overhang), and eight-quarter-ahead (inflation is regressed on five to eight-quarter-ahead and money overhang). The results of money overhang and inflation are the following equations.

One-quarter-ahead inflation and money overhang

$$INF = 0.58 INF_{t-1} + 0.001 OM2EX_{t-1}$$
$$(5.48) \qquad (2.34)$$

R-squared = 0.27 Prob(F-statistic) = 0.00 DW = 1.60

AR test: F (2,52) = 1.35 (0.26) ARCH test: F (4,43) = 0.23 (0.92)

Hetero test: F (4, 51) = 1.66 (0.17) RESET test F (1, 53) = 0.83 (0.36)

Four-quarter-ahead inflation and money overhang

$$INF = 0.75INF_{t-1} - 0.20INF_{t-2} + 0.05INF_{t-3} + 0.17INF_{t-4} - 0.003OM2EX_{t-1}$$
$$\quad (5.23) \qquad (-1.16) \qquad (0.29) \quad (0.54) \qquad (1.76)$$

R-squared = 0.35   Prob(F-statistic) = 0.04   DW = 1.98

AR test: F (2,46) = 0.00 (0.99)   ARCH test: F (4,44) = 0.35 (0.83)

Hetero test: F (10,42) = 0.74 (0.67)   RESET test F (1, 47) = 2.52 (0.11)

Eight-quarter-ahead inflation and money overhang

$$INF = 0.13INF_{t-5} + 0.08INF_{t-6} - 0.06INF_{t-7} + 0.19INF_{t-8} - 0.002OM2EX_{t-5}$$
$$\quad (0.74) \qquad (0.37) \quad (-0.30) \qquad (1.14) \qquad (-2.63)$$

R-squared = -0.05   Prob(F-statistic) = 0.68   DW = 0.71

AR test: F (15,29) = 1.82 (0.08)   ARCH test: F (8,32) = 1.39 (0.23)

Hetero test: F (10,38) = 1.57 (0.15)   RESET test F (1, 43) = 4.20 (0.05)

Overall, it seems that money overhang can help to predict inflation for only one quarter ahead since the money overhang is strongly significant and there is no evidence of serial correlation. However, when the model tests for four and eight quarter ahead, there is some evidence of negative coefficiency of money overhang and serial correlation.

4.3.4 Comparison and policy Implication

This section provides the comparison of the results that were achieved from previous parts of the chapter. There are a number of interesting findings from this chapter.

Firstly, the cointegration results of the money demand function, both full sample data and shorter data sets clearly show that there is a single cointegration vector among money demand (either M1 or M2), real income (GDP), and interest rates (R) for the simple model. Similarly, the model that includes exchange rates and LIBOR also shows the single cointegration between money demand (either M1 or M2), real income (GDP), interest rates (R), exchange rates (EXC), and LIBOR. It can be said that there is a stable relationship in the money demand function in Thailand and the money demand function is stable in the long-run.

Table 4.40 Comparison of Cointegration Results

	Full Sample (1980Q1–2007Q1)		Short Sample (1993Q1–2007Q1)	
	M1	M2	M1	M2
Simple Model	Single Cointegration	Single Cointegration	Single Cointegration	Single Cointegration
Model with exchange rate and LIBOR	Single Cointegration	Single Cointegration	Single Cointegration	Single Cointegration

The second interesting finding is the result of the long-run elasticity of the money demand function. As can be seen in Table 4.42, the coefficients of LnGDP and R are significant for every model. This means that money demand in Thailand is strongly dependent on domestic income and domestic interest rates. The result of the full data set (1980Q1-2007Q1) shows that income elasticity has a positive relationship with both the M1 and M2 money demand in Thailand (both simple and open economy models). However, the coefficient of M1 income elasticity is smaller than M2. This means that M2 money demand has grown much faster than the growth of GDP in Thailand, while it appears to be smaller in the M1 money demand. Regarding monetary theory, the growth of money aggregate should be similar to the growth of GDP. Therefore, M1 money demand seems to be more stable and it is more appropriate as an intermediate target of monetary policy. The estimations of the domestic interest rate (R) elasticity are significant for both M1 and M2 money demand functions with negative signs as expected. The effect of the interest rate on M1 is smaller that M2 for the simple model. It is interesting that the interest rate elasticity of M1 became bigger when the external factors were included. On the other hand, the interest rate elasticity for M2 is smaller when the external factor is included. The exchange rate plays an important role in both the M1 and M2 money demand in Thailand. However, the currency substitution happened only in the case of the M2 money demand function since the exchange rate elasticity appeared to be a negative sign. In addition, LIBOR has an affect on only M2 but not for M1.

The results from 1993-2007 indicate that both GDP and R have a long-run relationship with M1 (or M2) money demands in Thailand. It interesting that the income elasticity of M1 income elasticity is bigger than M2 as the M1 income elasticity is 1.40 and the M2 income elasticity equals 0.75. This means that M1 money demand is growing faster than the growth of GDP in Thailand, while it appears to be smaller in the M2 money demand.

The test with exchange rates and LIBOR show that the exchange rate and LIBOR have no affect on the M2 money demand but it does on the M1 money demand. Regarding the shorter data set model, M1 seems to be a more appropriate intermediate target for monetary policy, as it responds to external factors.

Table 4.41 Normalized Long-run elasticity of money demand in Thailand

	LnGDP	R	LnEXC	LIBOR	Trend	C
Full data set (1980-2007)						
Simple Model						
M1 money demand	0.65*	-0.06*				2.06
M2 money demand	3.26*	-0.12*			0.39*	14.01
Model included EXC and LIBOR						
M1 money demand	1.14*	-0.49*	6.97*	0.02		-22.91
M2 money demand	2.27*	-0.06*	-2.23*	-0.02*	0.02*	17.92
Full data set (1993-2007)						
Simple Model						
M1 money demand	1.40*	-0.02*				7.61*
M2 money demand	0.75*	-0.03*				-1.10*
Model included EXC and LIBOR						
M1 money demand	1.42*	-0.01*	0.09*	-0.03*		-7.96
M2 money demand	0.79*	-0.02*	-0.06	-0.001		1.00

Another interesting point of this chapter is the results of the error correction model. The coefficient of error terms appeared to be significant in every model, meaning that money demand has adjusted to the long-run equilibrium. The coefficient of each model is presented in Table 4.43. The results in the simple model indicate that the disequilibrium of the M1 money demand function has adjusted to the equilibrium faster than M2, as the coefficient of the error term is bigger. It can be said that M1 money demand is more flexible and faster to adjust to the equilibrium.

Table 4.42 Error Correction Model

	Coefficient of Error Term (1980Q- 2007Q1)		**Coefficient of Error Term (1993Q1-2007Q1)**	
	M1	**M2**	**M1**	**M2**
Simple Model	-0.19 (-5.38)	-0.07 (-3.60)	-0.32 (-2.05)	-0.08 (-2.04)
Model included EXC and LIBOR	-0.03 (-2.72)	-0.11 (-2.50)	-0.38 (-3.07)	-0.002 (-1.97)

The last finding in the chapter is the estimation of the relationship between money overhang and inflation. The results indicates that the M1 money demand function seem to be more reasonable in forecasting. As can be seen in Table 4.44, the coefficient money overhang for M1 money demand appeared to be significant with a positive relationship with the inflation rate for both the full sample data and the shorter data. In addition, the ARCH test shows that there is no evidence of serial correlation in the model. It can be concluded that the M1 money demand model can help in forecasting the inflation rate in Thailand.

Table 4.43 The relationship between money overhang and inflation

	1980-2007		1993-2007	
	Simple model	EXC and LIBOR model	Simple model	EXC and LIBOR model
Coefficient of Money overhang				
M1 money overhang and				
one-quarter-ahead inflation	0.005	0.0007*	0.014*	0.005*
four-quarter-ahead inflation	0.005	0.005	0.011**	0.005*
eight-quarter-ahead inflation	0.01**	0.007*	0.020*	0.009*
M2 money overhang and				
one-quarter-ahead inflation	0.001**	0.004**	0.01**	0.001*
four-quarter-ahead inflation	0.001	0.003**	0.02**	-0.003**
eight-quarter-ahead inflation	0.003*	0.007*	0.01**	-0.002
ARCH test (ρ value)				
M1 money overhang and				
one-quarter-ahead inflation	0.83	0.90	0.64	0.94
four-quarter-ahead inflation	0.91	0.91	0.91	0.98
eight-quarter-ahead inflation	0.72	0.68	0.11	0.31
M2 money overhang and				
one-quarter-ahead inflation	0.57	0.82	0.74	0.92.
four-quarter-ahead inflation	0.57	0.82	0.77	0.83
eight-quarter-ahead inflation	0.33	0.36	0.12	0.23

4.3.5 Conclusion

This chapter presents the empirical results of the stability of money demand function in Thailand by estimating both the M1 and M2 money demand function. There are two set of data tested in this chapter, the data from 1980-2007 and the date set from 1993-2007. Overall, the results show that the money demand (both M1 and M2) function in Thailand appears to be stable as there is an evidence of single cointegration in every model tested. *This evident support the study of Chowdhury (1997) , Chowdhundry (2004) that there is evidence of stability of M1 and M2 money demand function in Thailand. Similar to the study of* ***Sunner (2009)*** *also point that money balance in Thailand is stable.* In addition, the CUSUM and CUSUMSQ confirm that the money demand function is stable although there was a financial crisis in 1997. Moreover, this chapter also tested whether money overhang that is calculated from the money demand function can help in forecasting inflation in Thailand. The results show that the money overhang in this chapter can be used for estimating the inflation rate in Thailand.

CHAPTER 5
THE VECTOR AUTOREGRESSIVE MODEL AND MONETARY TRANSMISSION MECHANISM IN THAILAND

5.1 Introduction

This chapter presents the empirical results of the monetary transmission mechanism in Thailand. The outline of the chapter is divided into three sections. The first section overviews the concepts of the Vector Autoregression model (VAR). There are three major concerns in this section, the concepts of the VAR and impulse response analysis, the Granger Causality approach, and the Variance Decomposition analysis. The second section is an empirical analysis of the monetary transmission mechanism in Thailand by using the VAR model. Three channels of transmission mechanism are included in this section: the traditional interest rate channel, the credit channel, and the exchange rate channel. The last section presents the conclusions of the chapter.

5.2 Basic Concept of the Vector Autoregression model (VAR)

Generally, the econometric models were created for predicting the effect of change in exogenous or endogenous variables. However, in some cases when researchers have no confidence that the variable is actually an exogenous or endogenous variable, they might be too confused to generate the models. To resolve this problem Sims (1980) introduced the Vector Autoregression model or the VAR methodology to examine the relationship of the set of variables without distinguishing between the exogenous or the endogenous variables. All variables in the model are assumed endogenous. In addition all variables in the VAR system are allowed to interact linearly with their own and other past values.

Consider the simple bivariate VAR with two dependent variables $Y_t = (y_t, z_t)$ where t = 1, 2,… T

$$y_t = b_{10} - b_{12} z_t + c_{11} y_{t-1} + c_{12} z_{t-1} + \varepsilon_{yt} \tag{5.1}$$

$$z_t = b_{20} - b_{21} y_t + c_{21} y_{t-1} + c_{22} z_{t-1} + \varepsilon_{zt} \tag{5.2}$$

where both y_t and z_t are assumed to be stationary,

ε_{yt} and ε_{zt} are white noise and they are uncorrelated .

As can be seen in Equations 5.1 and 5.2, y_t and z_t are allowed to affect each other. The equations can be re-written in matrix form as:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

Alternatively, we can write in the structure VAR (SVAR) form as:

$$BX_t = \Gamma_0 + \Gamma_1 X_{t-1} + \varepsilon_t \tag{5.3}$$

where $B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}, X_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix}, \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}, \Gamma_1 = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$, and $\varepsilon_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$

Multiply Equation 5.3 by the inverse B (B^{-1}) to obtain a standard VAR form (unstructured form):

$$B^{-1} BX_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\varepsilon_t \tag{5.4}$$

or,

$$X_t = A_0 + A_1 X_{t-1} + e_t \tag{5.5}$$

where,

$$A_0 = B^{-1}\Gamma_0 ,\ A_2 = B^{-1}\Gamma_1 , \text{ and } e_t = B^{-1}\varepsilon_1$$

or,

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}$$

It can be written in the equivalent form as:

$$y_t = a_{10} + a_{11} y_{t-1} + a_{12} z_{t-1} + e_{1t} \tag{5.6}$$

$$z_t = a_{20} + a_{21} y_{t-1} + a_{22} z_{t-1} + e_{2t} \tag{5.7}$$

It should be noted that the error terms are composites of two shocks ε_{yt} and ε_{zt}. Since $e_t = B^{-1}\varepsilon_1$, we can calculate e_{1t} and e_{2t} as:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \frac{1}{(1-b_{21}b_{12})}\begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}\begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

or

$$e_{1t} = \frac{\varepsilon_{yt} - b_{12}\varepsilon_{zt}}{(1-b_{12}b_{21})} \tag{5.8}$$

$$e_{2t} = \frac{-b_{21}\varepsilon_{yt} + \varepsilon_{zt}}{(1-b_{12}b_{21})} \tag{5.9}$$

5.2.1 The Granger Causality Test

Since Granger (1969) introduced the Granger Causality technique for examining whether the time series (z_t) is useful for forecasting another time series (y_t), the Granger Causality became an important issue in empirical macroeconomic analysis.

Granger (1969) defined the time series z_t which is said to be Granger-causal for the time series y_t if the past value of y_t affects the current value of y_t. A simple causality model can be written as follows:

$$y_t = \beta_0 + \sum_{i=1}^{n} a_i z_{t-i} + \sum_{j=1}^{n} b_i y_{t-i} + \varepsilon_t$$

(5.10)

$$x_t = \beta_0 + \sum_{i=1}^{n} c_i z_{t-i} + \sum_{j=1}^{n} d_i y_{t-i} + e_t$$

(5.11)

where ε_t and e_t are uncorrelated.

Equation 5.10 indicates that z_t causes y_t if a_i is not zero. Similarly, with Equation 5.11, y_t is causing z_t if d_i is not equal to zero. In case both events occur, it can be said that there is a feedback relationship between z_t and y_t.

However, if both variables fail to cause the other, then both variables are independent.

Granger (1969) also offers the estimation of Granger Causality by using the VAR technique, which can be written as:

$$\Delta y_t = \phi_0 + \sum_{i=1}^{p} \beta_i z_{t-i} + \sum_{j=1}^{p} \lambda_i y_{t-i} + \varepsilon_t \qquad (5.12)$$

$$\Delta x_t = \theta_0 + \sum_{i=1}^{p} \alpha_i \Delta x_{t-i} + \sum_{j=1}^{p} \delta_i \Delta y_{t-i} + e_t \qquad (5.13)$$

Equation 5.12 means that the current y_t is related to the past value of itself and z_t .If the coefficient on the lag of z in Equation 5.12 is different from zero ($\sum \beta_i \neq 0$) and the set of coefficients on the lag y in Equation 5.13 is not different from zero ($\sum \delta_i = 0$), this means that there is unidirectional causality from z_t to y_t ($z_t \Rightarrow y_t$). On the other hand, the unidirectional causality from y_t to z_t ($z_t \Rightarrow y_t$) exists if the set of the lag y_t coefficients in Equation 5.13 is different from zero ($\sum \delta_i \neq 0$) and the set of the lag z_t coefficients in Equation 5.12 is not statistically different from zero ($\sum \beta_i = 0$).

The Granger Causality method can deal with the matrix VAR model. Consider the data set of general three-dimensional VAR models in a standard matrix form:

$$\begin{bmatrix} y_t \\ z_t \\ x_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{bmatrix} + \begin{bmatrix} A_{11}^1(L) & A_{12}^1(L) & A_{13}^1(L) \\ A_{21}^1(L) & A_{22}^1(L) & A_{23}^1(L) \\ A_{31}^1(L) & A_{32}^1(L) & A_{33}^1(L) \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{bmatrix}$$

where:

μ_i is a matrix of deterministic terms such as trend, intercept, or dummy variables

u_{ij} are the vector of white noise error terms.

In this model, we can test the hypothesis that x_t does not Granger cause y_t with respect to the information set generated by z_t if either $A_{13} = 0$ and $A_{23} = 0$ or $A_{13} = 0$ and $A_{12} = 0$

5.2.2 The Impulse Response Function

As the test of causality in the VAR model indicates, the time series variables in the model have significant affect on the future value of other variables. However, it does not explain the sign of relationship between the variables. Brook (2002) states that the F-statistic in the causality analysis will not explain whether changes in value of given variables have positive or negative impacts on other variables. The impulse offers the test of the response of dependent variables in the VAR system to a shock in the error terms.

The impulse response analysis is based on the vector auto regression or VAR model. Sims (1980) states that if we want to trace out the time path of the various shocks on the sets of variables included in the VAR system, the VAR needs to be transformed into a vector moving average (VMA). To transform the VAR model into a VMA, we first re-write the standard VAR in the equation to be more compact as:

$$X_t = A_0 + A_1 X_{t-1} + e_t \quad \Rightarrow \quad X_t = \frac{A_0}{I - A_1 L} + \frac{e_t}{I - A_1 L} \qquad (5.14)$$

where I = 2x2 identify matrix

Then, re-write the first component of Equation 5.14 to obtain:

$$\frac{A_0}{I - A_1} = (I - A_1)^{-1} A_0 = \frac{(I - A_1)^a A_0}{|I - A_1|}$$

$$= \frac{\begin{bmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{bmatrix} A_0}{\begin{vmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{vmatrix}} \qquad = \frac{\begin{bmatrix} 1-a_{22} & a_{21} \\ a_{12} & 1-a_{22} \end{bmatrix} \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix}}{(1-a_{11})(1-a_{22})-a_{21}a_{12}}$$

$$= \frac{1}{\Delta} \begin{bmatrix} (1-a_{22})a_{10} + a_{21}a_{20} \\ a_{12}a_{10} + (1-a_{22})a_{20} \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix}$$

As a condition of stability is that the root of $I - A_1 L$ lies outside the unit circle (Ender 2004, p.266), therefore the second component can be written as:

$$\frac{e_t}{I - A_1 L} = \sum_{i=0}^{\infty} A_1^i e_{t-i} = \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1,t-i} \\ e_{2,t-i} \end{bmatrix}$$

Therefore, we can write a VAR as a VMA with a standard error form as:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=1}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \tag{5.15}$$

However, the error terms in Equation 5.15 consist of structural innovations. We need to re-write the error terms e_{1t} and e_{2t} in Equation 5.15 with ε_{yt} and ε_{zt}. From Equations 5.8 and 5.9, we obtain:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \frac{1}{(1-b_{21}b_{12})} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \tag{5.16}$$

If we combine Equations 5.15 and 5.16, we obtain:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y}_t \\ \bar{z}_t \end{bmatrix} + \frac{1}{1-b_{12}b_{21}} \sum_{i=1}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \tag{5.17}$$

Equation 5.17 can be re-written by defining the 2x2 matrix ϕ with element $\phi_{jk}(i)$ to obtain:

$$\phi_i = \frac{A_1^i}{1-b_{12}b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \tag{5.18}$$

Therefore, the moving average in Equations 5.15 and 5.16 can be written in terms of ε_{yt} and ε_{zt} as:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \Phi_{11}^{(i)} & \Phi_{12}^{(i)} \\ \Phi_{21}^{(i)} & \Phi_{22}^{(i)} \end{bmatrix}^{i} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \quad (5.19)$$

or

$$X_t = \mu + \sum_{i=1}^{\infty} \phi_i \varepsilon_{t-i} \quad (5.20)$$

In fact, the vector moving average is a basic tool for examining the interaction between the variables. The coefficient ϕ_i can be used for generating the numerical effects of ε_{1t} and ε_{2t} shocks to the entire time paths of the series $\{y_t\}$ and $\{z_t\}$. It should be noted that the four elements $\phi_{jk}(0)$ are impact multipliers. For example, the coefficient $\phi_{12}(0)$ indicates the instantaneous effect of one unit change in ε_{zt} on y_t. Similarly, $\phi_{11}(1)$ is the one period response of unit change in ε_{yt-1} on y_t. It can be said that each $\phi_{jk}(i)$ parameter represents the time-specific partial derivative of the VMA function where:

$$\phi_{jk}(i) = \frac{\partial y_{ji}}{\partial \varepsilon_k} \quad (5.21)$$

Equation 5.21 measures the effect of the shock in the k^{th} variable in the present period to the j^{th} variable, ε_{2t}.

Ender (2004) states that the accumulated effects of unit impulses in ε_{yt} and ε_{zt} can be calculated by the summation of the coefficient of the impulse response function. He gives the example that the effect of ε_{zt} on the value of y_{t+n} after n period is $\phi_{12}(n)$. Therefore, after n period, the cumulated sum of effects of the unit impulse of ε_{zt} on $\{y_t\}$ series is:

$$\sum_{i=0}^{n} \phi_{12}(i) \quad (5.22)$$

If n is infinity $(n \to \infty)$, we obtain a long run impact multiplier. Given the series $\{y_t\}$ and $\{z_t\}$ are assumed to be stationary, it must be the case of j and k, $\sum_{i=0}^{\infty} \phi_{jk}(i)$ is finite. It can be said that the set of coefficients $\phi_{jk}(i)$ are called the **impulse response function**. In general, the plot of the impulse response function is more practical to present the response of series $\{y_t\}$ and $\{z_t\}$ to the various shocks.

5.2.3 Modeling of the monetary transmission mechanism in Thailand

Since another objective of this thesis is to test the monetary transmission mechanism and the effect of monetary policy on economic activities, this section will apply the conventional IS-LM model to derive a reduced form for testing equations. The IS-LM equation can be expressed in linear form as:

$$\text{IS} \; : \quad y = \alpha_t - \beta R_t \qquad (5.23)$$

$$\text{LM:} \quad mt = \varphi y_t - \delta R_t + u_{2t} \qquad (5.24)$$

Reduce form by solving Equation 5.23 for the interest rate (R) and subtract into Equation 5.24 to obtain:

$$y = \left(\frac{\delta}{\delta + \beta\phi} \right) \alpha_t + \left(\frac{\delta\beta}{\delta + \beta\phi} \right) m_t \qquad (5.25)$$

Considering Equation 5.25, it can be written in linear form as:

$$y = \gamma_t + \eta m_t \qquad (5.26)$$

The Equation 5.26 implies that monetary aggregate has a positive relationship with output.

Recently, the vector autoregressive model (VAR) has become popular in the literature of transmission mechanism because the VAR have proved to be a convenient method of summarizing dynamic relationships among variables. It seems to be that the VAR model was initiated by Sims (1980) as a general dissatisfaction with the structural econometric modeling approach, in which theoretical restrictions limit the interdependencies of the variables included in the model. After that, many scholars adopted the VAR model to estimate the affect of monetary policy on the economic activities. For example, Bernanke and Blinder (1992) adopt the VAR model to test the response by banks to a rise in short-term interest rates (the federal funds rate in the US). The variables in this model included the log of the consumer price index, the log of M1 and M2, the Federal rate, the three-month Treasury bill rate and the ten-year Treasury bond rate. As well, Bernanke and Gertler (1995) used the VAR to examine the dynamic response of variable economic aggregates to an unanticipated tightening of monetary policy. The VAR system involved a log of real GDP and the price level, a log of index of commodity prices, and the federal fund rate. The research found that the unanticipated tightening of monetary policy had only an affect on the interest rate. After that many researchers used the VAR for testing the transmission mechanism in a different countries, such as Friedman and Kuttner (1992) for the USA and Yu (1997) for China.

This research also employs a Vector Autoregression (VAR) model to achieve the objective. The VAR consists of a set of endogenous variables and exogenous variables.

Since the major objective of this section is to employ the Vector Autoregression model (VAR) to investigate the monetary transmission mechanism in Thailand, it focuses on the affect of monetary shock on economic growth and price stability. In order to achieve the effectiveness of the different channels of the monetary transmission mechanism, this thesis starts by estimating a basic model, which presents the relationship between money and major macroeconomic indicators (economic growth and price stability). Then, we analyze each particular channel of the monetary transmission mechanism by adding different variables of monetary policy, which represent each transmission mechanism of monetary policy in Thailand. There are three channels of monetary transmission mechanism included in this section, the interest channel, the credit channel, and the exchange rate channel. For the interest rate channel, the domestic interest rate is included as an intermediate target in monetary policy. The aggregate credit (CRE) is added in the credit channel, and the exchange rate is used in the exchange rate channel. Therefore, there are four models estimated in this chapter; the variables included in each models are presented in Table 5.1.

Table 5.1 Models of the Monetary Transmission Mechanism

Model	Variables included in the VAR system
Basic model	Money (M1 or M2), Real output (GDP), and Price level (P)
Interest rate channel	Interest rate (R), Money (M1 or M2), real output (GDP), and Price level (P)
Credit channel	Aggregate credit (CRR), Money (M1 or M2), real output (GDP), and Price level (P)
Exchange rate channel	Exchange Rate (EXC), Money (M1 or M2), Real output (GDP), and Price level (P)

5.3 Empirical Results of the Transmission Mechanism of Monetary Policy

The major objective of this section is to employ the Vector Autoregression model (VAR) to investigate the monetary transmission mechanism in Thailand, focusing on the affect of monetary shock on economic growth and price stability. In order to achieve the effectiveness of the different channels of the monetary transmission mechanism, this section starts by estimating a basic model, which presents the relationship between money and major macroeconomic indicators (economic growth and price stability). Then, we analyse each particular channel of the monetary transmission mechanism by adding a different variable of monetary policy, which represents each transmission mechanism of monetary policy in Thailand. The estimation in this chapter starts by selecting the optimal lag length for each VAR model. Then, we examine the short-term relationship between the set of variables by applying the Granger Causality test. After that, variance decomposition is adopted to test the response of each variable on the monetary shock. The last test of the chapter is to apply the impulse response analysis to show the response of economic indicators to monetary policy.

There are two major money demands in previous chapters, and both of them appeared to be stable over the sample period. Therefore, this chapter applies both M1 and M2 money demand in each transmission mechanism of monetary policy in order to compare the response of money to monetary policy in the sense of selecting the money demand as an intermediate target of monetary policy.

5.3.1 The lag length selection

Regarding the VAR methodology, the lag length selection is a necessary condition for estimating the VAR model. Therefore, before estimating the VAR, we apply the AIC and LR criteria to select the optimal lag length in each VAR model. The results of lag length selection are presented in Table 5.2. Given the smallest criteria, the optimal lag length for the M1 basic model is the lag of four, while the second lag is selected for the M2 basic model. Consider the lag length selection for each model of the transmission mechanism. The fifth lag is selected for the interest rate channel and the exchange channel when M1 is included in the model, while the lag of four is chosen for the credit channel of the transmission mechanism. For the model where M2 is included, the second lag appeared to be the optimal lag length for the interest rate channel and the credit channel. The most appropriate lag length for the exchange rate channel is the lag of three.

Table 5.2 Lag Length Selection of the VAR model

	Basic Model					
	Variables: LnRealM1, LnGDP, LnP			Variables: LnRealM2, LnGDP, LnP		
Lag	LogL	LR	AIC	LogL	LR	AIC
0	159.23	NA	-6.01	205.76	NA	-7.80
1	406.96	457.33	-15.19	472.04	491.60	-17.69
2	420.18	22.89	-15.35	488.56	28.60	-17.98*
3	440.04	32.07	-15.77	496.07	12.12	-17.93
4	452.58	18.81	-15.90*	503.56	11.24	-17.87
5	460.03	10.31	-15.85	508.22	6.46	-17.70
	Interest Rate Channel					
	Variables: R,LnRealM1, LnGDP,LnP			Variables: R, LnRealM2,LnGDP,LnP		
Lag	LogL	LR	AIC	LogL	LR	AIC
0	48.25	NA	-1.70	85.30	NA	-3.13
1	354.61	553.81	-12.87	421.11	607.04	-15.43
2	375.66	34.80	-13.06	443.03	36.24	-15.65*
3	405.53	44.81	-13.60	458.88	23.77	-15.65
4	430.96	34.23	-13.96	473.03	19.05	-15.58
5	449.47	22.07	-14.05*	485.06	14.34	-15.43
	Credit Channel					
	Variables: LnCRE LnRealM1,LnGDP,LnP			Variables: LnCRE LnRealM2,LnGDP,LnP		
Lag	LogL	LR	AIC	LogL	LR	AIC
0	206.95	NA	-8.46	243.32	NA	-9.97
1	504.97	533.95	-20.21	569.32	584.08	-22.89
2	522.65	28.73	-20.28	587.07	28.84	-22.96*
3	544.68	32.14	-20.53	600.07	18.96	-22.84
4	570.15	32.89	-20.92*	616.7	21.4	-22.9
5	584.04	15.63	-20.84	629.74	14.71	-22.74
	Exchange Rate Channel					
	Variables: LnEXC LnRealM1,LnGDP,LnP			Variables: LnEXC LnRealM2,LnGDP,LnP		
Lag	LogL	LR	AIC	LogL	LR	AIC
0	218.81	NA	-8.26	263.54	NA	-9.98
1	501.66	511.31	-18.53	558.45	533.11	-20.71
2	522.05	33.73	-18.69	582.56	39.87	-21.02
3	548.36	39.45	-19.09	600.10	26.30	-21.08*
4	573.58	33.95	-19.44	615.65	20.93	-21.06
5	592.99	23.14	-19.57*	630.59	17.82	-21.02

After the optimal lag length is selected for each model, the next step is to adopt the lag length achieved from this section to test the VAR model of each model of the transmission mechanism in Thailand.

5.3.2 Test for the Basic models

The traditional monetary theory claims that change in money aggregate leads to change in real economic activities such as real output and price level. The major concern of the basic model in this thesis is to test the relationship between money and real economic activities. As the aims of monetary policy usually focus on economic growth (GDP)and price stability (P), therefore two major real economic indicators concerned in this thesis are real output and price level. In addition, the paper examines two different basic models, the M1 and M2 basic models.

This section starts by using the Granger Causality method to examine the short-term interaction between money and real economic activities (real output and price level). The results of Granger Causality in the basic models are presented in Table 5.3. Panel (A) presents the Granger Causality of the M1 basic model, and the M2 basic model is shown in Panel(B). The numbers in the table present the F-statistic for the null hypothesis that variable x does not Granger-cause variable y.

The result of Granger Causality indicates that there is bidirectional Granger Causality between real output and M1. As the null hypothesis of LnGDP does not Granger-cause, LnRealM1 is rejected at 1% significant, and the hypothesis of there being Granger Causality from LnRealM1 to LnGDP is also rejected at 5% significant. Furthermore, there is unidirectionality from the price level to M1 (LnP →LnRealM1) in Thailand, since the ρ value is less than 0.01. However, the null hypothesis that LnRealM1 does not Granger-cause LNP cannot be rejected. This means that in the short period change in M1 affects real output, while it does not affect price level. The result of Granger Causality with the M2 basic model suggests that the null hypothesis that LnRealM2 does not

Granger-cause LNP is rejected at 10% significant, while the hypothesis that LnRealM2 does not Granger-cause LnGDP cannot be rejected. This implies that changes in M2 do not affect economic growth, while it does impact price levels in Thailand.

Given the monetary framework based on the basic models, we found that M1 seems to have more effect on economic growth while M2 has more impact on price levels in Thailand. Based on the results of the basic models above, if monetary policy in Thailand aims to stabilize price levels, M2 should be selected as an intermediate target in monetary policy. However, in the case of the policy focusing on economic growth, M1 appeared to be more appropriate as an intermediate target.

Table 5.3 Granger Causality Test for basic models

Null Hypothesis:	F-Statistic	Probability
(A) M1 basic model **Variable : LnRealM1 LnGDP LnP (4 lags)**		
LnGDP does not Granger-cause LnRealM1	13.40*	0.00
LnRealM1 does not Granger-cause LnGDP	3.10**	0.02
LnP does not Granger-cause LnRealM1	4.54*	0.00
LnRealM1 does not Granger-cause LnP	1.77	0.15
LnP does not Granger-cause LnGDP	1.16	0.34
LnGDP does not Granger-cause LnP	4.30*	0.01
(B) M2 basic model **Variable : LnRealM2 LnGDP LnP (2 lags)**		
LnGDP does not Granger-cause LnRealM2	4.89*	0.00
LnRealM2 does not Granger-cause LnGDP	0.54	0.65
LnP does not Granger-cause LnRealM2	1.66	0.19
LnRealM2 does not Granger-cause LnP	2.30***	0.09
LnP does not Granger-cause LnGDP	2.14	0.11
LnGDP does not Granger-cause LnP	7.72*	0.00

Note: Note that *, **, and *** indicate 1%, 5%, and 10% significant level.

Table 5.4 presents the variance decomposition for the basic model of both M1 and M2. The results give the idea of the fluctuations in each variable that are caused by a difference shock. The numbers of variance decomposition shows the percentage of the variance caused by each shock. The results of variance decomposition suggest that after four quarters, the M1 shock caused 13.95% fluctuation in real output, while only 4.31% fluctuation of real output was caused by the M2 shock. However, the shock of both M1 and M2 had a small affect on price levels in Thailand. The variance decomposition of the M1 and M2 shock on price levels are 1.94 and 2.59 in four quarters, meaning that the M1 shock caused only 1.94% fluctuation in price levels and the M2 shock caused around 2.59% fluctuation in price levels. It is interesting to note that the M1 shock had more affect on the fluctuation in output. However, the shock of M2 had slightly more affect on the price level. This confirms that M1 appeared to be more effective as an intermediate target in monetary policy if the monetary policy focuses on economic growth. On the other hand, M2 is seen as a better target if the monetary authorities are concerned about price stability.

Table 5.4 Table of Variance Decomposition for the basic models

Cholesky Ordering: LnRealM1 LnGDP LnP						**Cholesky Ordering: LnRealM2 LnGDP LnP**			
Variance Decomposition of LnRealM1:						**Variance Decomposition of LnRealM2:**			
Period	S.E.	LnRealM1	LnGDP	LnP		S.E.	LnRealM2	LnGDP	LnP
2	0.05	83.18	13.61	3.22		0.02	95.93	1.76	2.31
4	0.06	78.21	13.96	7.83		0.02	92.37	2.19	5.44
6	0.08	81.10	14.74	4.16		0.03	87.99	2.44	9.57
8	0.10	73.82	22.84	3.34		0.03	83.70	3.30	13.00
10	0.12	68.35	29.13	2.52		0.03	79.31	5.63	15.06
Variance Decomposition of LnGDP:						**Variance Decomposition of LnGDP:**			
Period	S.E.	LnRealM1	LnGDP	LnP		S.E.	LnRealM2	LnGDP	LnP
2	0.02	2.53	92.62	4.86		0.03	0.02	96.09	3.89
4	0.03	13.95	75.94	10.11		0.05	4.31	90.40	5.29
6	0.04	36.00	54.55	9.45		0.06	14.53	81.52	3.95
8	0.05	51.88	40.50	7.62		0.07	24.52	72.63	2.85
10	0.06	58.48	35.96	5.55		0.08	31.20	66.58	2.23
Variance Decomposition of LnP:						**Variance Decomposition of LnP**			
Period	S.E.	LnRealM1	LnGDP	LnP		S.E.	LnRealM2	LnGDP	LnP
2	0.01	1.99	15.02	82.99		0.01	4.11	7.06	88.83
4	0.01	1.94	15.73	82.34		0.01	2.59	6.57	90.84
6	0.02	4.13	15.07	80.80		0.02	5.32	7.57	87.12
8	0.02	3.76	20.32	75.92		0.02	6.31	18.39	75.30
10	0.02	3.82	26.23	69.95		0.02	5.21	32.57	62.23

The impulse response of the M1 basic models is shown in Figure 5.1. The result shows that GDP has a positive response to changes in M1 over the sample period. The price level is stable for about four quarters, and then slightly decreases until the end of quarter six. After that, it continues to increase.

The impulse response of the M2 basic model in Figure 5.2 suggests that economic growth seems to be stable for two quarters after the shock in M2. After that, it declines substantially. The response of the price level to the M2 shock shows that the price level slightly increases for two quarters after the shock. Then, the price level dramatically increases in the second to fourth quarter. After that, the price level became stable.

Overall, the result of basic model indicates that both M1 and M2 have small effect on price level while more effect on output in Thailand. It should be note that M 1 has more effect on output while M2 has more effect on price level. Given the basic model of transmission mechanism, if the policy maker concern more on economic growth, M1 should be better to use as an intermediate target in monetary policy

Figure 5.1 The impulse response of the M1 basic model

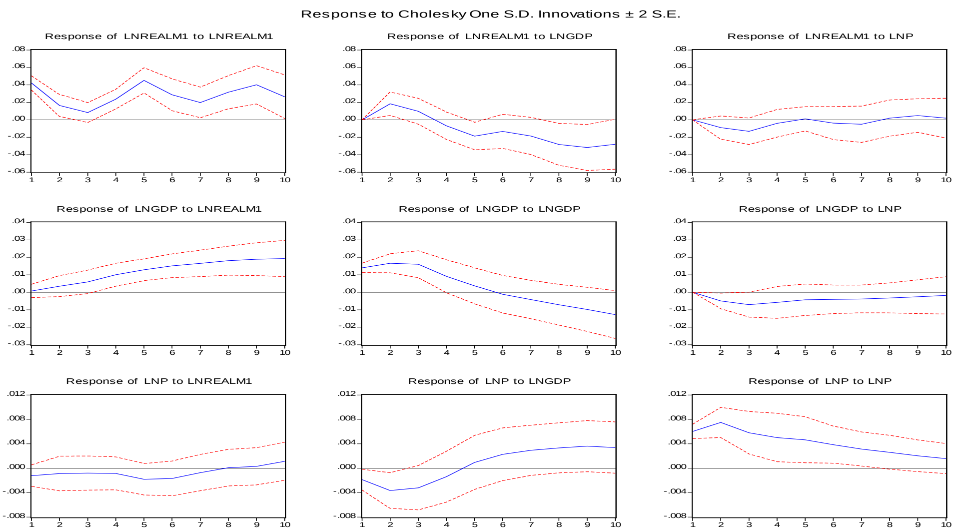
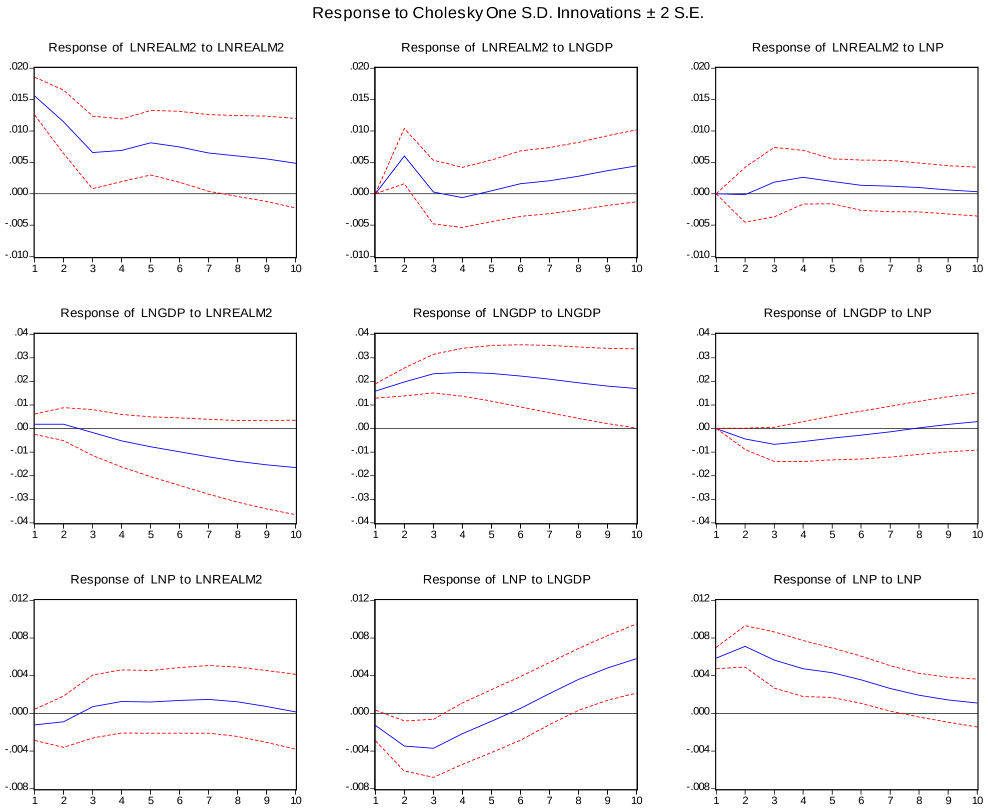


Figure 5.2 The impulse response of the M2 basic model



5.3.3 The channel of the monetary transmission mechanism

After analysing the basic models of monetary theory, this section will examine the particular channels of the monetary transmission mechanism in Thailand by adding monetary variables to each transmission mechanism of monetary policy. The interest rate is added in the interest channel, aggregate credit is adopted in the credit channel, and the exchange rate is used in the exchange rate channel of monetary policy.

5.3.3.1 Interest Rate channel of the Monetary Transmission Mechanism

In order to estimate the interest rate channel of the transmission mechanism in Thailand, the variable R (domestic interest rate) is added into the basic model.

Therefore, the variables included in the VAR system of the interest rate channel are domestic interest rates (R), real output (GDP), the price level(P), and money aggregate (M1 or M2).

The Granger Causality result of the interest channel of the monetary transmission mechanism are presented in Table 5.5. Panel(A) presents the interest channel when M1 is included and Panel(B) shows the interest channel of monetary policy where M 2 is added. The results found that there is unidirectionality from interest rates to real M1 money aggregate. As the F-statistic of R does not Granger-cause, LnRealM1 is rejected at 1% significant, but it is not rejected for the hypothesis that LnRealM1 does not Granger-cause R. In addition, the results also suggest that M1 Granger-caused both real output and price level in the economy at 5% significance, since the p value of the hypothesis that LnRealM1 does not Granger-cause LnP and LnRealM1 does not Granger-cause LnGDP, being smaller than 0.05. It can be concluded that the interest rate has significant affect on M1 and it in turn impacts on real output and price level. It is interesting to note that the interest rate also has a strong relationship with real output, but it does not affect the price level directly in the short term.

Consider the interest rate channel model with M2. The results state that the interest rate has a weak relationship with the price level, as the F-statistic of Granger Causality is rejected at 10% significance. However, interest rates do not affect M2 and real output. M2 does affect price level but there is no relationship between M2 and real output.

Given the interest rate channel of monetary policy framework, it seems that the interest rate has more affect on economic activity when M1 is selected as an intermediate target, since R has a strongly significant relationship with M1, economic growth, and price level.

Table 5.5 Granger Causality test for the interest rate channel of the monetary transmission mechanism

Null Hypothesis:	F-Statistic	Probability
Panel(A) ***Variables : R LnGDP LnP LnRealM1 (5 lags)***		
LnGDP does not Granger-cause R	2.784	0.030
R does not Granger-cause LnGDP	3.035	0.020
LnP does not Granger-cause R	4.677	0.002
R does not Granger-cause LnP	1.943	0.108
LnRealM1 does not Granger-cause R	1.305	0.281
R does not Granger-cause LnRealM1	7.028	0.000
LnP does not Granger-cause LnGDP	1.383	0.251
LnGDP does not Granger-cause LnP	3.213	0.015
LnRealM1 does not Granger-cause LnGDP	2.834	0.027
LnGDP does not Granger-cause LnRealM1	7.034	0.000
LnRealM1 does not Granger-cause LnP	3.364	0.012
LnP does not Granger-cause LnRealM1	2.219	0.071
Panel(B) ***Variables : R LnGDP LnP LnRealM2 (2 lags)***		
LnGDP does not Granger-cause R	0.099	0.906
R does not Granger-cause LnGDP	1.925	0.157
LnP does not Granger-cause R	9.328	0.000
R does not Granger-cause LnP	2.505	0.092
LnRealM2 does not Granger-cause R	1.536	0.225
R does not Granger-cause LnRealM2	0.639	0.532
LnP does not Granger-cause LnGDP	2.684	0.078
LnGDP does not Granger-cause LnP	8.189	0.001
LnRealM2 does not Granger-cause LnGDP	0.210	0.811
LnGDP does not Granger-cause LnRealM2	0.932	0.400
LnRealM2 does not Granger-cause LnP	2.666	0.079
LnP does not Granger-cause LnRealM2	2.386	0.102

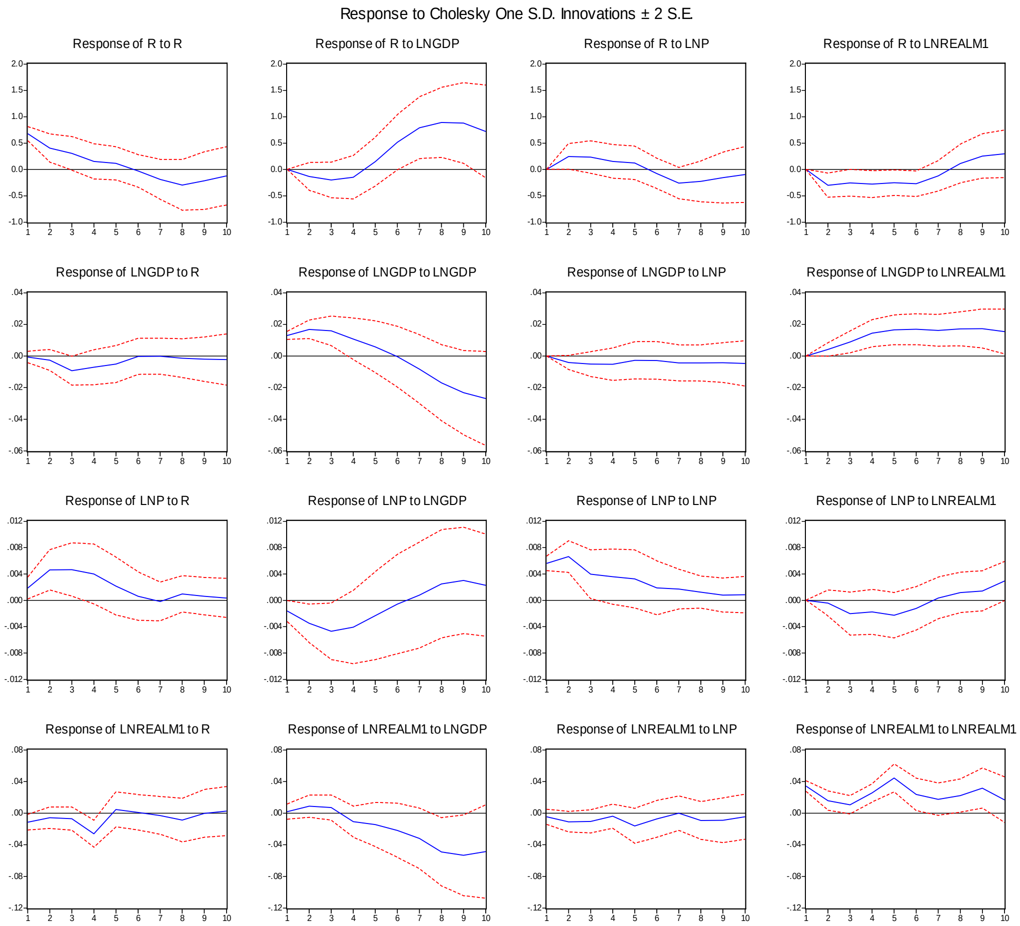
The variance decomposition for the interest rate channel is presented in Table 5.6. The results indicate that after four quarters, the response of the fluctuation in output to shock in M1 is 22.68% , while only a 8.44% response to shock in M2. Both are higher than the response in the basic models. Interest rate shocks account for 10% fluctuation in output, 27.4% fluctuation in price level, and account approximately for 24.8% of the fluctuation in M1. However, the result of the interest rate channel when M2 is included shows that the shock in interest rates is only 10% fluctuation on price level, and is around 7.81% of the fluctuation in M2. This evidence indicates that interest rates are a relatively weaker determinant of the fluctuation in the price level when M2 is included, while it has stronger relationship with real output when M1 is included.

Table 5.6 Variance Decomposition for the interest rate channel

	Cholesky Ordering: R LnGDP LnP LnRealM1					***Cholesky Ordering: R LnGDP LnP LnRealM2***				
Variance Decomposition of R:						***Variance Decomposition of R:***				
Period	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM1***	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM***
2	*0.89*	*78.93*	*2.20*	*7.64*	*11.23*	*1.08*	*90.63*	*2.09*	*5.01*	*2.27*
4	*1.09*	*62.26*	*6.62*	*11.71*	*19.42*	*1.45*	*87.30*	*1.71*	*5.95*	*5.05*
6	*1.29*	*45.71*	*22.29*	*9.72*	*22.27*	*1.62*	*81.38*	*4.40*	*5.64*	*8.58*
8	*1.83*	*26.30*	*53.49*	*8.37*	*11.84*	*1.73*	*72.23*	*11.37*	*7.95*	*8.45*
10	*2.21*	*19.25*	*63.10*	*6.41*	*11.24*	*1.84*	*65.28*	*17.01*	*9.32*	*8.39*
Variance Decomposition of LnGDP:						***Variance Decomposition of LnGDP:***				
Period	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM1***	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM***
2	*0.02*	*1.45*	*91.61*	*3.45*	*3.48*	*0.02*	*4.71*	*92.75*	*2.34*	*0.20*
4	*0.04*	*10.81*	*61.19*	*5.32*	*22.68*	*0.04*	*13.95*	*76.45*	*1.16*	*8.44*
6	*0.04*	*8.67*	*43.16*	*4.40*	*43.77*	*0.05*	*21.99*	*56.20*	*1.18*	*20.63*
8	*0.05*	*5.91*	*41.30*	*4.27*	*48.52*	*0.07*	*26.33*	*42.03*	*2.12*	*29.52*
10	*0.07*	*3.81*	*51.75*	*3.46*	*40.98*	*0.08*	*28.35*	*33.40*	*3.26*	*34.99*
Variance Decomposition of LnP:						***Variance Decomposition of LnP:***				
Period	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM1***	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM***
2	*0.01*	*21.46*	*12.92*	*65.47*	*0.15*	*0.01*	*5.80*	*3.63*	*90.52*	*0.05*
4	*0.02*	*27.41*	*23.65*	*45.69*	*3.25*	*0.01*	*10.66*	*2.74*	*82.66*	*3.94*
6	*0.02*	*26.00*	*23.01*	*45.56*	*5.43*	*0.02*	*12.63*	*5.02*	*71.88*	*10.46*
8	*0.02*	*25.05*	*24.36*	*44.87*	*5.72*	*0.02*	*11.27*	*13.74*	*62.32*	*12.67*
10	*0.02*	*22.99*	*26.93*	*41.33*	*8.74*	*0.02*	*9.79*	*24.70*	*54.45*	*11.06*
Variance Decomposition of LnRealM1:						***Variance Decomposition of LnRealM2:***				
Period	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM1***	***S.E.***	***R***	***LnGDP***	***LnP***	***LnRealM***
2	*0.04*	*9.12*	*4.58*	*7.74*	*78.55*	*0.02*	*4.97*	*5.23*	*6.19*	*83.61*
4	*0.06*	*24.82*	*6.92*	*7.34*	*60.92*	*0.03*	*7.81*	*5.15*	*4.85*	*82.20*
6	*0.08*	*12.81*	*13.04*	*8.02*	*66.13*	*0.03*	*8.89*	*5.13*	*5.92*	*80.06*
8	*0.11*	*8.70*	*37.68*	*5.72*	*47.91*	*0.03*	*9.08*	*6.00*	*7.04*	*77.89*
10	*0.13*	*5.57*	*52.65*	*4.21*	*37.58*	*0.03*	*8.74*	*8.01*	*7.97*	*75.29*

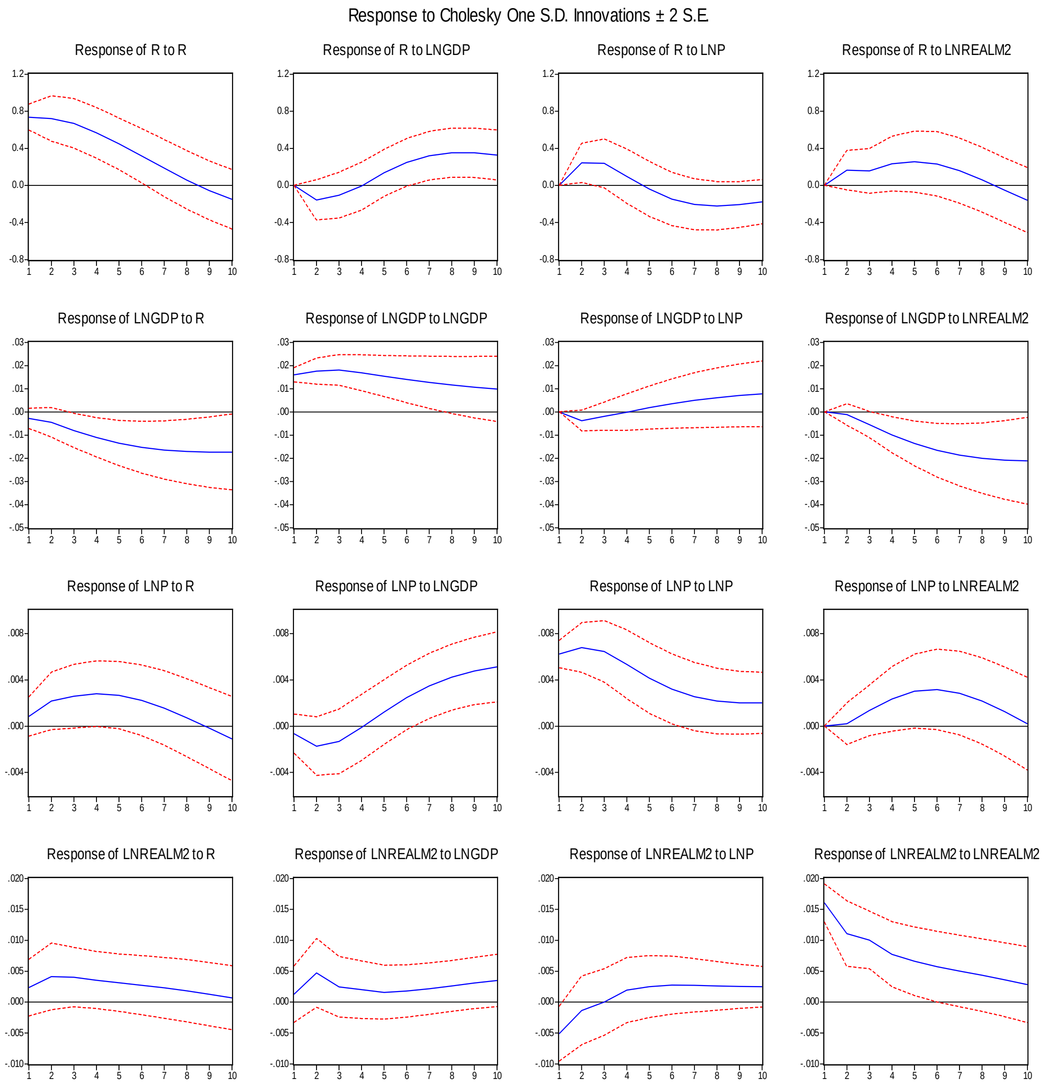
Figure 5.3 indicates the impulse response function of the interest rate channel of the monetary transmission mechanism where M1 is included. The response of M1 to interest rate shock appeared to be stable for about three quarters, and then it sharply decreased from the third to the fourth quarter. After that, the response of M1to interest rate shock increased dramatically until the fifth quarter. The response of price level to interest rate shock sharply increased from the first quarter to the second quarter, and then the price level continued to decline until the seventh quarter. Economic growth (GDP) was predicted to decrease for three quarters after the interest rate shock and then increased substantially.

Figure 5.3 The impulse response of the M1 interest rate channel



The impulse response functions of the interest rate channel of the monetary transmission mechanism where M2 is included are presented in Figure 5.4. M2 rose substantially for two quarters after the interest rate shock, and then it fell gradually. The response of the price level to interest rate shock seemed to increase for five quarters after the shock. After that, it decreased significantly. GDP responds to interest rate shock in a negative way from the first quarter of the shock.

Figure 5.4 The impulse response of the M2 interest rate channel



5.3.3.2 Credit channel of the Monetary Transmission Mechanism

As the suggestion of Miskin (1995) is that the credit channel operates through bank lending, the aggregate credit is included in the VAR system to analyse the credit channel of monetary policy. Therefore, the variables of the credit channel model include aggregate credit (CRE), real output (GDP), the price level (P), and money aggregate (M1 or M2).

Table 5.7 reports the Granger Causality test for the credit channel of the monetary transmission mechanism in Thailand. The result when M1 is included in the model shows that M1 Granger Causality real output (GDP) is at 5% significance level, while it does not Granger-cause price level (P). However, the results also indicate that aggregate credit Granger-caused price level, real output, and M1 at 5% significance level. Based on the monetary theory, an increase in domestic credit would increase growth rate and money aggregate. This confirms that the credit channel is a major injector of money into the economy.

The credit channel of monetary policy when M2 is included as an intermediate target shows that only the hypothesis that credit does not cause GDP is rejected at 5% significant. However, there is no rejection for the hypothesis that credit Granger-causes M2 and P. This means that in the model of the credit channel of the monetary transmission mechanism change in domestic credit only affects economic growth, but does not affect price level and M2 in the Thai economy.

Table 5.7Granger Causality Test for the Credit Channel Model

Null Hypothesis:	F-Statistic	Probability
Panel(A) ***Variables : LnCRE LnGDP LnP LnRealM1 (4 lags)***		
LnGDP does not Granger-cause LnCRE	2.726	0.043
LnCRE does not Granger-cause LnGDP	2.899	0.034
LnP does not Granger-cause LnCRE	0.450	0.772
LnCRE does not Granger-cause LnP	3.426	0.017
LnRealM1 does not Granger-cause LnCRE	1.098	0.371
LnCRE does not Granger-cause LnRealM1	3.226	0.022
LnP does not Granger-cause LnGDP	1.163	0.340
LnGDP does not Granger-cause LnP	4.298	0.005
LnRealM1 does not Granger-cause LnGDP	3.099	0.025
LnGDP does not Granger-cause LnRealM1	13.400	0.000
LnRealM1 does not Granger-cause LnP	1.771	0.152
LnP does not Granger-cause LnRealM1	4.542	0.004
Panel(B) ***Variables : LnCRE LnGDP LnP LnRealM2 (2 lags)***		
Null Hypothesis:	**F-Statistic**	**Probability**
LnGDP does not Granger-cause LnCRE	1.539	0.225
LnCRE does not Granger-cause LnGDP	3.264	0.047
LnP does not Granger-cause LnCRE	0.986	0.381
LnCRE does not Granger-cause LnP	0.600	0.553
LnRealM2 does not Granger-cause LnCRE	0.271	0.764
LnCRE does not Granger-cause LnRealM2	0.202	0.818
LnP does not Granger-cause LnGDP	2.684	0.078
LnGDP does not Granger-cause LnP	8.189	0.001
LnRealM2 does not Granger-cause LnGDP	0.210	0.811
LnGDP does not Granger-cause LnRealM2	0.932	0.400
LnRealM2 does not Granger-cause LnP	2.666	0.079
LnP does not Granger-cause LnRealM2	2.386	0.102

The variance decomposition of the credit channel of the monetary transmission mechanism is presented in Table 5.8. The results of the M1 credit channel of the transmission mechanism indicates that aggregate credit shock caused about 3.23% of the fluctuation in output, while about 11.23% of the fluctuation of price level was caused by credit shock. However, the model of the credit channel of the transmission mechanism which included M2 shows that there is only 1.37% of fluctuation in the GDP, and approximately 5.05% 1.37% of the fluctuation in price was caused by credit shock. This evidence confirms that M1 is more responsive to the credit channel of the transmission mechanism than M2 is. In addition, the model in which M1 is included appeared to be significantly stronger. It can be said that M1 is more effective than M2 in the sense of selecting an intermediate target for monetary policy.

Table 5.8 *Variance Decomposition for the credit rate channel*

	Cholesky Ordering: LnCRE LnGDP LnP LnRealM1					***Cholesky Ordering: LnCRE LnGDP LnP LnRealM2***				
	Variance Decomposition of LnCRE:					*Variance Decomposition of LnCRE:*				
Period	S.E.	LnCRE	LnGDP	LnP	LnRealM1	S.E.	LnCRE	LnGDP	LnP	LnRealM
2	0.03	96.27	2.59	0.20	0.93	0.03	96.27	1.95	0.34	1.44
4	0.04	78.41	3.39	17.14	1.06	0.05	88.31	10.14	0.62	0.93
6	0.05	66.63	5.33	27.23	0.81	0.06	75.38	21.92	1.91	0.78
8	0.06	54.90	6.70	35.34	3.06	0.07	63.25	32.34	2.49	1.92
10	0.07	43.09	6.20	42.24	8.47	0.08	53.52	40.05	2.40	4.03
	Variance Decomposition of LnGDP:					*Variance Decomposition of LnGDP:*				
Period	S.E.	LnCRE	LnGDP	LnP	LnRealM1	S.E.	LnCRE	LnGDP	LnP	LnRealM
2	0.02	3.72	70.94	19.41	5.93	0.02	2.64	91.73	5.49	0.14
4	0.03	3.23	31.57	27.80	37.39	0.04	1.37	90.43	4.61	3.59
6	0.04	2.32	19.15	25.64	52.90	0.04	2.40	83.73	4.07	9.80
8	0.04	3.09	16.27	24.64	56.00	0.05	5.46	75.61	6.17	12.76
10	0.04	3.06	16.36	23.47	57.11	0.05	9.17	69.73	8.08	13.02
	Variance Decomposition of LnP:					*Variance Decomposition of Lap:*				
Period	S.E.	LnCRE	LnGDP	LnP	LnRealM1	S.E.	LnCRE	LnGDP	LnP	LnRealM
2	0.01	3.50	2.90	93.49	0.11	0.01	4.47	3.73	91.72	0.08
4	0.01	11.23	2.25	84.13	2.39	0.01	5.05	3.44	89.82	1.68
6	0.02	14.99	6.44	72.20	6.37	0.01	9.11	5.98	79.45	5.45
8	0.02	14.21	8.89	69.92	6.98	0.02	11.82	16.68	66.04	5.46
10	0.02	14.24	11.49	63.81	10.46	0.02	11.56	27.95	55.89	4.60
	Variance Decomposition of LnRealM1:					Variance Decomposition of LnRealM2:				
Period	S.E.	LnCRE	LnGDP	LnP	LnRealM1	S.E.	LnCRE	LnGDP	LnP	LnRealM
2	0.05	3.02	16.24	8.14	72.60	0.02	14.25	4.03	5.67	76.06
4	0.06	2.23	12.36	18.35	67.06	0.02	19.25	8.04	7.28	65.44
6	0.07	4.03	8.53	12.41	75.04	0.02	19.35	9.29	16.91	54.45
8	0.07	4.88	8.74	13.48	72.91	0.02	18.87	12.86	21.43	46.83
10	0.08	6.30	8.30	14.28	71.13	0.03	17.80	20.80	20.98	40.43

The impulse response of the credit channel of the monetary transmission mechanism when M1 is included is shown in Figure 5.5. There is a fluctuation response of M1 to credit shock. Price level seems stable for two quarters after the credit shock, and then it increased gradually until the fifth quarter. After that, the price level dramatically decreased up to the eighth quarter. Economic growth appeared to decrease for four quarters after the credit shock and then GDP rose substantially until the seventh quarter. Then, GDP continued its fall down.

Figure 5.6 presents the impulse response of the credit channel of the monetary transmission mechanism when M2 is included. The response of M2 to credit shock seems to be a slight decrease from the first quarter after the shock. Similarly, the response of economic growth was to fall from the first quarter, and it continued to decrease. The price level declined for two quarters after the credit shock and then it increased.

Figure 5.5 The impulse response of the M1 credit channel

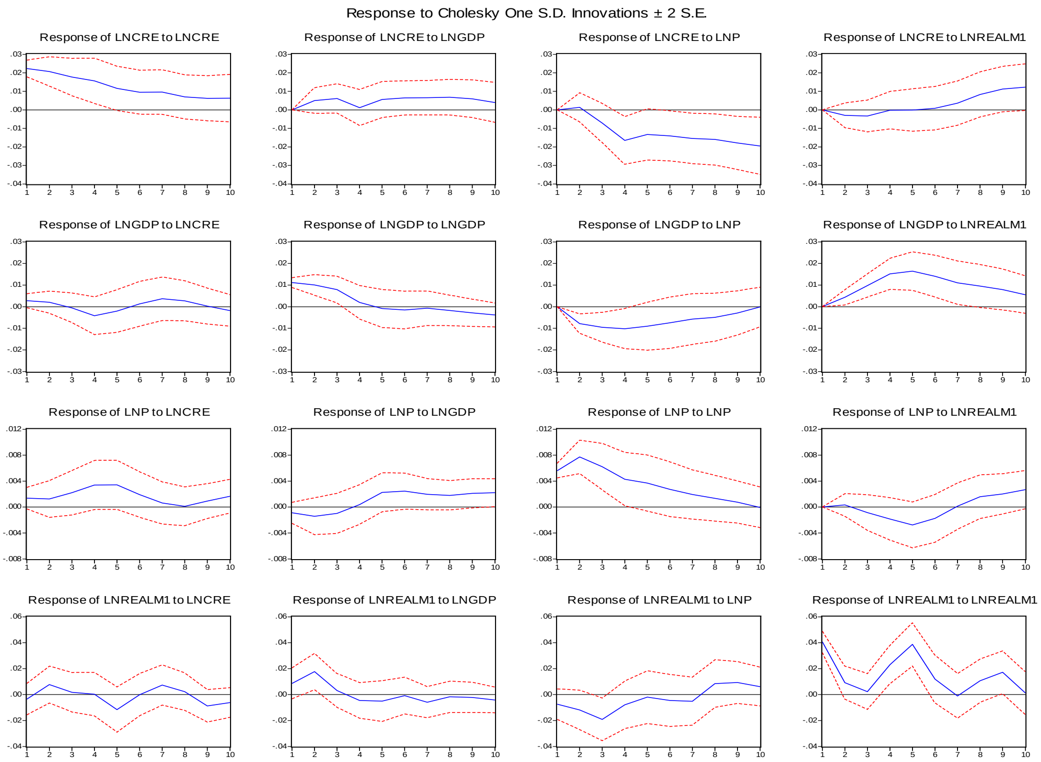
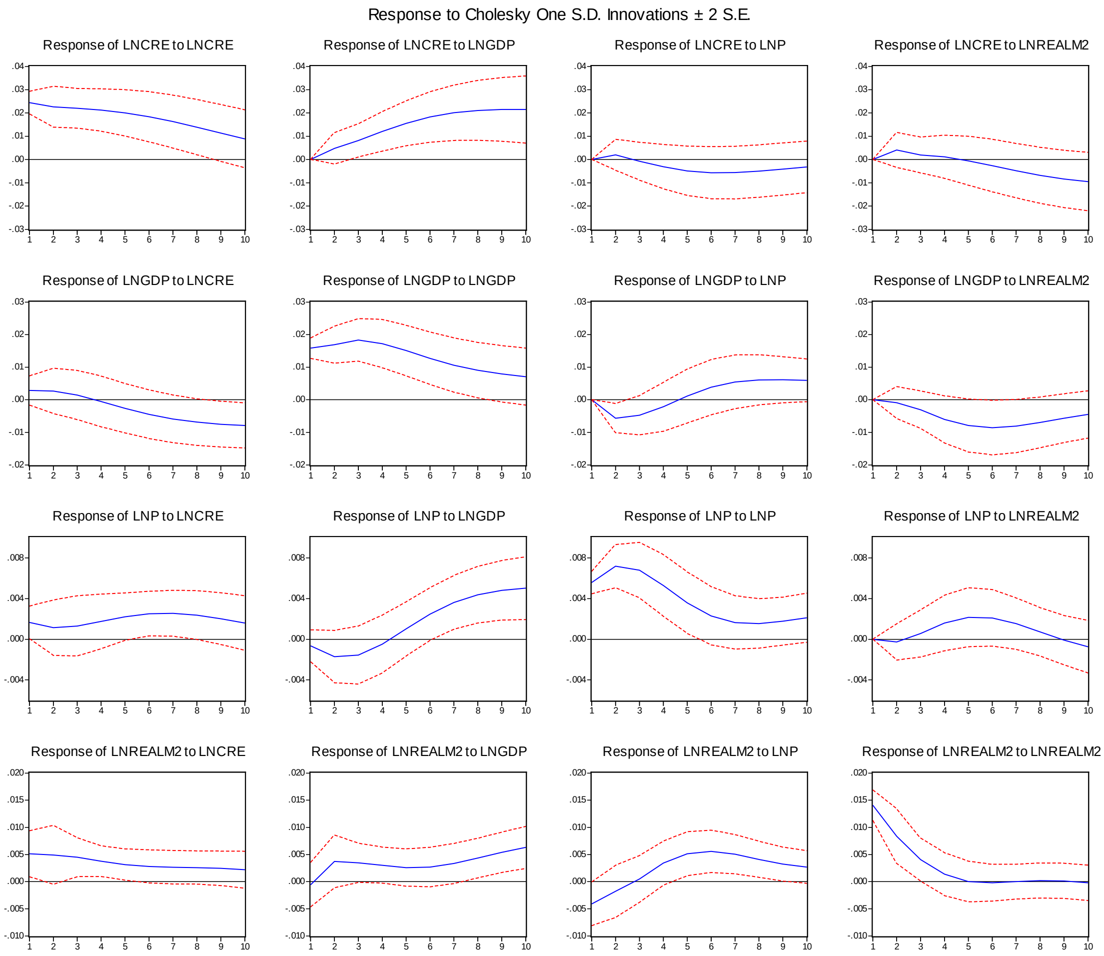


Figure 5.6 The impulse response of the M2 credit channel



5.3.3.3 The Exchange Rate channel of the Monetary Transmission Mechanism

In an open economy, the exchange rate also plays an important role in the monetary transmission mechanism. As Miskin (2006) claimed, an increase in money causes domestic interest rates to decrease. Then, it also causes domestic currency to become less attractive, resulting in depreciation of domestic currency. As a result, domestic prices are relatively cheaper than foreign products. Thereby, net exports increase, and then economic growth rises. To analyse the exchange rate channel of the monetary transmission mechanism in Thailand, the exchange rate variable (EXC) is added into the basic model. Therefore, the variables included in the VAR system of the exchange rate channel are the exchange rate (EXC), real output (GDP), price level (P), and money aggregate (M1 or M2).

The Granger Causality results for the model where M1 is included are presented in Table 5.9. The results suggest that exchange rates Granger-cause M1 and GDP at 1% significant level, whereas the F-statistic of EXC does not Granger-cause GDP, and EXC does not Granger-cause M1, these being at 1% significant level. The hypothesis that EXC does not Granger-cause P is rejected at 5 % significance, since the p value is less that 0.05. However, there is no reverse relationship between LnGDP→LnEXC, LnP→LnEXC, and LnRealM1→ LnEXC, as the F-statistics are not significant at any given significant level. In addition, the results also indicate that M1 Granger-caused both GAP and P at 5% significant level. Regarding the exchange rate channel of the monetary transmission mechanism, changes in the exchange rate affect M1 and it in turn affects GDP and price level.

The result of the exchange rate channel of the monetary transmission mechanism where M2 is included shows that LnEXC Granger-causes GDP at 5% significance. However, the LnEXC does not affect LnRealM2.

Comparing the models of the exchange rate channel of the monetary transmission mechanism when M1 and M2 are included in the sense of selecting intermediate targets for monetary policy, we found that M1 seems to be a more appropriate variable due to the exchange rate affecting M1, but not affecting M2.

Table 5.9 Granger Causality Test for the Exchange Rate Channel Model

Null Hypothesis:	F-Statistic	Probability
Panel(A) ***Variables : LnEXC LnGDP LnP LnRealM1(5 lags)***		
LnGDP does not Granger-cause LnEXC	0.333	0.890
LnEXC does not Granger-cause LnGDP	7.294	0.000
LnP does not Grange-cause LnEXC	1.738	0.148
LnEXC does not Granger-cause LnP	2.936	0.023
LnRealM1 does not Granger-cause LnEXC	1.144	0.353
LnEXC does not Granger-cause LnRealM1	4.144	0.004
LnP does not Granger-cause LnGDP	1.383	0.251
LnGDP does not Granger-cause LnP	3.213	0.015
LnRealM1 does not Granger-cause LnGDP	2.834	0.027
LnGDP does not Granger-cause LnRealM1	7.034	0.000
LnRealM1 does not Granger-cause LnP	3.364	0.012
LnP does not Granger-cause LnRealM1	2.219	0.071
Panel(B) ***Variables : LnEXC LnGDP LnP LnRealM2 (3 lags)***		
LnGDP does not Granger-cause LnEXC	0.127	0.944
LnEXC does not Granger-cause LnGDP	11.362	0.000
LnP does not Granger-cause LnEXC	1.948	0.135
LnEXC does not Granger-cause LnP	4.983	0.004
LnRealM2 does not Granger-cause LnEXC	1.136	0.344
LnEXC does not Granger-cause LnRealM2	0.255	0.857
LnP does not Granger-cause LnGDP	2.145	0.107
LnGDP does not Granger-cause LnP	7.720	0.000
LnRealM2 does not Granger-cause LnGDP	0.544	0.654
LnGDP does not Granger-cause LnRealM2	4.891	0.005
LnRealM2 does not Granger-cause LnP	2.298	0.090
LnP does not Granger-cause LnRealM2	1.663	0.188

Table 5.10 presents the variance decomposition for the exchange rate of the monetary transmission mechanism. The results show that a shock in the exchange rate caused the fluctuation in M1 around 16.23% in the fourth quarter, while only 1.17 % of fluctuation in M2. Furthermore, the shock in M1 caused about 11.74% of the fluctuation in GDP and 2.37 % of the fluctuation in the price level. However, the shock in M2 caused only 2.43% of the fluctuation in GDP and accounted for 2.57% of the shock in the price level.

Table 5.10 Variance Decomposition for the exchange rate channel

	Cholesky Ordering: LnEXC LnGDP LnP LnRealM1						Cholesky Ordering: LnEXC LnGDP LnP LnRealM2				
	Variance Decomposition of LnEXC:						Variance Decomposition of LnEXC:				
Period	S.E.	LnEXC	LnGDP	LnP	LnRealM1		S.E.	LnEXC	LnGDP	LnP	LnRealM
2	0.07	96.83	0.72	0.14	2.32		0.08	96.68	0.57	1.11	1.65
4	0.11	71.93	8.88	17.87	1.32		0.10	89.77	0.45	1.14	8.64
6	0.13	49.30	17.01	31.13	2.56		0.11	76.60	1.06	2.42	19.92
8	0.14	45.05	16.57	32.43	5.96		0.12	65.29	3.64	2.96	28.11
10	0.14	43.61	16.68	31.74	7.96		0.13	57.74	6.33	3.06	32.87
Variance Decomposition of LnGDP:							Variance Decomposition of LnGDP:				
Period	S.E.	LnEXC	LnGDP	LnP	LnRealM1		S.E.	LnEXC	LnGDP	LnP	LnRealM
2	0.02	24.43	70.27	0.84	4.46		0.02	11.92	87.19	0.89	0.00
4	0.03	53.02	31.06	4.18	11.74		0.04	32.35	64.69	0.53	2.43
6	0.04	41.04	30.95	13.59	14.42		0.05	25.85	66.28	0.49	7.38
8	0.05	31.94	32.72	15.85	19.50		0.05	18.20	69.66	0.71	11.44
10	0.05	28.84	29.20	14.42	27.55		0.06	14.37	72.28	0.68	12.67
Variance Decomposition of LnP:							Variance Decomposition of LnP:				
Period	S.E.	LnEXC	LnGDP	LnP	LnRealM1		S.E.	LnEXC	LnGDP	LnP	LnRealM
2	0.01	26.95	1.60	70.53	0.93		0.01	20.96	1.95	76.73	0.36
4	0.01	38.54	7.15	51.94	2.37		0.01	38.40	2.03	57.01	2.57
6	0.01	37.50	14.74	44.70	3.06		0.01	35.51	2.26	58.16	4.07
8	0.01	37.65	15.30	41.76	5.29		0.02	34.32	4.51	56.52	4.64
10	0.02	35.11	13.83	45.46	5.61		0.02	32.90	10.00	53.00	4.11
Variance Decomposition of LnRealM1:							Variance Decomposition of LnRealM2:				
Period	S.E.	LnEXC	LnGDP	LnP	LnRealM1		S.E.	LnEXC	LnGDP	LnP	LnRealM
2	0.05	12.24	14.90	0.48	72.38		0.02	1.28	9.30	5.89	83.53
4	0.05	16.23	13.64	3.76	66.37		0.02	1.17	7.20	4.97	86.67
6	0.06	16.28	20.35	2.87	60.50		0.03	3.17	6.88	4.18	85.77
8	0.07	21.47	18.72	3.29	56.52		0.03	3.13	8.10	3.68	85.09
10	0.08	20.54	13.42	17.70	48.34		0.03	2.96	10.52	3.47	83.05

Figure 5.7 presents the impulse response of the exchange rate channel of the monetary transmission mechanism when M2 is included. The response of M1 to exchange rate shock seems to be stable for four quarters, and then M1 dropped in the fifth quarter. After that, M1 sharply increased in quarters five and six after the shock. The price level increased for three quarters after the exchange rate shock. After the third quarter, the price level continued to decrease until the eighth quarter. The response of GDP to the exchange rate shock started from the first quarter after the shock. GDP dramatically dropped for four quarters. After that, GDP increased continually.

The impulse response of the exchange rate channel of the monetary transmission mechanism when M2 is included is shown in Figure 5.8. Similar to the response of M2 to the exchange rate model, there is a fluctuation response of M2 to credit shock. The price level increased for three quarters and after that the price level dropped. GDP appeared to decrease for three quarters after the exchange rate shock and then GDP rose substantially.

Figure 5. 7 The impulse response of the M1 Exchange rate channel

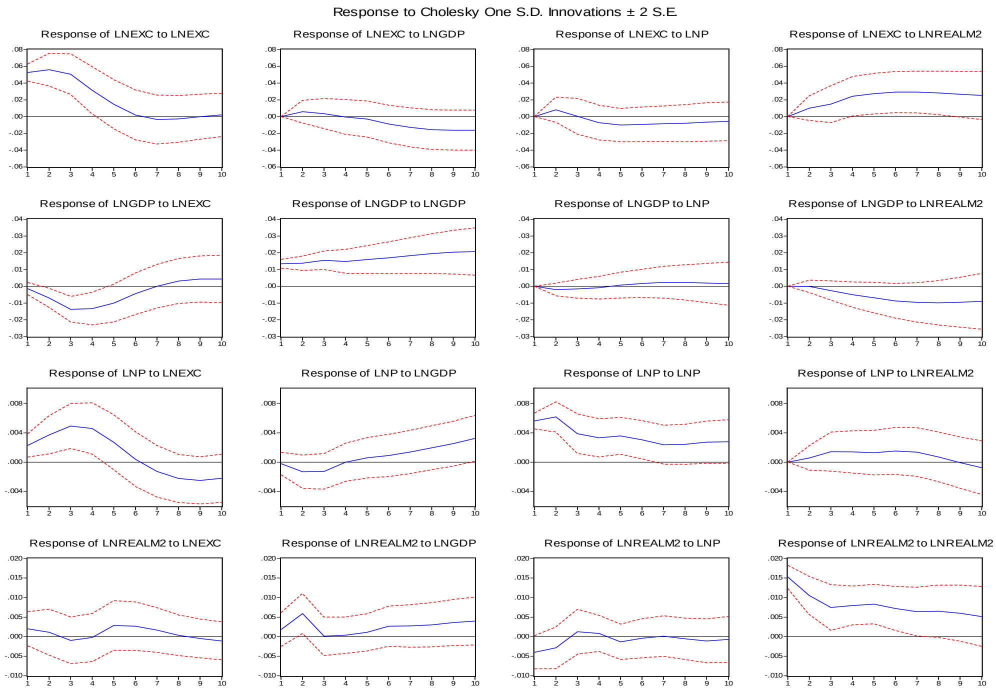
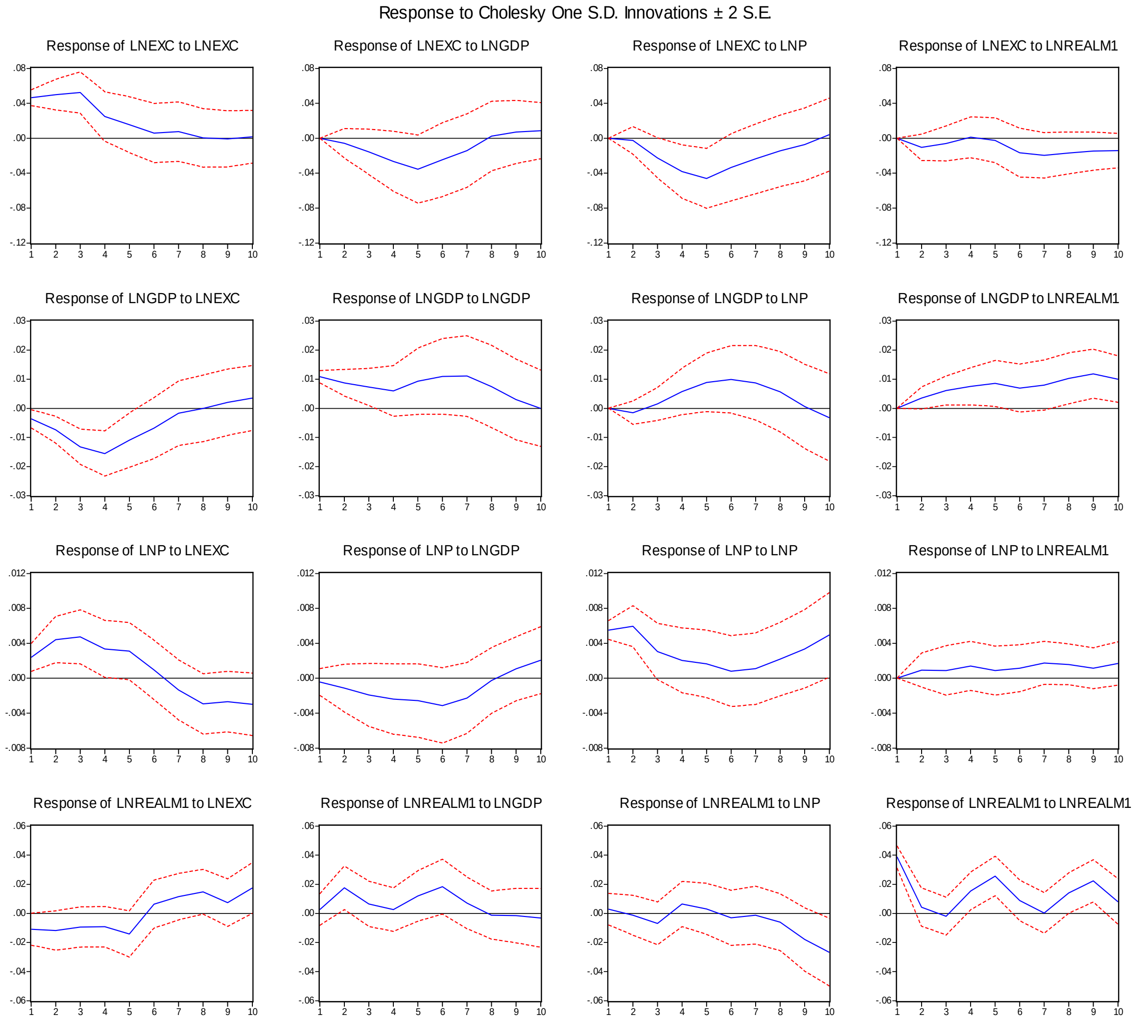


Figure 5. 8 The impulse response of the M2 Exchange rate channel



5.4 Conclusion

This chapter provided the empirical results of the monetary transmission mechanism in Thailand by using the Vector Autoregression model. There were four models tested in the chapter, the basic model, the interest rate channel model, the credit channel model, and the exchange rate channel model. The main findings in the chapter are that in the case of simple model, change in M1 has more affect on economic growth, while change in M2 has a stronger impact on price stability. Based on the simple model, if the monetary policy in Thailand focused on economic growth, M1 should be considered as the intermediate target. On the other hand, M2 may be selected if the policy aims for stability.

However, the interest rate channel shows evidence that M1 seems to be more effective as an intermediate target, since the interest rate has more affect on M1, and it in turn affects economic activities. In the case of the credit channel, the result confirms that M1 is more responsive to the credit channel of the transmission mechanism than M2 is. In addition, the exchange channel also indicates that M1 appeared to be more appropriate for the exchange rate of the transmission mechanism in Thailand.

Overall, the results of this chapter indicate that M1 has more response to monetary instruments, including interest rates, bank credit, and the exchange rate. Moreover, it has a stronger affect on economic activities. It can be said that the monetary authorities should concentrate more on M1as an intermediate target in monetary policy in Thailand.

CHAPTER 6

CONCLUSION

6.1 Introduction

This chapter briefly summarises the major findings and the policy implications of the thesis. The chapter is divided into two sections. The first section will present the major empirical findings in the thesis. There are two major findings, the empirical findings about the stability of the money demand function and the monetary transmission mechanism in Thailand. The last section of this chapter provides the policy implications and the suggestion for future research.

6.2 The Main Empirical Findings

In the first stage of the thesis, we detected the stationary of each variable by applying the unit root procedure. The results of the ADF and the KPSS clearly showed that all variables that were used in the thesis were integrated of order one (I (1)) and eligible for testing in the next step.

The second stage of the thesis was the testing of the money demand relationship by using cointegration and the error correction model. In this stage, we tested both the M1 and M2 money demand functions. There were two data sets that were used for the test, the full data set from 1980Q1-2007Q1 and the data set from 1993Q-2007Q1. The results of cointegration suggest that there is a single cointegration in both the M1 and M2 money demand function in Thailand. The long-run elasticity of income to money demand appeared to be a positive sign and the interest rate elasticity was negative as we expected.

Moreover, we also estimated money overhangs from the long-run money demand relationship and tested whether the money overhang from the estimation model can help in predicting the inflation rate in Thailand. The results found that most money overhang models could help to predict the inflation rate in Thailand, except the M1 money demand model from 1993Q1-2007Q4.

The last stage of this thesis was the test for the transmission mechanism of monetary policy in Thailand. The test started by estimating a basic VAR model. Then, each particular channel of the monetary transmission mechanism was analysed by adding a different variable of monetary policy. There were three different channels tested in that chapter, the interest rate channel, the credit channel, and the exchange rate channel. The results of the basic VAR model showed that changes in M1 money demand had more effect on economic growth, while changes in M2 money demand had a stronger affect on the price level. This evidence was confirmed by the results of the interest rate channel that interest rates are relatively stronger in the price level when the model used M2 as a target of monetary policy, while it has a stronger affect on economic growth when considering M1 as an intermediate target. In addition, the results also showed that M1 money demand was more responsive to the transmission mechanism in all channels tested in the thesis.

Based on the results of this thesis, it seems that M1 money demand appeared to be more stable than M2. Moreover, changes in M1 had more affect on economic activities. It can be suggested that the Bank of Thailand should be more concerned with M1 money demand when they conduct monetary policy in Thailand.

6.3 Policy Implications and Future Research

After adopting inflation targeting as a major framework of monetary policy in 2000, the major objective of monetary policy in Thailand was to achieve price stability rather than focusing on economic growth.

As the empirical results of this thesis show, there does exist a stable long-run relationship for both the M1 and M2 money demand function in Thailand, but M1 appears to be more stable. This result can imply that M1 would be more preferable than M2 as an intermediate target for monetary policy in Thailand. In addition, the results of the monetary transmission mechanism in Chapter 5 indicate that M1 has greater affect on the price level than M2 does in both the basic VAR model and the interest channel model. This confirms that M1 appears to be more appropriate to serve as an intermediate target in Thailand's monetary policy.

For future research on money demand and the monetary transmission mechanism in Thailand, we suggest that the study of the money demand function might consider more about applying multiple structural breaks to catch up the long-run money demand function in Thailand. In addition, the role of money in the transmission mechanism should be considered for the future research as money aggregate also play an important role in the transmission mechanism in monetary policy.

Another final suggestion is that other channels of the monetary transmission mechanism should be considered in future research as it has been ignored in this thesis due to a limited of data set.

Appendix A
Data and Source of Data

The research is basically use a quarterly macro economic time series data for estimate the money demand function and monetary transmission mechanism in Thailand. The sample of data are started from 1980Q1 to 2007Q1.The data are mainly collected from the Bank of Thailand (BOT), the office of National Economic and Social Development Broad (NESDB), and the International Financial Statistics (IFS) which providing by International Monetary Found. The summary of definition and source of each data are shown in table below

Data Definition and Data Source

Variable	Meaning	Source
M1	Quarterly Narrow Money ,which includes currency in circulation and demand deposit in commercial bank (Billions Baht)	IFS
M2	Quarterly Broad Money.M2 is the sum of M1 and quasi-money in commercial bank.(Billions Baht)	IFS
GDP	Quarterly Gross Domestic Product by expenditure at 1988 price. (Billions Baht)	IFS NESDB
P	Consumer Price Index .It can be a proxy of prive in Thailand.	Bank of Thailand
R	Discount rate.	IFS
LIBOR	London Interbank Rate	Bank of Thailand
EXC	Exchange Rate (Baht : US$)	IFS Bank of Thailand

There are two money aggregate used in the research to estimate money demand function, narrow money aggregate(M1) and broad money aggregate (M2).Both data are collected from International Financial Statistics (IFS). The variables used in the equation in real term, represent by RealM1 and R ealM2.Where Real M1 is calculated by $\frac{M1}{CPI}$ and Real M1 is $\frac{M2}{CPI}$.

GDP is Quarterly Gross Domestic Product by expenditure at 1988 price. It can be used as a proxy of income and economic growth. The data collected from IFS statistic and NESDB .As a Quarterly GDP from IFS and NESDB are variable only from 1993Q1 to 2007Q1, Historical quarterly GDP from 1980Q1 to 1992Q 4 were obtained from the estimation of Abeysinghe and Rajaquru (2004)[6].Seasonal adjustment is adopted in QGDP by using X12 - ARIMA[7] methodology.

P refers to price level in Thailand, proxy by consumer price index (2000=100). R represents domestic interest rate, proxy by discount rate. The reasons to use discount rate in this research are that the Bank of Thailand usually used discount rate as monetary instrument and it sometime appeared as the intermediate target on monetary policy. In addition the Bank of Thailand can directly control this interest rate. LIBOR is a London Interbank Rate, this variable represent the international interest rate which effect on money demand in Thailand.

Exc is the average of exchange rate of Thai baht against the US dollar (baht: us$) over the sample periods.

The estimation of money demand function is used the quarterly data over the period 1980Q1 to 2006Q4.All variables are estimated in form of logarithm except R and LIBOR.

[6] Abeysinghe,T. and Rajaguru, G. "Quarterly Real GDP Estimates for China and ASEAN4 with a Forecast Evaluation" Department of Economics Working Paper No.0404, National University of Singapore.

[7] X12 – ARIMA is a seasonal adjustment program developed by the US Bureau of the Census.

Appendix B
Data Used in the Estimation in Chapter 4 and 5

Year	M1	M2	GDP	R	Exc	P
Q1 1980	49.46	219.43	229.70	14	20.24	39.33
Q2 1980	47.69	222.99	222.30	12.5	20.48	41.8
Q3 1980	47.13	233.94	228.94	12.5	20.48	42.52
Q4 1980	69.89	251.8	234.76	13.5	20.63	43.56
Q1 1981	76.18	265.13	237.50	13.5	20.63	45.2
Q2 1981	73.28	269.73	240.56	13.5	20.6	47.01
Q3 1981	69.13	272	244.67	14.5	20.7	47.57
Q4 1981	71.58	292.91	246.36	14.5	20	48.62
Q1 1982	76.3	310.32	249.70	14.5	23	48.98
Q2 1982	74.1	320.28	257.21	14.5	23	49.45
Q3 1982	73.99	332.59	257.67	13.5	23	49.6
Q4 1982	75.66	363.82	255.73	12.5	23	50.28
Q1 1983	83.72	391.08	265.44	11.5	23	51.3
Q2 1983	81.74	404.96	264.68	11.5	23	51.5
Q3 1983	78.65	417.05	270.79	11.5	23	51.99
Q4 1983	79.52	450.5	276.43	13	23	52.33
Q1 1984	82.51	464.1	277.48	13	23	51.68
Q2 1984	81.98	481.93	280.31	13	23	52.02
Q3 1984	80.71	496.84	285.61	13	23	51.88
Q4 1984	84.28	537.89	295.66	12	27.15	51.89
Q1 1985	84.64	549.63	296.37	12	27.55	52.4
Q2 1985	80.77	563.65	300.69	12	27.42	53.05
Q3 1985	83.39	474.19	295.43	11	26.3	53.38
Q4 1985	80.92	593.5	298.82	11	26.65	53.69
Q1 1986	91.03	613.41	307.21	10	26.47	53.6
Q2 1986	91.48	627.62	311.66	10	26.01	54.02
Q3 1986	95.22	641.03	318.27	8	26.13	54.25
Q4 1986	96.8	672.77	319.85	8	25.87	54.58
Q1 1987	109.36	703.9	328.98	8	25.84	54.58
Q2 1987	112.81	726.5	338.54	8	25.83	55.1
Q3 1987	114.66	749.08	348.44	8	25.83	55.79
Q4 1987	122.47	808.58	361.11	8	25.07	56.33
Q1 1988	131.89	833.93	372.75	8	25.15	56.74
Q2 1988	140.43	865.92	382.97	8	25.47	57.36
Q3 1988	135.78	887.64	397.52	8	25.55	57.86
Q4 1988	137.13	956.13	406.59	8	25.24	58.4
Q1 1989	154.09	1004.31	417.58	8	25.54	59.12
Q2 1989	166.98	1060.15	439.92	8	25.95	59.9
Q3 1989	171.78	1113.68	439.18	8	25.79	61.58
Q4 1989	160.74	1207.1	453.30	8	25.69	62.1
Q1 1990	186.34	1302.76	462.82	8	25.98	62.73
Q2 1990	189.25	1376.63	478.86	9.5	25.79	63.81
Q3 1990	193.67	1447.26	497.70	9.5	25.34	64.46
Q4 1990	177.79	1529.12	506.27	12	25.29	66.09
Q1 1991	185.41	1589.8	514.68	12	25.65	66.36
Q2 1991	192.37	1641.78	519.35	12	25.71	67.78
Q3 1991	194.25	1718.51	540.21	11	25.54	68.34
Q4 1991	209.72	1832.38	536.85	11	25.38	69.26

Q1 1992	222.31	1911.47	548.72	11	25.6	69.48
Q2 1992	226.83	1948.69	562.90	11	25.29	70.79
Q3 1992	231.09	2005.01	578.30	11	25.09	71.62
Q4 1992	235.27	2117.79	591.82	11	25.52	71.08
Q1 1993	234.33	2165.88	595.49	11	25.36	71.68
Q2 1993	248.17	2256.54	604.32	10	25.25	72.7
Q3 1993	257.15	2350.8	628.51	9	25.2	73.79
Q4 1993	277.1	2507.1	642.09	9	25.54	74.2
Q1 1994	274.97	2473.52	661.26	9	25.23	75.12
Q2 1994	285.55	2539.55	661.69	9	25.99	76.39
Q3 1994	298.03	2648.34	665.42	9.5	25.97	77.58
Q4 1994	312.96	2829.38	703.89	9.5	25.99	78.16
Q1 1995	321.84	2846.69	724.88	10.5	25.74	78.77
Q2 1995	355.99	3026.33	740.96	10.5	25.66	80.48
Q3 1995	347.88	3135.45	731.70	10.5	25.07	82.15
Q4 1995	354.08	3310.56	744.33	10.5	25.19	83.68
Q1 1996	373.72	3470.28	758.92	10.5	25.23	84.57
Q2 1996	376.32	3537.28	788.23	10.5	25.36	85.52
Q3 1996	384.46	3574.12	791.14	10.5	25.42	86.41
Q4 1996	371.34	3726.65	778.16	10.5	25.61	87.54
Q1 1997	381.61	3808.18	764.96	10.5	25.89	88.32
Q2 1997	383.2	3958.09	784.28	10.5	25.79	89.19
Q3 1997	391.84	4166.27	780.43	12.5	36.52	91.73
Q4 1997	390.08	4339.34	744.54	12.5	47.24	94.08
Q1 1998	382.44	4408.75	708.79	12.5	38.8	96.27
Q2 1998	380.21	4502.49	676.93	12.5	42.31	98.41
Q3 1998	378.25	4689.3	673.32	12.5	39.3	99.23
Q4 1998	379.16	4753.36	690.34	12.5	36.69	98.72
Q1 1999	383.11	4789.06	704.71	7	37.64	98.72
Q2 1999	399.23	4764.12	703.18	5.55	36.84	98.01
Q3 1999	418.93	4786.58	730.91	4	40.93	98.31
Q4 1999	542.76	4854.75	732.95	4	37.47	98.79
Q1 2000	457.26	4824.47	747.73	4	37.8	99.61
Q2 2000	461.63	4801.32	747.13	4	39.12	99.57
Q3 2000	473.92	4907.46	752.07	4	42.21	100.39
Q4 2000	474.62	5032.68	761.45	4	43.26	100.43
Q1 2001	497.11	5113.56	758.83	4	44.77	101.01
Q2 2001	512.46	5122.38	764.70	4	45.2	102.06
Q3 2001	524.89	5165.68	769.66	4	44.38	102.03
Q4 2001	533.59	5243.65	780.04	3.75	44.22	101.45
Q1 2002	559.64	5365.09	792.28	3.5	43.47	101.55
Q2 2002	569.93	5385.68	803.33	3.5	41.52	102.3
Q3 2002	585.01	5257.76	815.16	3.5	43.42	102.3
Q4 2002	608.34	5378.86	825.82	3.25	43.5	102.92
Q1 2003	637.74	5444.82	846.82	3.25	42.85	103.56
Q2 2003	650.88	5479.63	857.17	2.75	41.97	104.08
Q3 2003	667.67	5518.46	869.83	2.75	39.94	104.25
Q4 2003	715.55	5641.84	893.23	2.75	39.59	104.55
Q1 2004	730.46	5794.33	903.75	2.75	39.4	105.58
Q2 2004	751.39	5797.96	913.92	2.75	40.88	106.84
Q3 2004	769.88	5875.19	923.35	3	41.44	107.69

Q4 2004	774.8	5948.37	943.91	3.5	39.06	107.86
Q1 2005	788.11	6029.52	935.52	3.75	39.11	108.54
Q2 2005	801.73	5987.77	957.26	4	41.26	110.79
Q3 2005	820.87	6163.35	973.89	4.75	40.96	113.76
Q4 2005	829.99	6438.93	984.23	5.5	40.03	114.31
Q1 2006	837.28	6742.69	993.47	6	38.79	114.75
Q2 2006	845.64	6671.38	1005.88	6.5	39.33	114.8
Q3 2006	832.19	6790.72	1018.93	6.5	38.11	115.2
Q4 2006	844.94	6824.04	1026.02	4.75	37.68	115.6
Q12007	865.99	6806.1	1033.11	4.25	35.06	118.7

GDP at 1988 Price

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