UNIVERSITY OF BIRMINGHAM

Monetary Transmission Mechanisms and the Macroeconomy in China

–VAR/VECM Approach and Bayesian DSGE Model Simulation

By

Lixin Sun

A Thesis Submitted to the University of Birmingham for the Degree of
DOCTOR OF PHILOSOPHY

Department of Economics
Business School, College of Social Science
The University of Birmingham
March, 2010

SYNOPSIS

In this thesis, by employing VAR/VECM approach and Bayesian Dynamic Stochastic General Equilibrium (DSGE) Model we have studied and tested the transmission mechanisms of China's monetary policy and measured the effects of the monetary policy shocks and other exogenous macro shocks on the real macro economy to uncover the attributes of China's business cycle.

On the basis of the specified VAR/VEC Models, a *bank lending channel*, an *interest rate channel* and an *asset price channel* have been identified by using the time series (monthly) data of banks balance sheet variables (deposits, loans, securitises) across bank categories (aggregate banks, state banks, non-state banks) and the macroeconomic variables (output, CPI inflation, exports, imports, foreign exchange reserves) from 1996 to 2006. Furthermore, the diverse responses of bank loans to different sectors to the china's monetary policy shocks qualitatively and quantitatively show that China's monetary policy plays the distribution and growth roles besides the stabilization role in the economic activity. This can provide some possible explanations for the rapid economic growth in China. In addition, the effects of China's monetary policy on the international trade have been investigated. It is shown that China's monetary policy did influence exports and imports and thereby influence the foreign exchange reserves and output by affecting the terms of trade. Finally, the cointegrating vectors are identified among these variables and the VEC Models are set up to uncover the long run relationships which connect the monetary policy indicators, bank balance sheet variables and the macroeconomic variables in China. The above results provide many implications for the operations of China's monetary policy and thereby for the stabilization roles of China's monetary policy in the business cycle.

We've estimated a benchmark Bayesian DSGE Model with Taylor's Rule by using Dynare and Matlab with China's quarterly data from 1996 to 2006. Comparing the estimated values of the parameters in the model among China, Euro Area and the US, many unique features of China's economy and policies operations have been found. Based on the estimated model we have simulated and identified the *interest rate channel*, *asset price channel* through *Tobin's Q* and *Wealth effects*, and the *expectation channel* of China's monetary policy transmission, measured the effects of monetary policy shocks and non-monetary shocks on the real economy and the contributions of the monetary policy shocks and other macro exogenous shocks to China's business cycle. We find that investment and preference shocks drive the forecasted GDP variance in the long run in this interest rate rule model, they can explain about 20% of output forecasted error variance respectively. Technology shock, monetary policy shock (interest rate shock), government expenditure shock and cost-pushed shocks (price mark up and wage mark up shocks) also play distinguished roles. Each contributes about 10% of the output forecasted variance respectively. Money supply shock has no impact on output variance in the long run. This is in line with the assumption that the money is neutral in our system. The cost-pushed shock dominates the forecasted error of inflation. It contributes about 50% of the inflation variation which uncovers the unique characteristics of the formulation of inflation in China. The preference shock accounts for 20%, the technology shock accounts for 12%, whereas the monetary policy shock also contributes about 10% of the inflation variation. It is worth noting that the wage mark-up shock and the technology shock determine 50% of labour supply variation in the long run. The investment and government expenditure shocks also play important role in labour supply in China.

We also set up an improved Smets-Wouters model by replacing the Taylor's rule with a money growth rule for China's monetary policy in Chapter 5. In the money growth rule model, the same monetary policy transmission channels such as the *monetary channel*, the *asset price channel* and the *expectation channel* are identified. The effects of monetary policy shocks and other non monetary shocks are qualitatively similar as in Taylor's rule. The main differences appear in the variance decompositions or the contributions to the business cycle in China's economy. In this money growth model, the main contributions to the variations of the output are government expenditure, preference and productive shocks. The preference and technology shocks also contribute significantly to the forecast errors of the inflation; the cost-pushed shocks contribute about 40% of inflation variance. These results are different to the Taylor's rule and seem more justified due to the reality of China's economy, but it is difficult to confirm which rule the PBC takes in its implementations.

In summary, it seems reasonable to suggest that the PBC follows both the interest rate rule (Taylor's rule) and the money growth rule with discretion.

Key Words: China's Monetary Policy, Monetary Transmission Mechanism, VAR/VEC Model, Bayesian Approach, DSGE Model, Macroeconomy.

To my son: Sun, Jingzhou

ACKNOWLEDGEMENTS

In the September of 2005, I came to the University of Birmingham of UK with the strong economic interests, bright expectation and some anxiety in my heart as a mature research student. Four years of hard-working passed when I finish my thesis, my stronger interests become faith and attempt and my expectation becomes my commitment to an economic academic career.

I take pleasure in very deeply acknowledging the esteemed supervisory works of Professor Nick Horsewood and Professor Jim Ford.

I am also deeply appreciative of the kind helps and academic guidance by Professor David G Dickinson, my second supervisor, who provided essential advice and contributions to my study.

I gratefully extend my acknowledgement to the following academic and administrant staff of the department: Professor Somnath Sen for his course of Development Economics; Professor Peter Sinclair for his course of Dynamic Macroeconomics and Growth Theory; Professor John Fender for his course of Open Economy Macroeconomics; Professor Roger Backhouse for his Research Method course; Dr. Martin Jensen for his course of Advanced Microeconomics; Mr. Nick Horsewood for his Applied Econometrics course; Professor Indrajit Ray for his management works for PhD students; Ms. Julie W Tomkinson, Miss Emma Steadman, Miss Wendy Rose and Ms. Jackie Gough for their kind supports and assistance.

Acknowledgement is made to the Department of Economics for its award of a three-year scholarship, this supported my research.

Finally, I should send lots thanks to my wife, Hu Jing for her essential supports and contributions, and my son, Sun Jingzhou whose birth during this period has brought so much happiness and stimulus to me.

CONTENTS

ABBREVIATIONS, DEFINATIONS AND TERMINOLOGY

BPS: Base Points

CED: China Economic Networks.

CBRC: China Banking Regulatory Commission

CGSDTC: China Government Securities Depository Trust & Clearing Co. Ltd

CHIBOR: China Interbank Offered Rates

CPI: Consumer Price Index

CSD: Central Securities Depository of China

CSRC: China Securities Regulatory Commission

DSGE: Dynamic Stochastic General Equilibrium

ECB: Europe Central Bank

FED: Federal Reserve System

HQC: Hannan-Quinn Criterion

IFS: International Finance Statistics by IMF

I.I.D.: Independent, Identical Distribution

IP: Industrial Production

IRF: Impulse Response Function

LM: Lagrange Multiplier

LOOP: Law of One Price

LR: Likelihood Ratio

MB: Monetary Base

MBC: Monetary Business Cycle

MTM: Monetary Transmission Mechanism

NPL: Non-Performing Loan

NKM: New Keynesian Model

OMO: Open Market Operation

OTC: Over the Counter

PBC: the People's Bank of China, the Central Bank of China

RBC: Real Business Cycle

RMB: Ren Min Bi, The Currency of China, Unit: Yuan.

RR(R): Required Rate (of Reserve)

SHIBOR: Shanghai Inter-bank Overnight Rate

SIC: Schwarz Information Criterion

SSE: Shanghai Stock Exchange

VAR: Vector Autoregression

VECM: Vector Error Correction Model

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Preface

Monetary policy is a very important, intensive and rapidly expanding research topic in macro and monetary economics. This is because theoretical and empirical studies have confirmed that monetary variables impact on key nominal macro variables such as price level, rate of inflation, nominal interest rate and the nominal exchange rate both in the short-medium term and long term. They also influence the real macroeconomic objective variables such as real output, employment, real rate of interest and GDP growth in the short run. Also, empirical evidence shows that monetary policy shocks play a great role in the business cycle; this has heightened the interest of many macroeconomists in monetary aspects of the business cycle (monetary business cycle) helping to develop and improve models for monetary policy evaluations[1]. The actions of monetary policy by the policy makers and the economic events following them, according to Christiano, Eichenbaum and Evans (1998) are the effects of all the shocks to the economy. Therefore, to explore the effects of monetary policy on economy is to test the effects of monetary policy shocks on the economy by diverse transmission channels.

The monetary policy transmission mechanism (MTM) is the process through which monetary policy triggers changes in macroeconomic variables by certain transmission channels[2]. Although there exist different arguments on the monetary transmission channels among different schools, two views on MTM, the so-called “money view” and “credit view”, have been accepted by most macroeconomists. The traditional ‘money view’ works through the interest rate channel, money channel and exchange rate channel; the ‘credit view’ works through the bank lending channel and the balance sheet channel; the asset price channel and the expectation channel also identified affect how the monetary policy functions on the real economy.

As the expanding of China’s economy and its rapid integrating with the global economy, an efficient monetary policy regime is not only important for stable, sustainable and low-inflation growth of China’s economy but an essential condition for fostering sound and stable growth of the world economy. To improve the effectiveness and efficiency of China’s monetary policy, exploring the monetary transmission mechanism in the real economy and the monetary roles in business cycle in China is not only the precondition, but also the crucial routine and means to establish a market oriented, highly effective monetary policy system.

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[1] See, for example, Peter N Ireland (2000) developed a small, structural dynamic stochastic general equilibrium model to test the money’s role in monetary business cycle.

[2] See John B. Taylor (1995)

The objectives of this thesis are to identify and test the transmission channels of China's monetary policy, to uncover the mechanism through which monetary policy affects the real economy and what monetary policy's roles are in the business cycle of China's macro economy since 1996 and thereby provide suggestions and implications on the operations of China's monetary policy to the monetary authority, the People's Bank of China (PBC).

In this thesis, by employing VAR/VECM approach following Ford et al. (2003) and Bernanke and Blinder (1992) we have measured the effects of monetary policy shocks on Chinese economy through diverse transmission channels of monetary policies, especially *the bank lending channels, the interest rate channel* and *the asset price channel* and identified the long run relationships between macroeconomic variables and monetary policy parameters in China. We have examined the differential effects of monetary policy shock on banks balance sheet variables (deposits, loans, securitises) across bank categories (aggregate banks, state banks, non-state banks) and macroeconomic activities (output, consumer price index, exports, imports and foreign exchange reserves) by estimating VAR Models to uncover the transmission mechanism of China's monetary policy. Our study identifies and tests the existence of a *bank lending channel, an interest rate channel* and an *asset price channel* based on the monthly aggregate banks data and disaggregated data from 1996 to 2006 in term of bank and loan types. Furthermore, we explore and discuss the distribution and growth effects of China's monetary policy by using data regarding bank loans to different sectors. Thirdly, we investigate the effects of China's monetary policy on China's international trade in money contraction and expansion respectively. Finally, we identify the cointegrating vectors among these variables and set up VEC Models to uncover the long run relationships which connect the monetary policy indicators, bank balance sheet variables and the macroeconomic variables in China.

Furthermore, using a benchmark Bayesian Dynamic Stochastic General Equilibrium (Bayesian DSGE) model (Smets-Wouters Model) with Taylor's rule and an improved Smets-Wouters model with a money growth rule, we have simulated China's monetary policy transmission process and the roles of monetary variables and non monetary variables in China's business cycle by incorporating many so-called New Keynesian Macroeconomic (NKM) approaches such as nominal stickiness and market imperfections in the model. The model economy consist of a utility-maximizing rational agent (Households), profit-maximizing two-sector firms-private final good firms in a competitive market and state owned monopolistic intermediate firms as well as monetary authority. By calculating the first-order solutions to the behavioral equations and state equations, we obtain a group of nonlinear equations for the model economy. The parameters of these equations are estimated by the Bayesian approach using Dynare code under Matlab environment. These estimated parameters reflect the unique characters of China's economy compared with that of Europe and US. On the basis of perturbation algorithms developed in Dynare software[3], the above nonlinear equations have been solved and transformed to policy and transmission equations to simulate the monetary policy transmission and business cycle in China with real time series data from 1996q1 to 2006q4.

The simulation results from the benchmark Smets-Wouter model with Taylor's rule highlight several points. First, *the transmission channels of monetary policy shocks and the liquidity effect are identified.* A money supply shock makes the capital stock, consumption, investment and output rise, the real interest rate falls immediately, demonstrating a liquidity effect following an inflation effect. This clearly confirms the existence of the *interest rate channel* in China's monetary policy transmission. Also, the *asset price channel* through *Tobin's Q* and *Wealth effects* are identified by the simulation, the incorporation of rational expectation in inflation equation implies the effects of expectation in the monetary transmission (the *expectation channel*). These results support and complement the results from VAR/VECM approach in Chapter 4. Second, *we have tested the effects of non-monetary shocks on China's business cycle.* The cost-push shocks increase the rate of inflation significantly; a positive *productivity shock* makes the consumption, investment, output, capital stock and real wage rise, while labour supply (employment) falls. The rental rate of capital, return on equity market, interest rate and inflation rate also fall. These effects are the same for models applied in US and Euro Area using the same approach. The effects of a positive *labour supply shock* on consumption, investment, output, capital stock, inflation and interest rate are similar to those of a productivity shock. A *preference shock* increases consumption and output significantly while investment increases initially and then begins to fall, demonstrating a delay significant crowding out effect; the labour supply and real wage also increase, this causes the rise in marginal cost and thereby increases the inflation rate. The interest rate rises following the rise in inflation. The *government expenditure shock* has distinguished effects on China's economy (the effects of *fiscal policy* in China): increasing the labour supply, real wage and output immediately (multiplier effects) and thereby causing the demand-pull inflation gradually. It decreases private consumption and investment. This also implies a significant crowding out effect on private consumption and private investment. The fall in consumption leads to a rise in the marginal utility of working, this increases the labour supply. The return on the equity market rises while the capital stock falls. The effects of a positive *investment shock* are qualitatively similar to the government expenditure shock. Third, *we have*

[3] Dynare V4.02 is employed on Matlab 2007a.

measured the contributions of monetary policy shocks and non-policy shocks to the business cycle developments in China's economy. Depending on the results of variance decomposition in infinite horizon, we find that preference shock and investment shock play significant roles on china's business cycle. The cost-pushed shocks, the technology shock, and the monetary policy (interest rate) shock also explain distinguished fraction of output, inflation, interest rate and consumption. Money is truly neutral in the long run.

The improved Smets-Wouters model with a money growth rule uncovers the same monetary policy transmission mechanisms: the existence of the monetary channel, the asset price channel and the expectation channel. The responses to the monetary policy shocks and non monetary policy shocks are qualitatively similar as to Taylor's rule although there are some differences. The main differences emerge in the variance decompositions or the contributions to the business cycle of China's economy. In the money growth rule model, the government expenditure, preference and productive shocks play significant rules in the variation of output. On the determinants of inflation, the preference and technology shocks also contribute significantly to the forecast errors. The cost-push shocks contribute about 40% of inflation variance. Due to the reality of China's economy, in which government investment plays a significant rule, it seems that the money growth rule model is more justified than Taylor's rule, but it's difficult to make this conclusion.

This thesis consists of 6 chapters. Chapter 1 describes the framework of China's monetary policy: the goals, instruments of monetary policy and the operational environment in which it takes effect on the real economy-the financial market and banking system.

In chapter 2, we review the literature on the monetary transmission mechanism and the main research methods introduced.

Chapter 3 presents empirical evidence on China's monetary transmission research and the stylized facts of China's economy, especially the recent facts showing china's business cycle.

Chapter 4 contains an empirical study on China's monetary policy transmission with VAR/VECM approach and Johnson's technique to uncover the transmission mechanism of China's monetary policy. We identify the bank lending channel, interest rate channel and the asset price channel; test the effects of the distribution and growth of China's monetary policy and the roles of the monetary policy on the international trade. The long run relationships are discussed by identifying the cointegrating vectors and the VEC models.

In Chapter 5, we employ a benchmark Bayesian DSGE model (Smets-Wouters model) with Taylor's rule and an improved Smets-Wouter's model with a money growth rule to simulate China's monetary policy transmission process and estimate the contributions of monetary policy and other macro variables shocks to China's business cycle. The results from Chapter 4 and 5 support and complement each other.

Chapter 6 makes conclusions, suggestions and discusses further research work.

Chapter 1 The Framework and Background of China's Monetary Policy

1.1 Introduction

The People's Bank of China (hereinafter PBC), China's central bank, was established on the 1st of December in 1948, one year ahead of the foundation of New China, People's Republic of China in the October of 1949. Although the PBC has over 50 years of history, it did not operate as a central bank until the September of 1983. On March the 18th 1995, the Third Plenum of the Eighth National People's Congress ratified The Law of the People's Republic of China concerning the People's Bank of China, and the PBC began to implement monetary policy legally as the central bank of China. Similarly, before 1978 when China began to open up and reform, China's banking system, following the Soviet pattern, was highly centralized and widely distributed across the country as a monolithic financial network to ration the loans only to state companies (Hsiao Huang, 1971). In 1984, State banks were classified as central bank (PBC) and commercial banks. The state-owned banks (Bank of China, Commercial and Industrial Bank, Construction Bank, Agricultural Bank and others) can be treated as independent commercial banks, supervised and monitored by the PBC. On July the 1st 1995 Law of the People's Republic of China on Commercial Banks was made effective. Since then many private and cooperative banking institutions have emerged in China. After the access to WTO in 2001, with the permission of the Chinese government, foreign banks have established subsidiaries in the main cities of China.

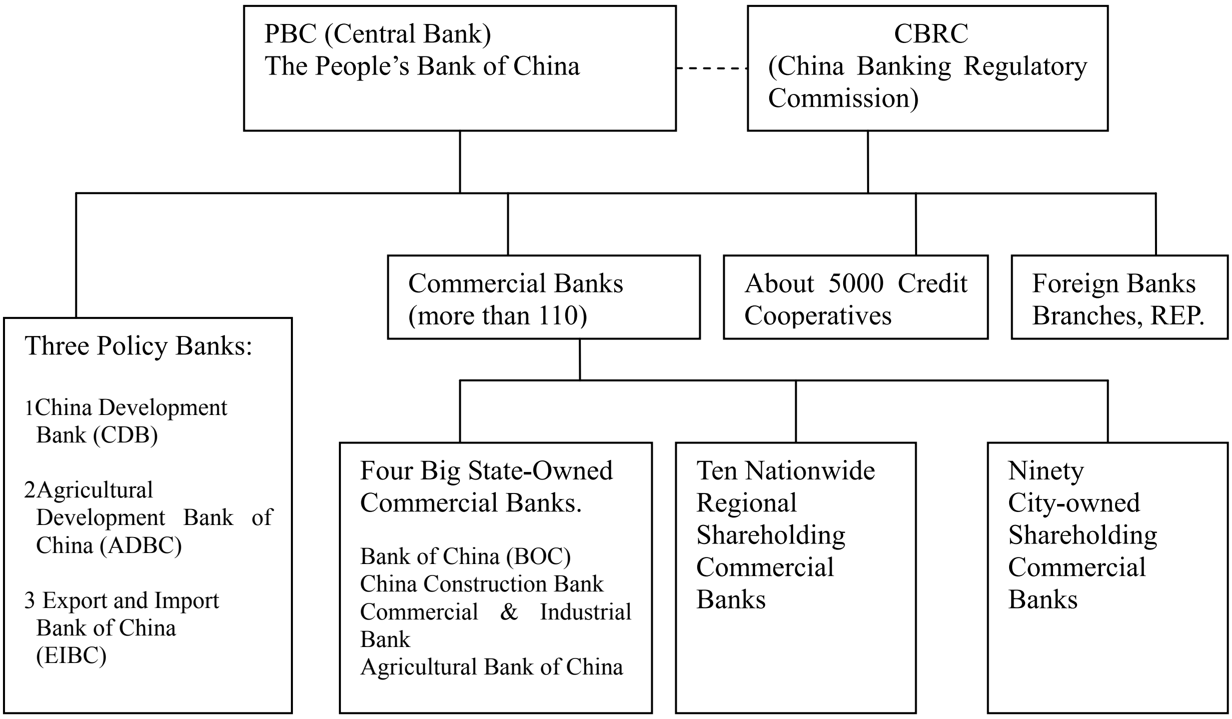
According to The Law of the People's Republic of China on the People's Bank of China (1995) "the PBC shall, under the leadership of the State Council, formulate and implement monetary policies and exercise supervision and control over the banking industry". In 2003 a specific banking regulatory agency, China's Banking Regulatory Commission was established by the National People's Congress of China, while the PBC is in charge of monetary policy matters. The objectives of the monetary policy in China are to maintain the stability of the currency and thereby promote sustainable economic growth. The PBC has established the Monetary Policy Committee as a consultative body to provide advice on the formulation and adjustment of monetary policy and also targets for setting monetary policy instruments. The instruments of monetary policy include reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending, open market operation and so on. In the view of Mr. Zhou Xiaochuan (2006), President of the PBC, there exist many special characteristics of China's monetary policies compared with those in advanced economies. First of all, China's monetary policy has multiple objectives and has to keep a balance between price stability and economic growth, which is different to in most western countries which have the solitary objective of price stability. Secondly, to achieve the above mentioned objectives the monetary aggregate and interest rate instruments are used alternatively and discretely. The monetary aggregate is still a main target at present. Finally, as a transition economy, the money market and financial markets in China are underdeveloped, so more time is needed to establish more effective transmission channels for monetary policy.

1.2 The Framework of China's Monetary Policy and its Implementation

1.2.1The Banking System and Financial Institutions

Up to the December of 2006 China's banking system could be described by Figure 1.1. CBRC, as the state authorized supervisory body for banks, was separated from PBC in 2004. Its main objectives include: 1). Protecting the interests of depositors and consumers through prudential and effective supervision; 2). Maintaining market confidence through prudent and effective supervision; 3). Enhancing public knowledge of modern finance through customer education and information disclosure; 4) Combating financial crimes. (Source: Website of CBRC).

Figure 1.1 China's Banking System.



Source: Hong Kong Trade Development Council

Table 1.1 shows the market structure of banking system in China. (Up to November, 2006)

Table 1.1 Market Structure of Banking System in China

Bank type	Policy Banks	State Owned Commercial Banks	Shareholding Commercial Banks	City-owned Commercial Banks	Agricultural Cooperative	Non-Bank Financial Institutions	Post Deposit Banks	Foreign Banks
Capital share	8%	52%	16%	6%	10%	2%	4%	2%

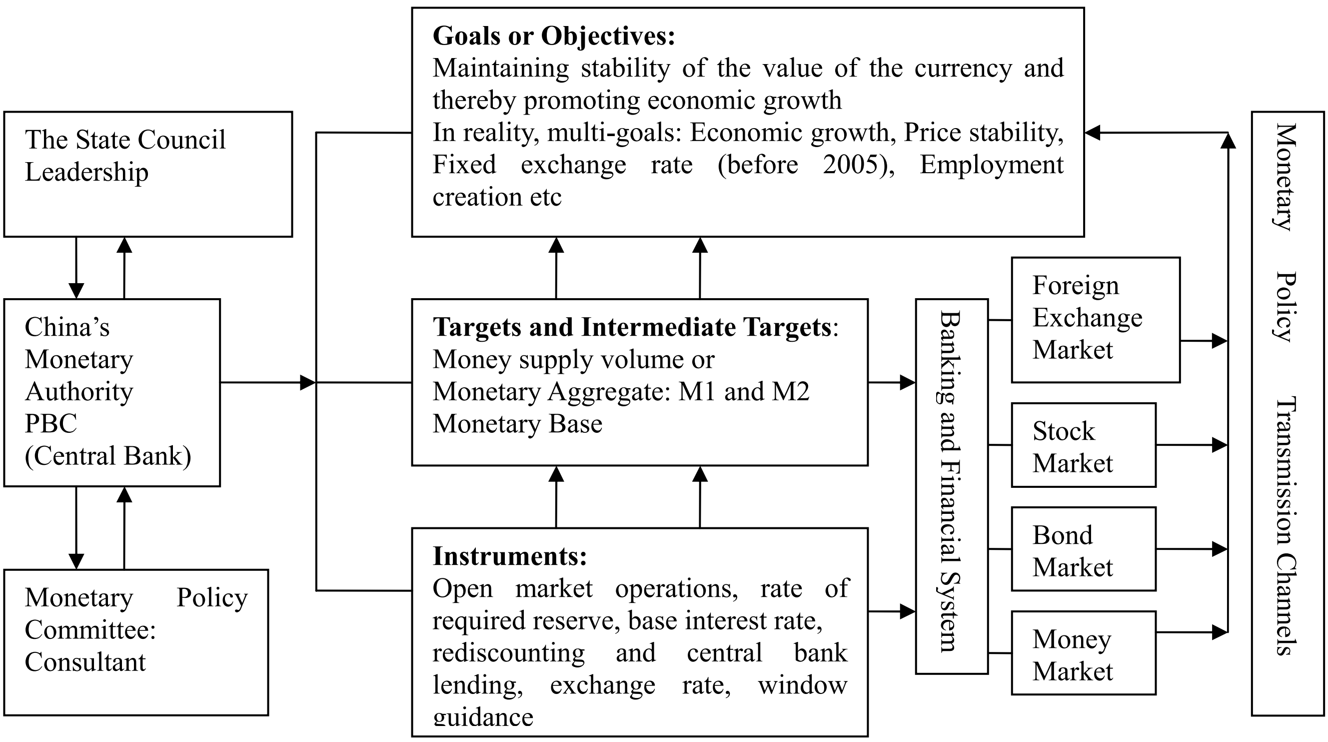
Source: CBRC, Nov. 2006

From Table 1.1, it can be seen that China's banking system is dominated by state-owned banks, among which are the so called big 4 state commercial banks, these account for about 52% of total capital shares in the banking system. Shareholding commercial banks account for 16%. The shares of other financial institutions are: policy banks 8%, agricultural cooperative 10%, city-owned commercial banks 6%, post deposit bank 4%, foreign banks and non-bank financial institutions are both 2%.

1.2.2 The General Framework of monetary policy in China and the Implementations

The general policy framework in China can be summarized by Figure 1.2. In what follows, this framework is described and explained, and the implementation of China's monetary policy is detailed.

Figure 1.2 The Framework of Monetary Policy in China

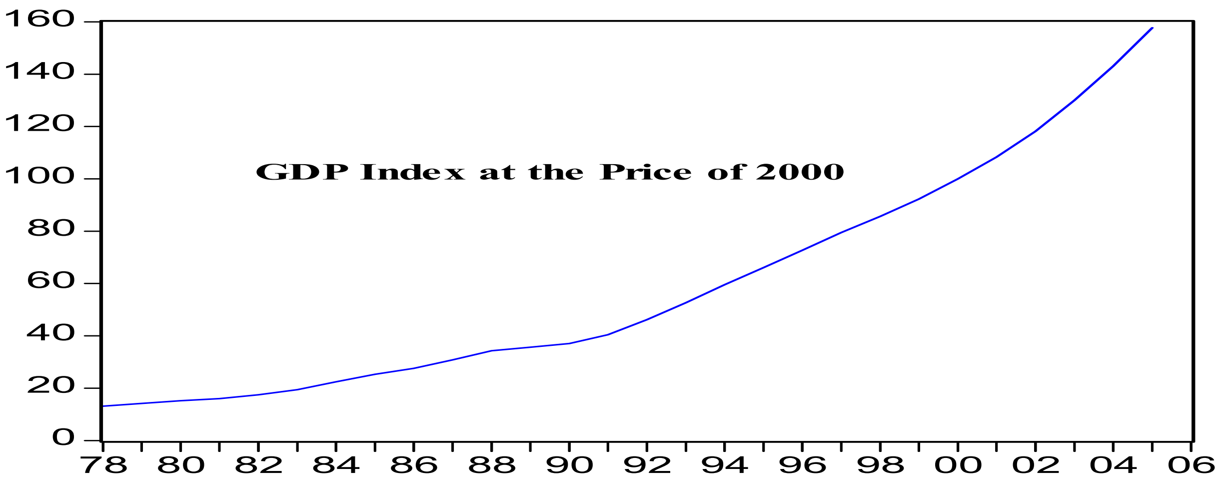


Source: By Author

The Goals

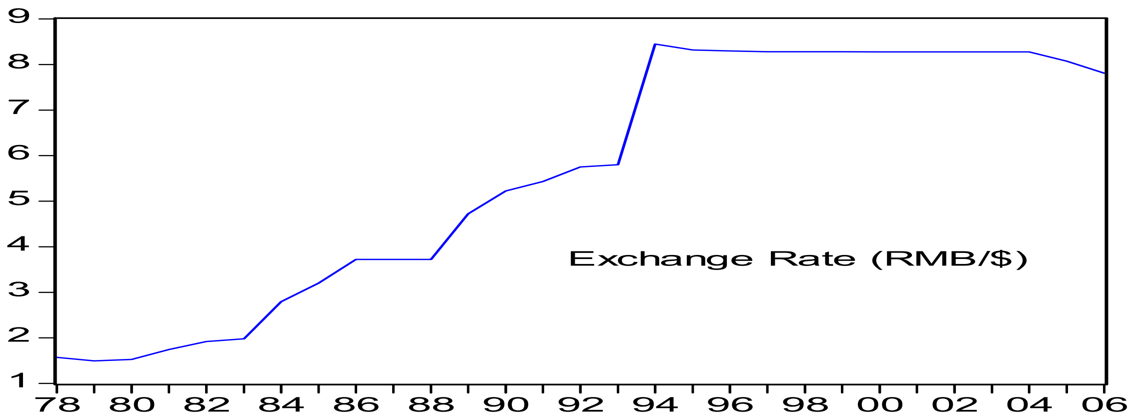
Although The Law of the People's Republic of China on the People's Bank of China (1995) stipulates that the goal of the China's monetary policy is to maintain the stability of the value of the currency and thereby promote economic growth, in reality the implementation of monetary policy in China by the PBC serves many objectives established by the government: Achieving sustainable growth of the economy, at an average annual rate 0f above 8% (real GDP). Maintaining a stable exchange rate: before May 2005, China had a fixed exchange rate regime, with the RMB (the currency of China, Unit: Yuan) pegged to the US dollar at the rate of about 3 Y/$ before 1983, this depreciated to 4 Y/$ in 1986 and 5 Y/$ in 1986 and further depreciated to 8.23 Y/$ in 1994. As a result, China gave up this system and the RMB has been pegged to a basket of foreign currencies since May 2005. It is believed that PBC set a precautionary level for the rate of inflation at 3% (annual rate). Also, the PBC has to serve other political and economic goals formulated by the central government such as low unemployment and promoting the growth of special sectors. Figure 1.3 is the real GDP index of China since 1978 (calculated at the price in 2000). Figure 1.4 is the exchange rate of RMB with US dollars. Figure 1.5 demonstrates the evolution of CPI inflation rate in China since 1978. This data for economic growth, inflation rate and CPI demonstrate that china's monetary policy has successfully achieved fast and stable economic growth and a stable exchange rate after 1994 but failed to keep the price stable since the 1990s.

Figure 1.3 The Real GDP Index (Price in 2000) of China since 1978



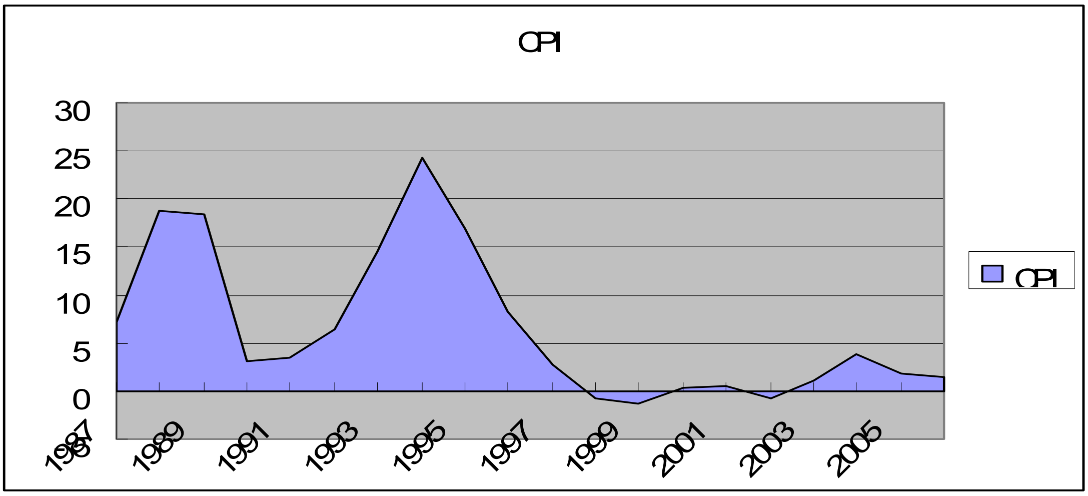
Source: IFS

Figure 1.4 The Exchange Rate of RMB on US dollar since 1978



Source: IFS

Figure 1.5 The Evolution of CPI Inflation in China since 1987



Source: IFS

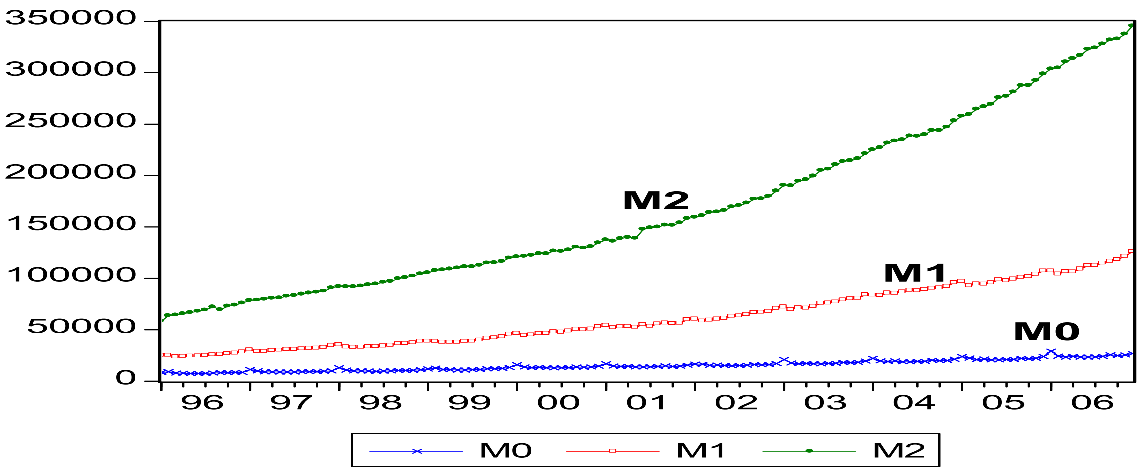
Intermediate and Operational Targeting

China started to anchor on intermediate monetary targets in the late 1980s. Until 1986, PBC had no explicit intermediate monetary targets given a centrally-planned economic system in China. During the period 1986–1993, currency in circulation and banks' loan portfolio were adopted as intermediate targets. In September 1994, three levels of money supply indicators, M0, M1, and M2 were defined and announced. In 1996, the PBC formally took money supply (monetary targeting) as an intermediary target.

In the current phase started in 1998 when the credit ceilings were eliminated, the PBC, like Deutsch Bundesbank and ECB, takes the monetary aggregate or money supply as its intermediate target, In practice, this means that the PBC changes official interest rates in an attempt to either speed up or slow down monetary growth (growth rate of M2) to a specific and pre-announced rate as the nominal anchor under the current framework. According to Xie (2004), the operational target of China's monetary policy is the monetary base.

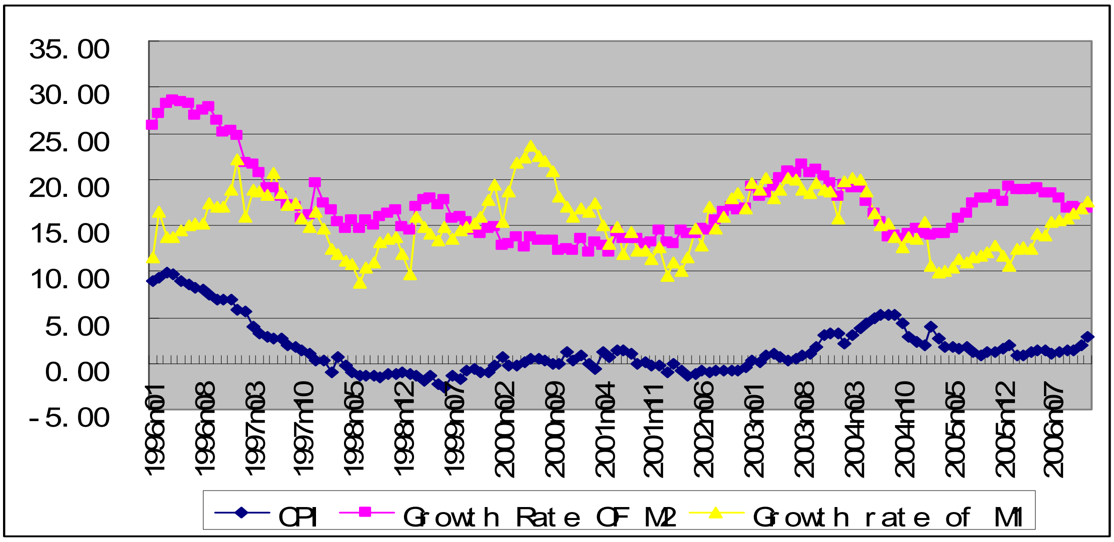
The trend of money supply (M0, M1 and M2) in China from 1996 is presented by Figure 1.6:

Figure 1.6 The Money Supply since 1996 (Unit: 100 Millions Yuan.)



Source: CEN, China Economic Network

Figure 1.7 Relationships between CPI, the Growths of M2, M1



Source: CEN

Figure 1.7 shows that the growth rate trend of M2 is closely correlated with the trend of CPI inflation, which suggests the long term relationship between money supply and inflation rate.

Instruments

The primary instruments of monetary policy used by the PBC are open market operations, rate of reserve required, base interest rate, rediscounting and central bank lending, exchange rate, and the "window guidance"[4] to banks on their lending operations.

Open market operations of the PBC began in 1998 with a primary dealer system. The chosen counterparties are about 40 commercial banks. The main instruments of trade consist of outright cash trading, Repo (Repurchase) transactions and issuance of central bank bills. Repurchase transactions include positive Repo and reverse Repo. Positive Repo is a process of the sale of equities by PBC to the commercial banks with agreement; this reduces the market liquidity, buying the equities back at maturity increases the market liquidity. Reverse Repo is a reverse operation; the sale of bonds and issuing of central bank bills can decrease monetary base while the buying of bonds and notes increase the monetary base. The effects of open market operations depend on the maturity of the short term debt market, unfortunately the bonds issued by the Chinese government are medium to long-term maturities and the short end is dominated by central bank bills. In the December of 2005 the PBC introduced the foreign exchange swaps[5].

Table 1.2 is an illusion of some open market operations (OMOs) by PBC in Q32007

Table 1.2 Some OMOs by PBC in Q3, 2007 (unit: 100 million Yuan)

Data		19 July	31 July	16 August	4 September	7 September
Central Bank Bills(3 months)	Volume Issued	10	230	140	330	1510
	Yield	3.62	3.2205	3.71	3.3165	3.71
Central Bank Bills (1 year)	Volume Issued	330		300		
	Yield	2.7461		2.7868		
Repo (6 months)	Bidding Volume	200	450		100	
	Yield	3.00	3.02		3.20	

Source: Reuters. Note: OMOs: Operational Market Operations

In the central bank open market operations, biddings are made on price (interest rate) and quantity. With quantity determined by the central bank, primary dealers bid on prices (interest rate), which is determined through bidding. When the central bank determines the price and the total quantity to offer, the primary dealers bid on the quantity. If oversubscribed, liquidity is appropriated on a pro rata basis, whereas if it's under- subscribed, liquidity is allocated according to the actual bidding. Bidding on price is a price-finding process while bidding on quantity helps the central bank to find the market demand at a certain price. The central bank can choose

[4] Window guidance is a moderate instrument of monetary policy implementation in China, by which the PBC impacts the bank lending operations through policy advice and moral suasion.

[5] Refer to website of PBC: http://www.pbc.gov.cn/

between different bidding methods according to its intention in the open market operation at the time.[6]

The PBC resumed open market operations in May 1998. In its repo, reverse repo, and outright cash transactions it took advantage of the open market operation, alternated between bidding on price and quality as the situation required, adjusting the base money, market liquidity and guiding the money market rates.

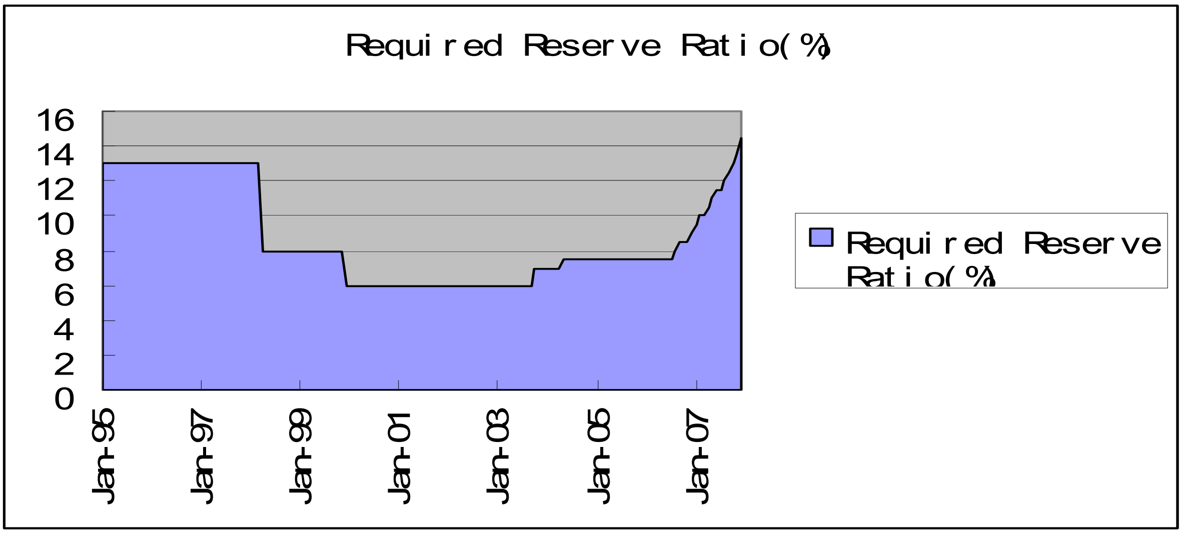
On April the 22nd 2003 the PBC initiated the issue of central bank bills as the new instrument to adjust base money. Central bank bills with maturities of 3-, 6- and 12-months were issued on a continuous basis to test the level of money market rate and the interest rate expectations of the commercial banks. Between the end of April and October the PBC offered the central bank bills with bidding on prices. At the same time, varying with market conditions, the PBC used a combination of short-term reverse repo and issue of central bank bills or issue of central bank bills and the purchase of government Securities, which indicated the central bank's intention to maintain a steady growth of the base money and effectively alleviated the sporadic and seasonal liquidity problems. From mid-November, in order to stabilize the money market rates and comply with the reduction of interest rate on excess reserves while issuing central bank bills, the PBC changed to bidding on quantity.[7]

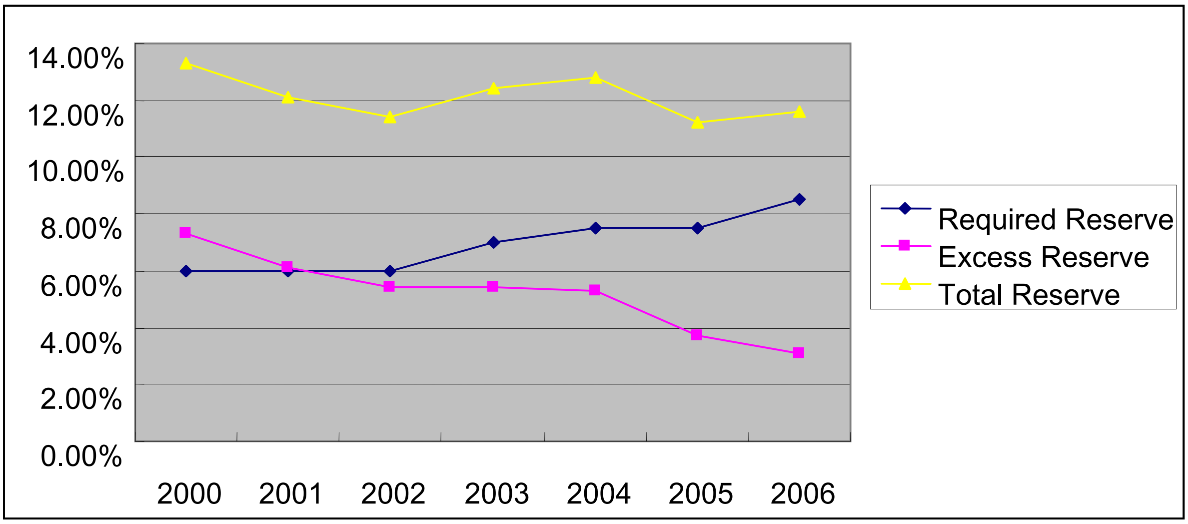
Minimum reserve requirement has been intensively and extensively used as an instrument by PBC, especially to maintain tighter monetary policy. In the 1980s the rate of required reserve was about 13%. This was reduced to 8% in March 1998 and 6% in November 1999 and stayed at this level to 2003; the PBC raised RR to 7 % in September 2003 and further to 7.5% in April 2004; it was raised to 8% in July, 8.5% in August, and 9% in November 2006 respectively; in January 2007, the PBC raised RR to 9.5%. Although the RR in China is higher than that in most developed countries because of the existence of excess reserves in most commercial banks in China, the effects of RR operations on commercial bank loans are weak. Figure 1.8 is the required reserve rate and excess reserve rate.

6 See Implementation Report of China's Monetary Policy (2003q4)

7 More descriptions on the open market operations of China's monetary policy refer to the Implementation Reports of China's Monetary Policy in 2002q4, 2003q2, 2003q4, 2004q3.

Figure 1.8 Required Reserve Rate and Excess Reserve Rate





Source: PBC

In the view of monetary policy management, given the interest rate on excess reserves is set at a relatively high level, high levels of excess reserves held by commercial banks in central bank make it more difficult for the central bank to forecast the demand for base money and accurately manage base money and money supply. Relatively high interest rate on excess reserve may also reduce the sensitivity of financial institutions with respect to the central bank's money policy conduct and undermine the effectiveness of monetary policy management. To cut the interest rate on excess reserves is conducive to promoting money market activities and improving the sensitivity of financial institutions.

In December 2003, the PBC reformed the interest rate system for deposit reserves by differentiating interest panel on required reserve and excess reserve. The interest rate on the required reserves of financial institutions is 1.89%, while the rate on the excess reserve is 1.62 percent. On March the 17th 2005 the PBC cut the interest rate on excess reserves by another 0.63 percentage points to 0.99 percent.

In 2004, the PBC adopted a regime of differentiated required reserve ratios in line with China's actual financial developments, this embodies four aspects:

1. The differentiated required reserve ratios are determined, which consist of the capital adequacy ratio, NPL ratio, the status of internal control, major violations of regulations and occurrence of severe risks, obvious worsening of the ability to pay and the risks that are likely to damage the safety of the payment system of financial institutions.

2. The financial institutions are subject to differentiated required reserve ratios. The system of differentiated required reserve ratios adopts a uniform framework and standard classification. All depository financial institutions are subject to this framework. Given financial institutions are undergoing different stages of restructuring, the wholly state-owned commercial banks that have not carried out share-holding reform and Urban and Rural Credit Cooperatives will put off implementing the arrangement of differentiated required reserve ratios.

3. The methodology for the differentiated required reserve ratios is adopted. Financial institutions will be classified based on four quality indicators including capital adequacy ratio. In line with the need of macro financial management, differentiated required reserve ratios will be applied to the financial institutions of different categories.

4. The adjustment operation of required reserve ratio is conducted. The PBC will regularly adjust the required reserve ratio of financial institutions based on such indicators as their quarterly average capital adequacy ratio and NPL ratio of the previous year calculated by the China Banking Regulatory Commission (CBRC). Where there are major violations of regulations, occurrence of severe risks or payment problems in a financial institution, the PBC will, in consultation with the CBRC, timely adjust its required reserve ratio.

The differentiated required reserve ratio system helps facilitate the stable and healthy development of China's financial sector. The overall framework and the incentives contained in the arrangement of differentiated required reserve ratios will provide clear direction and applicable standards for the reform of the financial institutions. Financial institutions, in particular those that are required to observe higher required reserve ratios will be forced to improve their performance under this arrangement. Meanwhile the system will also lay a foundation for improving the transmission mechanism of the monetary policy and for enhancing its effectiveness.

The required reserve ratio is not only a tool for managing money supply but also an effective means to promote stable operation of and to prevent payment risks in financial institutions. In light of China's current macroeconomic and financial developments the required reserve ratio system still needs to be fully leveraged for some time in the future. So far, financial authorities of most economies have all stipulated that depository financial institutions abide by the minimum capital adequacy ratio of 8 percent. For those financial institutions failing to meet the criteria the financial authorities will take corrective actions and enforce recapitalization, merger or even liquidation. With such a mechanism of incentives in place the financial institutions with sound asset liability structure can afford to expand at a faster pace while those with poor balance sheets will face restrictions in business expansion[8].

Standing facilities include central bank lending and rediscounting, the term of lending is generally less than one year and must be collateralized at rediscount rate minus 27 bps. The commercial banks can obtain liquidity by rediscounting their own commercial bank bills.

In 2001 the PBC provided loans to the Agricultural Cooperative to reform and strengthen the finance infrastructure in rural areas. Since 2001 central bank lending has been rare. The volume of bills rediscounted appears to have been decreasing since 2004, after the rediscount rate was floated in the first quarter of 2004.

In 2004, with the consent of the State Council, PBC decided to establish floating interest rates for central bank lending to further strengthen the Central Banks' ability to adjust central bank lending (rediscount) interest rates. Floating interest rates for central bank lending mainly refer to the arrangement under which, on the basis of central bank lending (rediscount) benchmark rate, the PBC decided on and published a spread of interest rates for loans (discounts) issued by the Central Bank to financial institutions. The system is an important measure for advancing steadily market-based interest rate reform.

Due to the economic and financial situations and the required support to small-and medium-sized enterprises, the PBC decided to raise the interest rates on central bank lending used for position adjustment and short-term liquidity support of financial institutions by 0.63 percentage points, rediscount interest rate by 0.27 percentage points. The increased interest rates should apply to all financial institutions applying for liquidity support and rediscount financing.[9]

Since the intermediate target of the monetary policy in China is the supply of money, central bank lending (rediscount) interest rate is formed by adding certain basis points to the central bank lending (rediscount) benchmark interest rate.

[8] See Implementation Report of China’s Monetary Policy (2004q1), Implementation Report of China’s Monetary Policy (2005q1), Implementation Report of China’s Monetary Policy (2006q2),

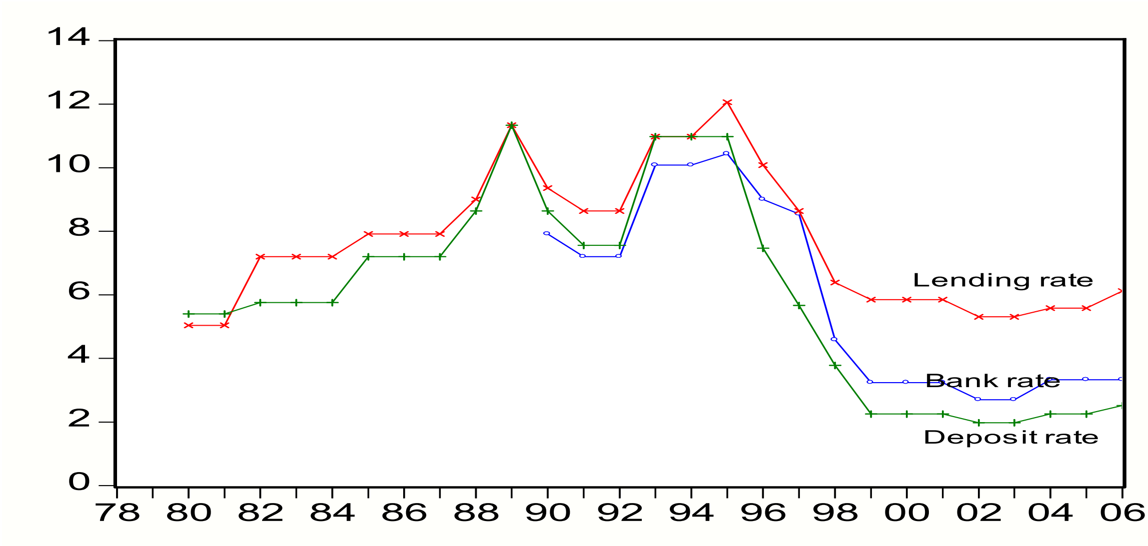
[9] Implementation Report of China’s Monetary Policy (2004q1)

The interest rate is an important instrument towards the goals of monetary policy. In China, interest rate structures are complicated and strictly controlled by the central bank although some deregulations have been conducted.

Besides the central bank lending rate and rediscount rate in the section of standing facilities, the most important interest rates are the benchmark lending and deposit rates set by the PBC, these must be strictly adhered to by commercial banks. The third kinds of interest rates are market interest rates, which consist of inter-bank repo and borrowing rate.

The benchmark lending and deposit interest rate are shown by Figure 1.9:

Figure 1.9 The benchmark bank rate, lending and deposit interest rate



Source: IFS

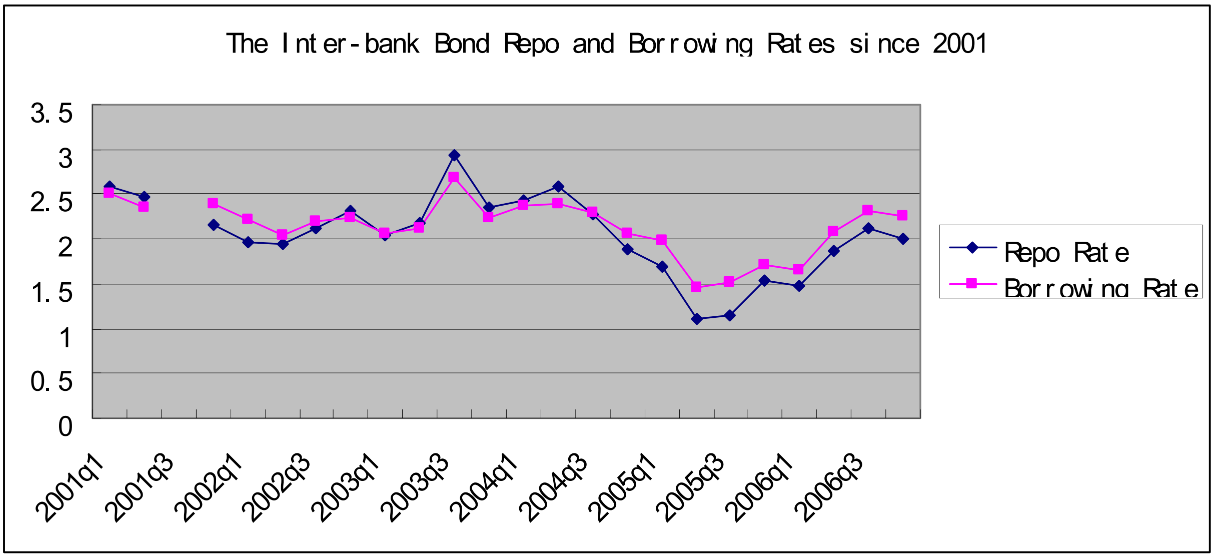
The deregulation of the interest rates has been gradually undertaken by the PBC with the consent of the State Council. On January the 1st of 2004 the PBC decided to widen the floating band of lending rates, effective from January the 1st 2004. Commercial banks and urban credit cooperatives were allowed to float their lending rate to 1.7 times the benchmark rate announced by the central bank and rural credit cooperatives to twice the benchmark rate, the lower band remained at 0.9 times the benchmark rate.

Meanwhile, the PBC conducted some reforms on interest rate administration to rationalize the interest rate structure and promote market-based interest rate reform. First, the interest rate accrual and payment method was determined between the borrower and lender through negotiation. Next, interest rates of small deposits in pounds sterling, Swiss francs, and Canadian dollars were determined and announced by the commercial banks. For small deposits in the US dollar, Japanese yen, Hong Kong dollar and Euro, under the interest rate ceilings, the commercial banks had some discretion according to the development of the international financial markets. Finally, interest rates accrual of deposits transformed from postal savings were reformed.

The expansion of a floating band of lending rates and further autonomy given to the commercial banks significantly increased the degree of liberalization and the risk compensation function of lending rates. The financial institutions established and improved the interest rate pricing mechanism and risk control system, which strengthened their risk control, and played a positive role in promoting the financial reforms.

The market interest rate, including the inter-bank bond repo rate and borrowing rate have been fully deregulated and fluctuated in terms of the market discipline since 2004. Figure 1.11 shows the inter-bank bond repo rate and inter-bank borrowing rate since 2001q1.

Figure 1.10 The inter-bank bond repo rate and inter-bank borrowing rate since 2001



Source: PBC

Window guidance or moral suasion has been an important instrument for the PBC to implement its monetary policy to achieve its special liquidity and credit management; for example, in q2, 2006, the PBC conducted the following measure under window guidance. First, the PBC called three window guidance meetings, requiring commercial banks to be on the alert to the risks associated with an excessive growth of loans. The purpose being to enhance risk control capacity, to avoid blind credit expansion driven by excessive profit seeking and to control credit aggregates. Next, the PBC guided financial institutions to strengthen capital constraints, establish a philosophy of sustained and sound operations, implement the requirements of the macro adjustment policy and the industrial policy of the state, enhance adjustments of the credit structure, strictly control lending to industries with excessive investment in line with the government's macro management and industrial policies, tighten control on mortgage loans and stop issuing package loans and credit lines to local governments. Finally, the PBC played a further role in credit policy guidance by encouraging financial institutions to improve financial services and strengthen credit supply in support of rural areas, farmers, job creation, education, rural workers and the non-public economy[10].

1.2.3 Financial Markets in China

Financial markets are the main medium and platform for monetary policy transmission. Mature financial markets are not only preconditions for effective transmission of monetary policy but also means of promoting the efficiency of the transmissions of monetary policies. In China, after 20 years of development financial markets are playing a more important role in implementing monetary policy. However they are still shallow and there is a long way to go, this impedes the effects of monetary policies on the variables of the real economy.

Money Market

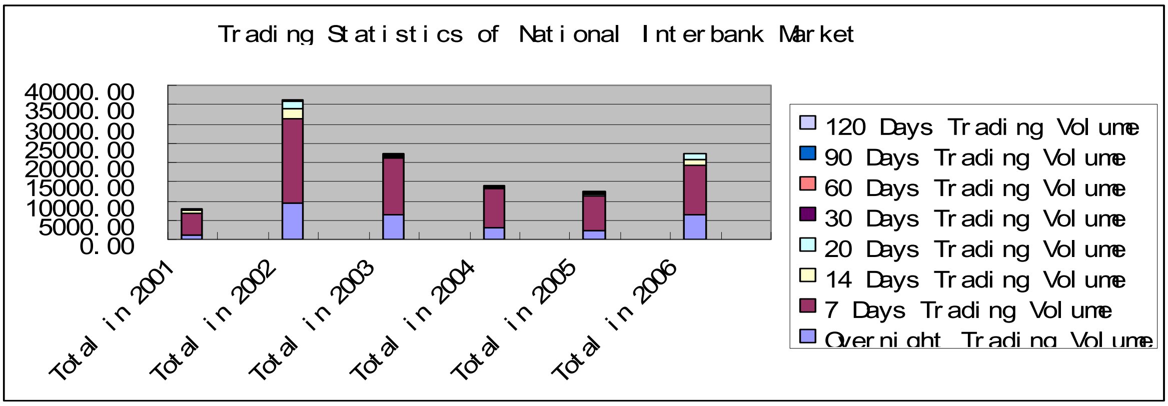
China's money market consists of three submarkets; the inter-bank borrowing market, the inter-bank bonds repurchase market and the commercial paper market.

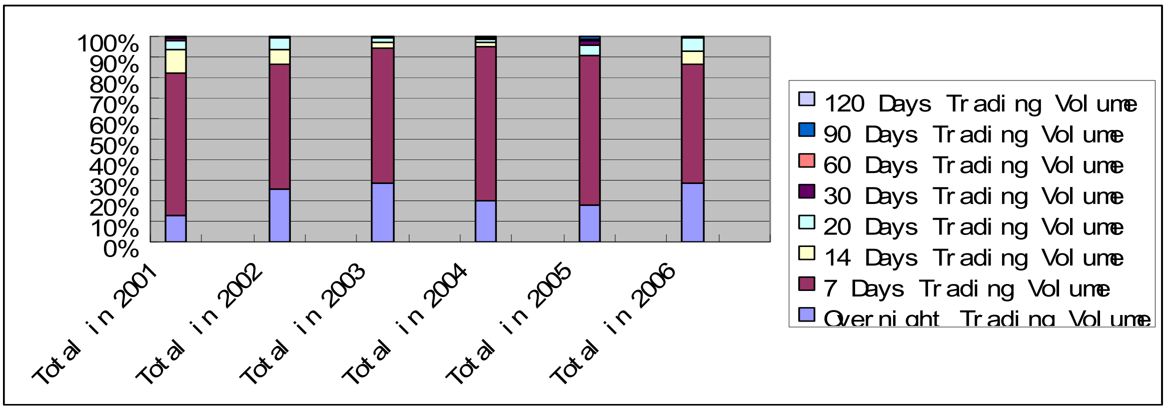
The inter-bank borrowing market of China has operated since January the 3rd 1996 when the number of members was 63. In 2002 there were more than 500 participants and at the end of 2005 there were 695 members. These were comprised of policy banks, commercial banks, financial companies, insurance institutions, security brokers, investment funds and foreign banks. Trade categories include overnight, 7 days, 14 days, 20 days, 30 days, 60 days, 90 days and the longest maturity being 4 months (120 days). The trade volume increased about 13 times in 2005 compared to that in 1997.

Figure 1.11 summarizes the trade volume of the inter-bank market since 1996. Figure 1.11 shows that the overnight borrowing trade and 7 days trades dominate the inter-bank transactions. The inter-bank CHIBOR (China interbank offered rates) and another important inter-bank offered rate SHIBOR (Shanghai Inter-bank Overnight Rate) have been established and this market has become the core money market, where banks lend funds among themselves for their liquidity needs.

[10] See Implementation Report of China's Monetary Policy (2006q2).

Figure 1.11 Statistics of National Inter-bank Market based on Maturity since 1996.
(Unit: 100 Million Yuan.)





Source: PBC

The national inter-bank bond repurchase market began to operate in June the 16th of 1997. Based on "The regulation on bond transactions in national inter-bank markets" and "The agreements of bonds repurchased in national inter-bank market" the trade volume and participants in this market have increased rapidly. The repo market tends to be less volatile and more liquid than the CHIBOR market. Since 1997 the repo rate has also been set by the market and the most active contracts have terms of 1-7 days. Table 1.2 shows the trade volumes of bonds repo made in China's interbank market since 2001.

The commercial paper market was established in the early 1980s. After 20 years' development, it becomes the main market of the short term capital financing for the monetary and non-financial institutions.

The money market plays the key role in the transmission of monetary policy in China:

·The National inter-bank markets provide the platform on which the PBC can conduct the necessary liquidity managements.

·With the developments of bonds repo in National interbank market the PBC can undertake and deepen its open market operations effectively.

·The rediscount operations of the PBC depend on the commercial paper market.

·The development of the money market promote the deregulation of interest rates.

Table 1.3 Treasury Bonds Repurchase Trading of National Interbank Market (Unit:100 Million Yuan)

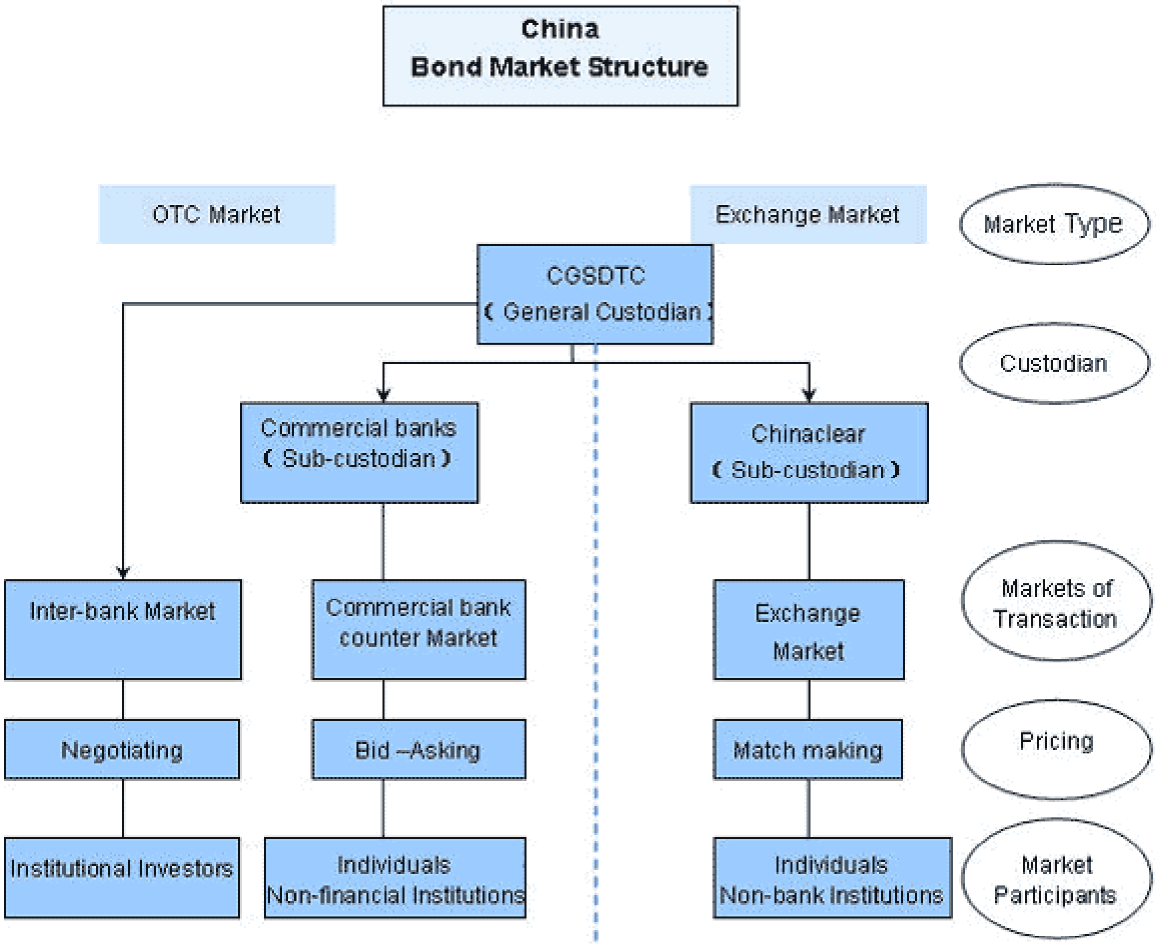
Time	Overnight	7Days	14Days	21Days	1Month	2Months	3Months	4Months	6Months	9Months	1Year
	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading	Turnover of Trading
Total in 2001	31271.32	5168.67	1945.45	916.71	490.07	250.98	19.05	39.75	25.31	6.00	40133.30
Total in 2002	206821.71	133851.09	31343.95	5466.60	4320.87	903.76	725.27	49.14	69.48	121.43	40453.54
Total in 2003	78330.93	13382.31	2185.82	1729.09	925.06	633.27	88.92	143.09	0.00	0.00	117203.42
Total in 2004	54208.63	10700.87	2866.30	2331.55	903.78	696.07	145.29	131.78	36.40	34.00	93104.90
Total in 2005	72747.21	61598.90	14530.78	3770.70	2310.51	788.21	535.29	55.29	211.08	87.22	149.15
Total in 2006	134254.83	98269.13	22354.82	3521.22	3196.83	560.54	457.99	8.79	42.32	115.38	238.74

Source: PBC

Bond Market

There exist three bond markets in China; the Inter-bank bonds market, the Stock Exchange market and the commercial bank over the counter market. The wholesale transactions of booked bonds and policy banks bonds are conducted in the Inter-bank bonds market by the institutional investors while the bonds are traded at the Stock Exchange between institutions and individuals. In the commercial banks over the counter market treasury bonds are issued to individuals and corporations where they are traded by investors. Among these three markets the stock exchange trade dominates according to turnover. The whole bond market is organized by 2-level custody arrangements. As China's central Securities depository (CSD) for the bond Market: **China Government Securities Depository Trust & Clearing Co. Ltd, (CGSDTC)** takes the responsibility of the General Custodian.

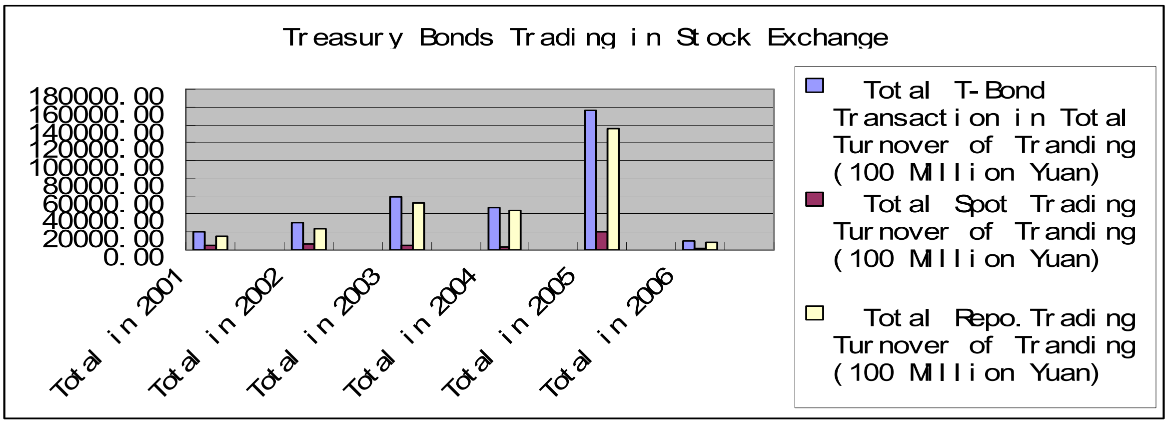
Figure 1.12 China Bond Market Structure



Source: http://www.chinabond.com.cn

Figure 1.13 presents the trading turnover since 2001 by transaction categories.

Figure 1.13 Treasury Bonds Trading in Stock Exchange (Unit: 100M Yuan)



Source: PBC

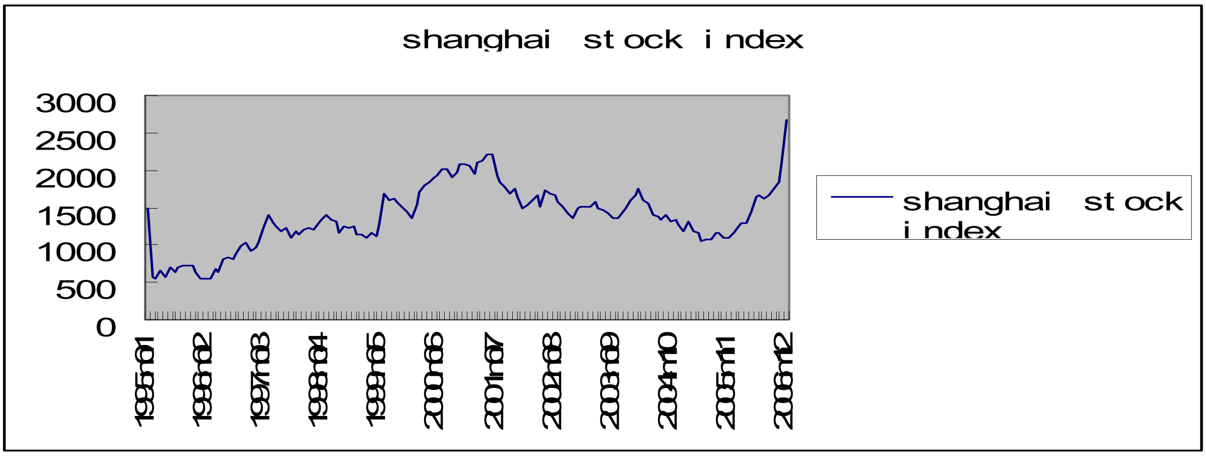
China's bond markets are underdeveloped compared with those in advanced economies because of the following reasons:

1. The supply of bonds is lower and the structure of bonds is imbalanced, main bonds are issued by the government and policy banks owned by the state. The issuances of corporation bonds are strictly regulated.
2. Long term bonds dominate over short term bonds making it difficult for the PBC to conduct OMOs in this shallow market.
3. An independent and accountable rating system supporting the improvement of infrastructure is needed to promote the transparency and liquidity in the market.

Stock market

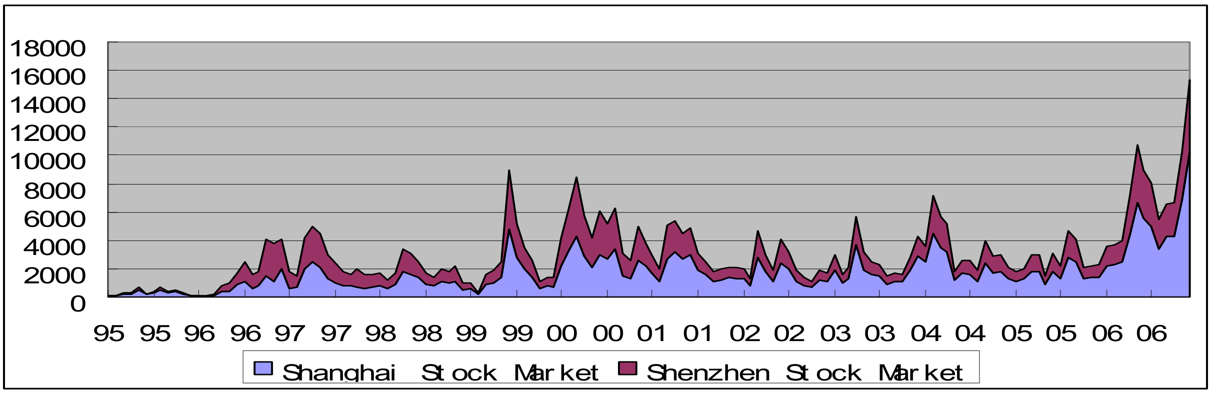
There are two stock exchanges in China, Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange, both founded in 1990 and governed by the China Securities Regulatory Commission (CSRC). After about 20 years operationing at the end of 2006 the total market values in the two markets were 7.16 trillion Yuan and 1.78 trillion Yuan respectively, the ratio to GDP is 42.69%. This ranks it as the 10th biggest stock market across the world, playing an important role in raising capital and thereby in economic growth. Figure 1.14 shows the evolution of Shanghai Stock Index from 1995 to 2006.

Figure 1.14 Shanghai Stock Index from 1995 to 2006



Source: PBC

Figure 1.15 Statistics of Stock Trading on Nationwide Basis (Unit: 100 Million Yuan)



Source: PBC

The stock markets not only provide important channels for China's monetary policy transmission but also challenge the implementation of China's monetary policy in the following ways:

·Monetary policies can impact on the real economy through wealth effects and asset price effects generated by stock markets.

·The development of the stock market increases the complexity of China's monetary policy transmission which makes the control of money supply more difficult.

·The bubble problems of the stock market challenge the policymakers in PBC and the respective regulatory body.

·A small scale, opaque and unsound monitoring system affects the efficiency of monetary policy transmission.

Foreign exchange market

China had a fixed exchange rate system for a long time; the foreign exchange transactions have been strictly controlled by the government up to now although some deregulation is under way. With the capital flows being controlled China can have an independent monetary policy under a fixed exchange rate regime. The participants of foreign exchange markets are primarily composed of institutional investors in China.

Table 1.4 shows the trade volume measured in US dollars before the reform of the exchange rate system, it demonstrates that the foreign exchange market is tiny compared with that in developed countries.

Table 1.4 Statistics of Foreign Exchange Transactions (Unit: 100 Million)

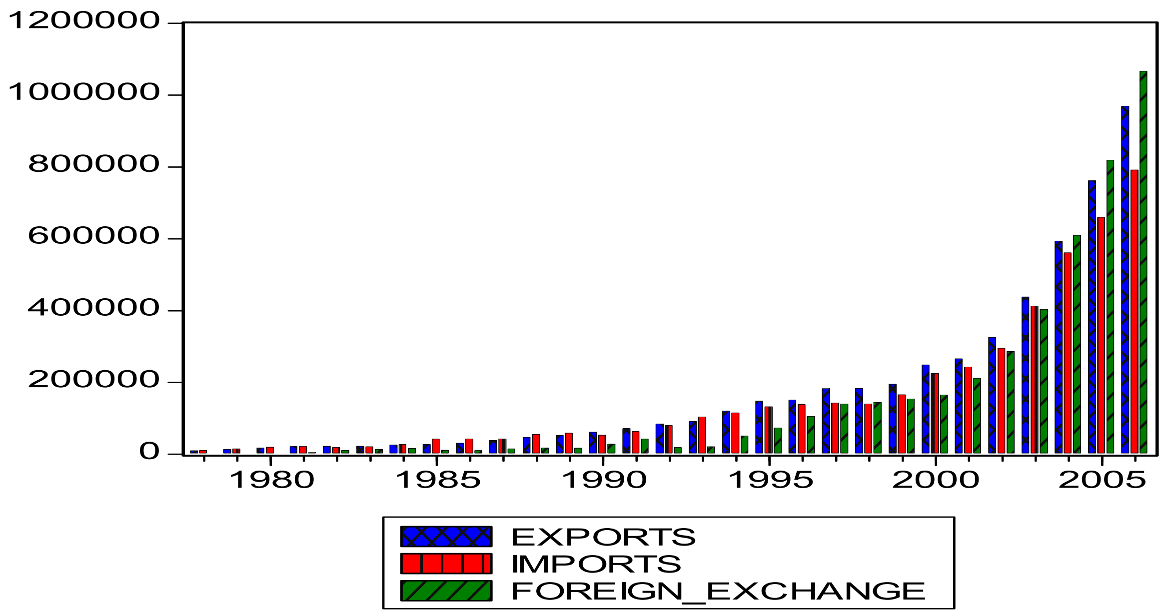
	Measured in USD	**USD**	**HKD**	**JPY**	**EURO**

	Value Date	Overall Turnover	Trading Volume	Trading Volume	Trading Volume	Trading Volume
Total in 2001	253	750.32	741.33	30.62	613.93	
Total in 2002	249	971.90	951.09	108.81	730.79	1.07
Total in 2003	251	1511.32	1478.17	186.32	761.57	2.97
Total in 2004	252	2090.41	2044.10	244.94	1349.63	1.86
Total in 2005	1009	5102.37	5004.93	492.50	3339.06	4.83

Source: PBC

Before July the 21st of 2005 while under the fixed rate system (which pegged the value of RMB on US dollar) the PBC announced several depreciations of the value of RMB to promote exports and improve the current account and increase foreign exchange reserves. Figure 1.17 displays the change of exports, imports and foreign exchange reserves since 1978. Combining Figure 1.5 and Figure 1.16, it shows that the depreciations of the RMB achieved above objectives: increasing the net exports and the foreign exchange and thereby increasing the GDP.

Figure 1.16 Exports, Imports and Foreign Exchange Reserves since 1978 (Unit: Million US$).



Source: IFS

Exchange Rate Regime Reform

On the 21st of July 2005 the Chinese government reformed the exchange rate regime by moving into a managed floating exchange rate system with reference to a basket of currencies. Since then the PBC has announced the closing price of a foreign currency traded against the RMB in the inter-bank foreign exchange market after the closing of the market on each transaction day and makes it the central parity for the currency trading against the RMB on the following transaction day. At the beginning of the reform of the RMB exchange rate regime the value of the RMB was appreciated by 2 percent immediately.

On the 18th of May 2005, foreign currency trading was formerly launched in the inter-bank foreign exchange market where spot transactions of eight currency pairs were conducted. This included the euro vs. US dollar, the Australian dollar vs. the US dollar, British pound vs. the US dollar, the US dollar vs. the Swiss franc, the US dollar vs. the HK dollar, the US dollar vs. the Canadian dollar, the US dollar vs. the Japanese yen, and the euro vs. the Japanese yen.

On the 2nd of August 2005 the PBC released a *Notice on Expanding Designated Banks Forward Purchases and Sales Business and Launching RMB and Foreign Currencies Swaps* which permits qualified commercial banks to undertake RMB and foreign currency swaps. This is also employed as a monetary policy instrument by central banks to manage the market liquidity condition.

Further, on the 4th of January 2006 the PBC issued the Public Announcement on Further Improving the Inter-Bank Spot Foreign Exchange Market (Public Announcement of the PBC No. 1[2006]), introducing the market-maker system and over the counter transactions (OTC transactions) into the inter-bank spot foreign exchange market.

Under the new market framework there are three different prices of the RMB in the RMB exchange rate regime: the central parity of the RMB, the OTC rate, and the price-matching rate. They are linked by the following relationships: first the central parity dominates with the OTC rate and price-matching rate varying within a specified band around the central parity as the benchmark rate depending on changes in market supply and demand. Second, the OTC rate and the price-matching rate are closed correlated, as arbitrage across the two markets, differing in terms of trading approaches, resulting in obvious co-movements of the two rates. Third, due to other factors such as credit risk and fees, there usually exists some difference between the OTC rate and the price-matching rate.[11]

Exchange rate channel has begun to take effects since May 2005 because China has adopted a managed floating exchange rate system. The appreciation of RMB will reduce the prices of imported goods and raise the price level of the exports to improve the imbalance of international trade. Up to now, RMB has appreciated about 15% but this has not decreased the foreign trade surplus. On one hand, the degree of depreciation of RMB is perhaps not enough, on the other hand, the effects of exchange rate channel maybe covered by the effects of other factors. To

[11] See Implementation Report of China's Monetary Policy (2005q2), (2006q1), (2007q2).

rebalance the world economy, the further gradual appreciation of RMB and restructuring the growth model of China's economy are not only crucial to China but also to the whole world.

1.3 The Independence of PBC and the Efficiency of Monetary Policy Transmission

The effectiveness and efficiency of monetary policy operations is closely related to the institutional environment in which it is conducted. The evolution of monetary policy interacts in a complex way with the general path of the financial market development (Jens Forssback et al, 2005). Therefore strict scrutiny is needed in the institutional environment and the evolution of the financial markets for assessing the effectiveness and efficiency of China's monetary policy.

With respect to the institutional environment for the operations of monetary policy in China; in terms of the Law of the People's Republic of China on the People's Bank of China (1995) the PBC should formulate and implement monetary policy under the leadership of the State Council of China. It is not an independent central bank although it can operate independently in selecting its instruments of control.

Zhou Zhongfei and Li Jingwei (2006) assessed the independence of the PBC by employing three aspects: Functional, Personal and Financial independence. With respect to the functional independence the PBC does not hold goal autonomy and target autonomy, its instruments autonomy is limited compared with the FED which enjoys goal autonomy and the ECB which possesses target and instruments autonomy. In practice all the annual decisions concerning the amount of money supply, interest rates, exchange rates, and other important matters are determined by the State Council. The PBC can conduct its policy only under the prior approval of the State Council. Also the PBC is not free from government pressures because most members of its advisory body, the monetary policy committee, are representatives of government departments from the State Council. Nevertheless, the PBC holds operations autonomy and it is authorized to deal with payment and settlement matters independently. For personal independence, many factors are involved: the qualification requirement, nomination of MPC, term of office and conflict of interest. All these matters mark unique Chinese political characteristics. Thirdly, financial independence, the Law of the People's Republic of China on the People's Bank of China (1995) regulates that the capital of PBC is subscribed by the state but it does not specify the amount of capital. Although the Law prohibits any government departments (especially the Minister of Finance) from interfering with the activities of the PBC the government can intervene on the PBC's operations through the appropriate channel. In summary, they suggest that reforming the law based on the prevailing standards is the precondition for an independent and accountable central bank in China.

The financial market in China is clearly underdeveloped; many measures should be taken to improve and foster sound money and capital markets. This would enable the PBC to obtain more policy instruments and operate more efficiently. To this end further deregulation of financial markets are necessary. Although this process did begin in the 1990s, it has a long way to go. The deregulation of financial markets can be summarised: in 1996 China abolished inter bank interest rate ceilings; in 2004 the central bank rediscount rate was liberalized and the lending interest rate ceilings for banks were removed. However the interest rate liberalization is still ongoing and administrative influence on price-setting is probably still sustainable. The issuance of the Securities (debt and equity) is still surrounded by formal and informal restrictions and the existing stock market was characterised as a “policy market”. State-owned banks dominate the financial sector in China; four big state banks held 57% of the market shares in 2003. Local banks held 20%, ten jointed commercial banks had 10% market share, the three policy banks had 8%, and foreign banks 1% (Forssback et al, 2005).

The development of the financial markets in China is not enough for PBC to operate as a modern western central bank. China’s money market, consisting of the inter-bank market, the primary and secondary short-term Securities market and the derivatives market is small. China’s CHIBOR inter bank market had only existed for 10 years prior to 2007, the stock of treasury bills or equivalent government Securities are tiny so far: outstanding bonds (government only) are about 20% of GDP(2004), among which less than 5% are less than 2 years, implying a short term bill market is around 1% of GDP. The PBC issued the rules of “short term financing bills” and the rules governing derivatives trading between banks in 2004, but not viable markets exist yet, which implies that PBC cannot conduct repo operations in China.

For the operation of monetary policy in China, due to the failure of the pricing mechanism in the money market, the PBC has conducted more operations by adjusting RR recently, although most Chinese banks cannot meet the minimum required capital requirement imposed by PBC for the long term. With respect to operations on the public market, because the bond market is so shallow, cash trading of bonds, repo transaction in bonds, and reverse repo in bonds cannot be effective. The foreign exchange rate market operations also cannot provide the PBC with effective liquidity management in China. Moreover, the huge foreign reserves and large international trade surplus cause many problems for monetary policy operations such as an excess of liquidity and appreciation pressure on the exchange rate.

To improve the effects and efficiencies of monetary policy in China an independent monetary policy regime needs to be established and the financial markets need to be reformed. Referring to the political reality and the Law of the PBC, a complete independent central bank is not viable in the near future in China, but some independence, such as operational instruments autonomy, professional people independent, and an independent MPC under the National People's Congress rather than State Council are feasible. In the long run, Goodfriend and Prasad (2006) suggest that PBC should change its target of monetary policy from money growth to nominal anchor-inflation with the interest rate as its main instrument, given that China has given up its fixed exchange rate regime, which constrains the effects of monetary policy. By employing an inflation target, the PBC can keep the price stable, stabilize employment, sustain economic growth and prevent inflation and deflation scares with its credible commitments. As pointed out by Ben Bernanke (2005, p2), long-run price stability could have several advantages, including further reducing public uncertainty on monetary policy and anchoring long-term expectations even more effectively. At the micro-level of operations by PBC, Goodfriend and Prasad advised that PBC must have timely access to accurate and detailed data on macroeconomic and financial conditions along with the help of other government statistics agencies, this is most important for conducting macroeconomic management; the PBC should acquire the analytical capacity to shift its instruments flexibly according to the type of economic shocks, also the PBC should improve its communication on monetary policy. Banking system reforms are also essential for more effective monetary policy, this could make the state-owned banks market-oriented by adopting a prudential standard to regulate operations and assess asset quality, improve accounting and disclosure standards.

With respect to the reforms of financial markets and infrastructure building, speeding up the reform of the interest rate system to foster the market-based interest rate and sound money market may be the best route towards effective and efficient transmission of monetary policy. Expanding and strengthening the inter-bank market will smooth and effect the PBC’s monetary policy operation through the interest rate channel and open market operations; and the creation of treasury bills could improve the efficiency of PBC’s policy operations. To increase the effect of assets price transmission of monetary policy, developing and improving the bond market and stock market are necessary, moreover, strengthening the link and communication between money market and capital market are very important for the flexibility of monetary policy operations in China. A flexible exchange rate regime is also suggested by many economists for an effective monetary policy operation in China, although many uncertainties exist.

Chapter 2 Monetary Policy and Monetary Transmission Mechanism: An Overview

2.1 Introduction

Theoretical and empirical studies have uncovered and confirmed that monetary variables have effects on key nominal macro variables either in short-medium run or long run. These effects can also be transmitted to the real macroeconomic objective variables, such as real output, employment and GDP growth in the short run. Therefore, in most countries, an authorized institution, the central bank, is established to conduct monetary policy to achieve sustainable economic growth, low inflation and unemployment rates. The central bank, by controlling and adjusting the money supply, interest rates, or other monetary policy instruments, implements monetary policy to affect target or ultimate objectives of its policies. Given the money supply process controlled by the central bank and the money demand functions identified in the theoretical and empirical studies by economists, monetary authorities can employ monetary variables to achieve the special objectives of economy, however many difficulties still exist during this process because the knowledge of economists and policy makers about the transmission mechanism of monetary policy is limited.

The transmission mechanism of monetary policy uncovers the process by which those monetary policy instruments affect the target variables of monetary policy in real economy. As mentioned in the preface, although there are different arguments on the monetary transmission channels among different schools, two views on the monetary transmission mechanism (MTM), the so-called "money view" and "credit view", have been accepted by most macroeconomists. The traditional 'money view' works through the interest rate channel, money channel and exchange rate channel; the 'credit view' works through the bank lending channel and the balance sheet channel; the asset price channel and the expectation channel are also identified through which the monetary policy functions on the real economy. Needless to say, these channels are not mutually exclusive: the economy's overall response to monetary policy will incorporate the impact of a variety of channels (Kuttner and Mosser, 2002). Moreover, in a different economy or in a different monetary policy system, different transmission channels are identified and uncovered because of the differences of targets, intermediate targets and the instruments in diverse monetary policy regime. Nevertheless, common transmission mechanisms of monetary policy can be found in different economic systems. In the conference of Financial Innovation and Monetary Transmission, sponsored by the Federal Reserve Bank of New York on April the 5th and 6th of 2001, the monetary policy transmission channels were summarized in Figure 2.1 by Kuttner and Mosser (2002).The Monetary Policy Committee of the Bank of England, for example describes the view of monetary policy transmission mechanism in its report on the transmission mechanism of monetary policy as illustrated in Figure 2.2. Based on the empirical research results on China's monetary policy transmission mechanisms, China's monetary policy transmission channels are summarized and provided in Figure 2.3.

In the following two sections, we summarize the identified monetary transmission channels recognized by most economists up to now, and then discuss the main research methods on MTM.

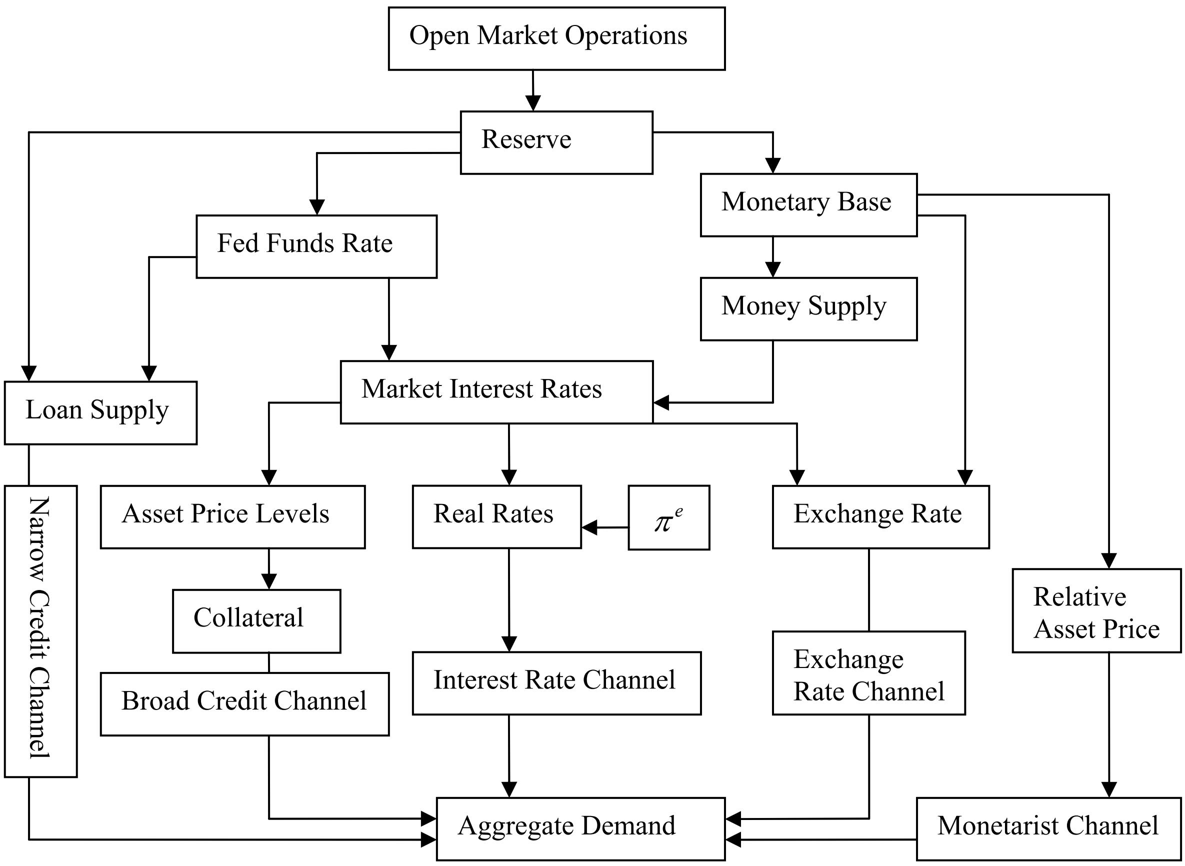


Figure 2.1 Monetary Policy Transmissions in Fed

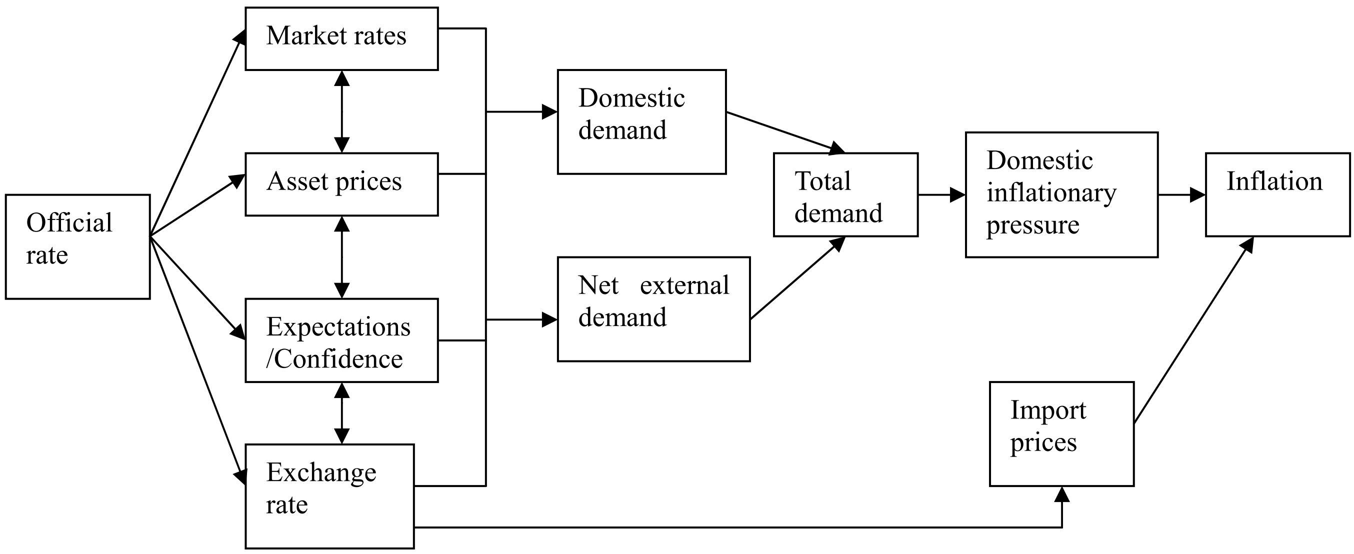


Figure 2.2 Monetary Transmission Mechanism from MPC of Bank of England (www.bankofengland.co.uk)

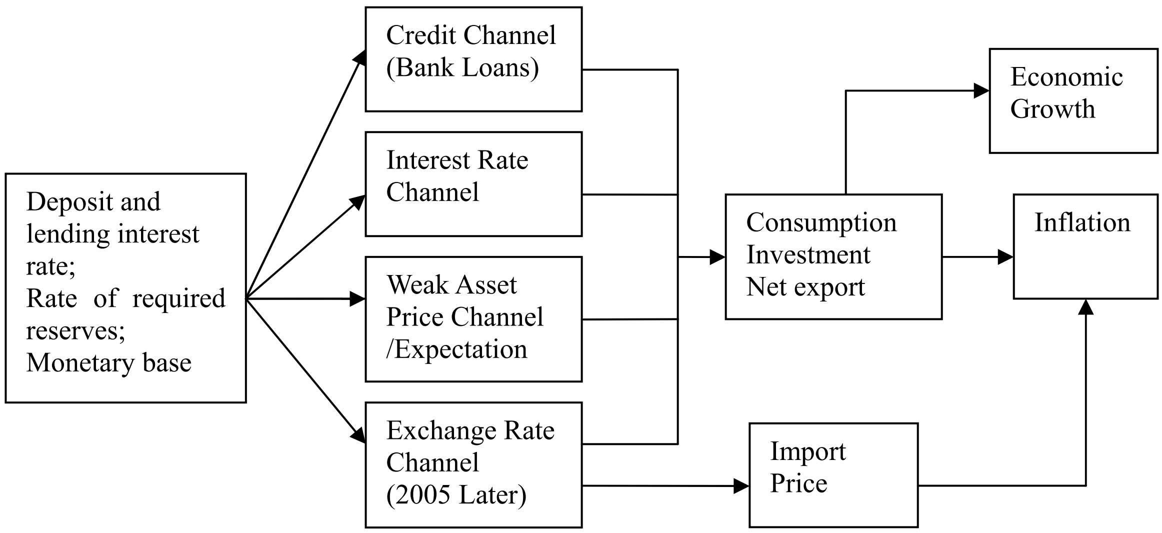


Figure 2.3 Monetary Transmission Mechanisms in China (Source: by Author)

2.2 The Transmission Mechanism of Monetary Policy

In this section each channel which is generally accepted by most macroeconomists will be described in turn.

2.2.1 The Quantity Theory Channel

According to Bofinger (2001), the quantity channel is connected with the classical quantity theory of money, which took effect only during the period of metallic currency system in which the money was available solely in the form of gold and silver coins. Under such conditions an expansion in the money supply can only stimulate the mining gold and silver, which is minted in the form of coins.

The main idea of the quantity theory of money is that the price level will change at the proportional ratio of the fluctuation of money supply, this dominated economics during the 19th century. The Fisher equation, the so-called equation of exchange is

$$MV_T \equiv PT \qquad (2.1)$$

Where M represents the quantity of money, V_T is the velocity of circulation, P is the price level and T is the volume transactions. This Equation was developed to the standard form of the quantity theory:

$$M\overline{V} = PY, \qquad (2.2)$$

For a given money supply:

$$M^S = M = M^D, \qquad (2.3)$$

Equation (2.2) can be rewritten as the macroeconomic demand curve:

$$Y^D = \frac{M}{P}\overline{V}. \qquad (2.4)$$

Based on this simple transmission relationship, an expansion of monetary policy will lead directly to an increase in economic demand; in this system we ignored other determinants such as real income and the interest rate. The above relationship implies that all the inflation during the metallic periods can be attributed to central bank financed state expenditure[12].

2.2.2 The Interest Rate Channel-Money View

This channel is the most important and primary channel studied by most economists. Smets (1995) gave the following conclusions:

In most of the central banks' macro-econometric models the transmission process of monetary policy is modeled as an interest rate transmission process. The central bank sets the short-term interest rate, which influences interest rates over whole maturity spectrum, other assets prices, and the exchange rate. These changes in financial variables then affect output and prices through the different spending components. The role of money is in most cases a passive one, in the sense that money is demand determined.

The traditional interest rate channel was developed by Keynes in which the monetary transmission mechanism can be expressed as following scheme:

[12] See Bofinger (2001)

$$M \downarrow \rightarrow r \uparrow \rightarrow I \downarrow \rightarrow Y \downarrow$$

Where M$\downarrow$ indicates the contraction monetary policy leading to a rise in real interest rates ($r \uparrow$), which in turn raises the cost of capital, causing a reduction in investment spending ($I \downarrow$), thereby leading to a decrease in aggregate demand and a fall in output ($Y \downarrow$). In this scheme and relationship, the interest rate means the *real* rate other than the nominal interest rate as the indicator which impacts on the consumer and on business decisions. (Mishkin, 2001)

The above conclusion provides an important mechanism for how monetary policy can stimulate the economy: an expansion of money supply (M$\uparrow$) can raise the expected price level ($P^e \uparrow$) and therefore the expected inflation rises ($\pi^e \uparrow$), which decreases the real rate of interest ($r \downarrow = i - \pi^e$), and stimulates investment and hence raises the output.

$$M \uparrow \rightarrow P^e \uparrow \rightarrow \pi^e \uparrow \rightarrow r \downarrow \rightarrow I \uparrow \rightarrow Y \uparrow \quad \text{(Mishkin, 2001)}$$

The IS-LM analysis framework (Sir John Hicks, 1937) for the traditional Keynesian view is the most important and clearest tool for this approach. New Keynesian Models, which uncover more implications for this channel, have been developed, for example, in Rotemberg and Woodford (1997), Clarida, Gali and Gertler (1999) and so on.

2.2.3 The Credit View

This channel was developed in the late 1980s, the main contribution of this view is that it incorporates bank loans into the IS/LM model. There exist many arguments over this approach of monetary policy transmission mechanism, some economists claimed that this channel belongs to the interest rate channel because the 'Credit View' impacts on the economy indirectly through the interest rate; some economists argue that the 'Credit View' is inconsistent and does not matter[13].

Generally, the credit channel composes two types of monetary transmission channels (the Bank lending channel and the Balance sheet channel) and arises as a result of information problems in credit markets: Asymmetric information problem which introduces adverse selection and moral hazard in credit markets.

The Bank Lending Channel

This channel emphasizes the role of banks in monetary policy transmission not only from their assets but also from their liabilities (Bernanke and Blinder (1988)). Ford et al (2003) summarized the *bank lending channel* as: in a monetary contraction, banks deposits fall because

[13] For a comprehensive discussion on this issue, see, for example, chapter 7 in Carl E. Walsh (2003)

of the decrease of banks reserves (assuming that the required ratio of reserve keeps constant or upward); if this decline cannot be offset by a decline of Securities hold by the banks, the consequence is the reduction of bank loans, which cause a decrease in investment and thereby in total output.

Based on the asymmetric information problem, banks as the intermediaries play a special role in the financial system because they are experts at solving the above problem in credit markets. Certain borrowers only borrow from the bank and some smaller firms are more dependent on bank loans than larger firms, therefore monetary policy can affect the behavior of these borrowers and smaller firms by controlling the bank deposits and loans through the credit channel. Schematically, the bank lending channel of monetary policy can operate as follows:

$$M \downarrow \Rightarrow BankDeposits \downarrow \Rightarrow Bankloans \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

Ford et al (2003) did find the evidence of the bank lending channel in the transmission of Japan's Monetary Policy (1965-1999) by employing a VAR approach. More and further discussion and extension of the empirical work in this area can refer to Gertler (1988), Bernanke and Gertler (1995), Bernanke, Gertler, and Glichrist (1996).

The Balance Sheet Channel

The Balance Sheet Channel stresses the impact of changes in monetary policy on the borrower's balance sheet and income statement variables such as net worth, cash flow and liquid assets. This channel mainly arises because of the adverse selection and moral hazard of the lower net worth of business firms. Borrowers with lower net worth are less creditworthy since the lender must bear higher costs in the event of the project's failure, in contrast, the higher a borrower's net worth, the greater his collateral, and hence the lower the monitoring cost borne by the lenders.

Monetary policy can affect firm's balance sheets in several ways, according to Mishkin (2001), a monetary expansion ($M \uparrow$) causes a rise in equity prices ($P_e \uparrow$), this raises the net worth of firms and hence leads to higher investment spending ($I \uparrow$) and output ($Y \uparrow$) because of the decline in adverse selection and moral hazard problems. Schematically this is:

$$M \uparrow \Rightarrow P_e \uparrow \Rightarrow \text{adverse selection} \downarrow, \text{ moral hazard } \downarrow \Rightarrow lending \uparrow \Rightarrow I \uparrow \Rightarrow Y \uparrow$$

Mishkin (2001) points out that there are two sub-channels for the balance channel: the Cash Flow Channel and the Unanticipated Price Level Channel represented schematically as below.

The Cash Flow Channel:

$$M \downarrow \Rightarrow i \uparrow \Rightarrow cashflow \downarrow \Rightarrow \text{ adverse selection} \uparrow \text{, moral hazard } \uparrow$$
$$\Rightarrow lending \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

The Unanticipated Price Level Channel:

$$M \downarrow \Rightarrow unanticiptedP \downarrow \Rightarrow \text{ adverse selection} \uparrow \text{, moral hazard } \uparrow$$
$$\Rightarrow lending \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$$

According to Gertlerand Gilchrist (1996) the Credit channels of monetary policy transmission have three implications:

· Assuming no collateral requirement, the external finance is more expensive for borrowers than internal finance.

· Because of the existence of agency costs, the cost differential between internal and external is inversely correlated with the borrower's net worth. A fall in net worth increases the cost of external finance.

· The decline of net worth because of the adverse shock should reduce borrowers' access to finance, thereby reducing their investment and production levels.[14]

2.2.4 The Assets Price Channel

There are assumed two assets price channel: Tobin's q theory and the Wealth Effects, which can be expressed schematically as following

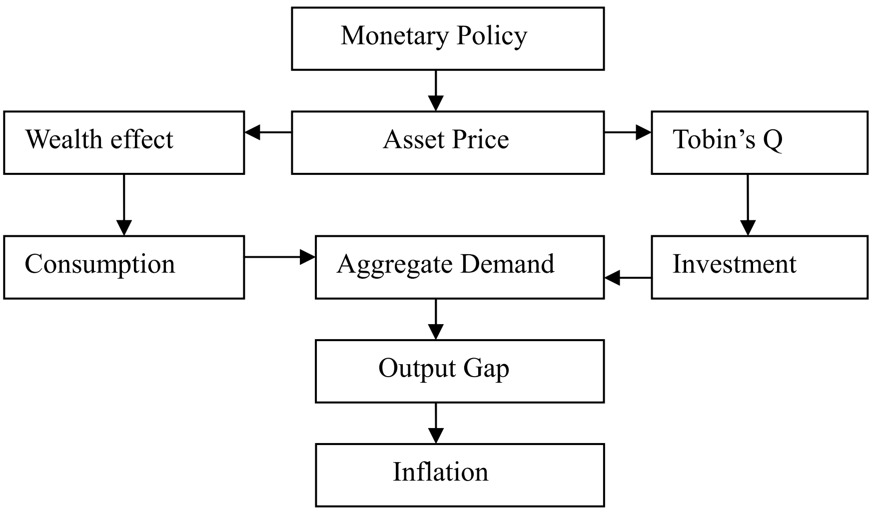


Figure 2.4 the Asset Price Channel (Wibowo, 2005)

[14] More detailed discussions on credit channel see, for example, Chapter 7 in Carl E. Walsh (2003), Gertler and Glichrist (1993) and Bernanke and Gertler (1995).

Tobin's q

James Tobin (1969) developed the q relationship which is still regarded as an important explanatory approach to the monetary transmission process. Tobin's q is defined as:

q = (Market value of an enterprise)/ (Replacement value of capital)

This relationship is actually given by the natural[15] (i_N) and market rates (i) of interest. The market value (V_M) of an enterprise can be calculated as the capitalized earnings value:

$$V_M = \sum_{t=1}^{n} (r_t - e_t) \frac{1}{(1+i)^t}. \tag{2.5}$$

Where $r_t - e_t$ is the expected surplus of receipts (r_t) over expenditure (e_t)

i is the market interest rate

Assuming that replacement cost can be measured by the initial expenditure (E_0), invested on the project:

$$0 = -E_0 + \sum_{t=1}^{n} (r_t - e_t) \frac{1}{(1+i_N)^t}. \tag{2.6}$$

Where i_N represents the internal rate of return.

If we regard the internal rate of return as the natural rate of interest, the q relationship can be rewritten as:

$$q = \frac{V_M}{E_0} = \frac{\sum_{t=1}^{n} (r_t - e_t)[1/(1+i)^t]}{\sum_{t=1}^{n} (r_t - e_t)[1/(1+i_N)^t]}. \tag{2.7}$$

When $n \to \infty$, $q = \frac{i_N}{i}$ (2.8)

Because the market value of an enterprise can be calculated by the share prices, monetary policy can affect the investment of firms by affecting stock markets. When monetary policy is expansionary, the public finds that it has more money and will spend more on stocks, consequently raising the share prices. Higher stock prices will lead to a higher q and thus to higher investment expenditure I (Mishkin, 2001):

$$M \uparrow \Rightarrow P_e \uparrow \Rightarrow q \uparrow \Rightarrow I \uparrow \Rightarrow Y \uparrow$$

Wealth Effects

Franco Modigliani (1971) first developed this approach to the monetary transmission

[15] Knut Wicksel (1898) defines the natural rate of interest, which governs the allocation of resources between current consumption and investment for the future by keeping saving and investment in balance.

mechanism using his famous life cycle hypothesis of consumption. Because consumers smooth out their consumption over time in terms of their lifetime resources, when stock prices rise, the value of their financial wealth increases, this will raise their consumption. The expansionary monetary policy can lead to a rise in stock prices and through this channel to stimulate final output. The process can be expresses schematically as following

$$M \uparrow \Rightarrow P_e \uparrow \Rightarrow wealth \uparrow \Rightarrow consumption \uparrow \Rightarrow Y \uparrow$$

2.2.5 The Expectation Channel

A change in monetary policy (especially a change in official interest rate) can influence the expectation of economic agents about the future course of real activity in the economy by changes in the expected inflation, expected future income, unemployment and profits of agents. Another important aspect of expectation channel is that the central bank can influence the expectations of participants in financial markets regarding the future path of monetary policy and thereby impact on market interest rates.

It is the real interest rate that matters for agents decisions of their investment, consumption and saving rather than the nominal interest rate. According to the Fisher equation, the real interest rate equal the nominal interest rate minus the expected inflation, thus, this channel first depends on expectations of inflation, a key ingredient of which is price rigidities due to transaction costs. Three kinds of expectation mechanism exist for inflation: extrapolative, adaptive and rational expectation formulation. In extrapolative expectations, economic agents assume that the coming period of inflation is equal to the inflation for the previous period (static expectations), which can be expressed as:

$$\pi_t^e = \pi_{t-1}. \tag{2.9}$$

Adaptive expectations also depend on past inflation expectations but economic agents here take into consideration the errors in past expectations and make adjustments based on these past expectations, this can be expressed as:

$$\pi_t^e = \beta\pi_{t-1} + (1-\beta)\pi_{t-1}^e \quad \text{where} \quad 0 < \beta < 1 \tag{2.10}$$

Muth (1961) and Lucas (1976) developed the hypothesis of rational expectations, which assumes that economic agents form their expectations by using all the information available at the time of the forecasting (I_{t-1}). The model is:

$$\pi_t^e = E[\pi_t / I_{t-1}]. \tag{2.11}$$

Based on the expectations assumption, an improved Philips curve (Bofinger, 2002) can be expressed as

$$\pi_t = f(U_{T-1}) - \lambda + \pi_t^e \quad (2.12)$$

Here λ denotes a constant growth in productivity over time, $f(U_{T-1})$ represents the function of unemployment, U_{t-1} is the rate of unemployment at time $t-1$.

More modified Philips curves have been developed to explain the role of expected inflation in the formation of monetary policy such as Taylor's model, Calvo's model, Fuchrer and Moore's Model and the New Keynesian Model.[16]

These modified Philips curves with expectations imply that monetary policy can take effect by exploiting the channel of expectations; an activist central bank can pursue a policy of 'surprise inflation' which aims at raising the short-run employment rate. For a conservative central bank, this channel and Philips relations can be used to control inflation at a low level. Most macroeconomists today believe that a credible and transparent monetary policy strategy is critical for the central bank to guide expectations about future monetary policy, which at the same time provide an anchor for expectations about inflation and general economic activity.

When financial market expectations play a key role in the monetary policy transmission, a central bank can affect the structure of market interest rates by influencing financial market expectations about the future path of policy. This provides a new perspective on how monetary policy works, especially for interest rate targets, it also highlights the important role of central bank communications in the transmission process.[17]

2.2.6 The Exchange Rate Channel

Under a floating exchange rate regime, this transmission channel can be simply expressed as

$$M\uparrow \Rightarrow r\downarrow \Rightarrow e\downarrow \Rightarrow NX\uparrow \Rightarrow Y\uparrow$$

The decrease of interest rate will cause depreciation of home currencies, increasing net exports and thereby increasing GDP.

Under a fixed exchange rate system the monetary authority can achieve the same objective by undervaluing its currency.

The Covered Interest Rate Parity (CIP), Uncovered Interest Rate parity (UIP) and Marshall-Lerner conditions provide some theoretical explanations of the exchange rate pass through. Many models have been developed in this field such as Mundell-Fleming model, Dornbush model and the New Open Economy Macroeconomic models.

2.3 Main Research Methods on Monetary Transmission Mechanism

Because of the importance and complication of formulating and implementing of monetary

[16] See chapter 5 in Carl E. Walsh (2003).

[17] More comprehensive discussion on this aspect of expectation channel see, for example, Gordon H. Sellon, Jr. (2004).

policy and the effects of monetary policies on macro economy, the monetary policy transmission mechanism is one of the central concerns of macroeconomists from central banks; many theoretical models have been established to explain the transmission mechanism of monetary policy as mentioned above, for example IS-LM framework, Mundell-Fleming model, Dornbush overshooting model, Dynamic Stochastic General Equilibrium models (see section 2.4.2, for example, Bernanke, Mark and Gilchirst, 1998; Christiano, Eichenbaum and Evans, 2001,2005; etc), New open-economy macroeconomic models and so on. Vast empirical works have also been conducted by employing diverse econometric techniques to trace and test the existence, the effects and the efficiencies of the transmission channels in different economies. These have included the employments of Large-scale structural models, Granger Causality[18] Test, Narrative methods[19] (Romer and Romer, 1989, 2004), Factor model (Stock and Watson, 2002; Bernanke and Boivin, 2003), VAR (vector autoregression) approach with cointegration (Bernanke and Blinder, 1992; Bernanke and Gertler, 1995; Chrisriano, Eichenbaum and Evans, 1998; Ford et al, 2003; Boivin and Giannoni, 2002 and so on), Bayesian methods (Bayesian VAR such as Leeper and Zha (2001) etc, Bayesian DSGE, such as Smets and Wouters , 2002), and State Space[20] techniques amongst them.

In this section we focus on VAR approaches and DSGE Models because most of the recent literature on the MTM has used VAR/VECM approach or DSGE models or both, as Faboi Canova (2001, P2)[21] pointed out:

> *"Two methodologies which have acquired a permanent status in the toolkit of macroeconomists in the last 15 years are structural VARs and Dynamic Stochastic General Equilibrium (DSGE) models."*

2.3.1 VAR/VECM Approach for Monetary Transmission Mechanism

Since the collapse of the traditional Cowles Commission models by the Lucas' (1976) critique, vector autoregressive (VAR) approaches are widely used in the empirical analysis of monetary policy transmission mechanism because of Sims' (1980) excellent work. Before VAR models have emerged, most literature employed narrative methods, single equation (Rules of thumb) or

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[18] Cochrane (1997, see *Times Series for Macroeconomics and Finance*) define the Granger Causality as

x_t *Granger causes* y_t *if* x_t *helps to forecast* y_t *, given past* y_t .

For a VAR: $y_t = a(L)y_{t-1} + b(L)x_{t-1} + \varepsilon_t$, If $b(L)$=0 then x_t does not Granger causes y_t .
$x_t = c(L)y_{t-1} + d(L)x_{t-1} + \theta_t$

[19] Narrative methods can be used to overcome the so-called "identification" problem in VARs approach.

[20] See, for example, Ireland (1998, 1999, 2000, 2001, and 2004).

[21] Fabio Canova (2001), "Validating monetary DSGE models Through VARs", ECB workshop, June 5-6, 2001.

large-scale structural econometric models to uncover the effects of monetary policy on real economy. Rules of thumb are quantitatively unreliable; Large-scale structural models are difficult to produce and evaluate independently. Given the short period of macroeconomic data after WWII, traditional OLS estimation of a large model becomes imprecise because of a large number of parameters. Thus, recently macroeconomists have often used small-size dynamic multivariate models-VAR/VEC models- to measure monetary policy; the quantitative analysis from these models can be informative[22].

Generally, a finite-order VAR is a multivariate model in which each endogenous variable is regressed on its own lags and lags of all other variables in the system, this can be employed to investigate the dynamic response of the endogenous variables to the shocks.

A representative reduced form VAR for MTM can be expressed as (Hamilton, 1994)[23]

$$y_t = C(L)y_t + D(L)x_t + \varepsilon_t \qquad (2.13)$$

Where y_t is a (m x 1) vector of endogenous variables, x_t is an n vector of exogenous variables, C and D are matrices of coefficients to be estimated, L is the lag operator, $C(L), D(L)$ denotes the matrix polynomials in L. The error term ε_t is a vector of innovations which are *I.I.D.*.

If omitting the vector of exogenous variables, we have

$$y_t = C(L)y_t + \varepsilon_t \qquad E[\varepsilon_t \varepsilon_t'] = \Omega \qquad (2.14)$$

Where Ω is an (n x n) symmetric positive definite variance-covariance matrix.

A structural VAR like 2.36 assumes that the one step ahead prediction errors, ε_t, are related to 'fundamental' or structural macroeconomic shocks, ν_t, via a matrix, B ($m \times m$); such that

$$\varepsilon_t = B\nu_t \qquad (2.15)$$

Therefore, the identification of the structural shocks is the traditional problem in the context of VAR models for measuring monetary policies, this is generally solved by imposing some restrictions on B and C. According to Bagliano and Favero (1997), the VAR models can be identified by the following methods: (1) Orthogonal[24] assumptions on structural disturbance; (2)

[22] See Zha (1998).

[23] In chapter 4, a formal VAR/VEC model is specified for investigating the monetary transmission mechanism in China.

[24] In simulation process using a structural VAR, the general assumption is that the shocks should be orthogonal (uncorrelated), Cochrane (1997) points out that if the two shocks are correlated, it doesn't make sense to ask "what if one error term shock has a unit impulse" given no change in another shock, because usually the two shocks come at the same time. Thus constructing an orthogonal shock is very important for impulse response simulation, one way of which is via the ***Cheoleski decomposition***. If we can find a matrices R such that

Recursive assumptions like in Christiano, Eichenbaum and Evans (1998) or so-called "initial sector" assumption in Sims and Zha (2005) : assuming that macroeconomic variables do not simultaneously react to monetary variables, but opposite feedback can be simultaneous; (3) Imposing restrictions on the monetary block of the model reflecting the operational procedure by the monetary policy maker, or (4) Other restrictions such as sign restrictions for impulse response function in Uhlig (1999, 2005).

Given a stationary[25] VAR system, the so-called *impulse response function* (IRF)[26] and the *variance decomposition*[27] are the two main useful techniques offered to explore the effects of monetary policy shocks on real economy.

$$R^{-1}R^{-1T} = \Sigma \quad \text{and} \quad E(R\varepsilon_t\varepsilon_t^T R^T) = R\,\Sigma\, R^T = I$$

Then we can solve this problem. Sims (1980) suggests that a lower triangular can be used to achieve this end, and the Choleski decomposition produces such a lower triangular R.

[25] We say a process $\{y_t\}$ is strictly stationary if the joint probability distribution function of $\{y_{t-s},\ldots,y_t,\ldots y_{t+s}\}$ is independent of t for all s, also, if $E(y_t), E(y_t^2)$ are finite and $E(y_t y_{t-i})$ depends only on i and not on t, the process $\{y_t\}$ is weakly stationary or covariance stationary.

The condition for stationary AR process is that all roots of the lag polynomial lie outside the unit circle, all $|\varsigma_i|$ >1 or the all $|\lambda_i|$ <1, which implies that on a general AR:

$$C(L)y_t = \varepsilon_t = (1-\lambda_1 L)(1-\lambda_2 L)\ldots y_t$$

The lag polynomial must be invertible, namely $|\lambda_i|$ <1, if the ς_i are the roots of the lag polynomial, $C(L) = \text{constant}(-\varsigma_1)(1-\frac{1}{\varsigma_1}L)(-\varsigma_2)(1-\frac{1}{\varsigma_2}L)\ldots$, $\varsigma_i = \frac{1}{\lambda_i}$, then the condition for a stationary AR can be expressed as above.

If and only if $|\lambda_i| < 1$, which means the conditions for stability are satisfied, y_t can be expressed as functions of the current and lagged values ε_t, which are called as impulse response functions (Hamilton, 1994).

[26] An impulse response function traces the path and the effects of a one-time shock or one of innovations on the endogenous variables, which can explore the "cause" and "effects" of the fluctuations of some important economic variables. For a reduced form VAR as $y_t = C(L)y_t + v_t$, the shock(or innovation) and the impulse-response can be displays as

$$v_t:\; 0 \quad 0 \quad B^{-1} \quad 0 \quad 0 \quad 0$$

$$y_t:\; 0 \quad 0 \quad B^{-1} \quad B^{-1}C(L) \quad [B^{-1}C(L)]^2 \quad [B^{-1}C(L)]^3 \quad \ldots$$

See Cochrane (1997).

[27] The variance decomposition technique answers the following question: how much does the error variance of one explanatory variable contribute to the *s* period ahead forecast error variance of explained variable in an orthogonal system? See Cochrane (1997).

When the VAR system is not stationary but all endogenous variables are integrated as $I(1)$ [28], the Cointegration[29] technique can be employed to test if there are long run linear relationships among the endogenous variables, in this case, the *vector error correction model* (VECM) can be used to measure the effects of monetary policy shocks on the macroeconomic variables in the system.

A vast amount of literature has used VAR/VECM approaches to uncover the effects of monetary policy on real economy and the monetary policy transmission mechanism because of their ability to produce consistent and fruitful results to account for the structural innovations to the monetary policy indicator, such as Bernanke and Mark (1995), Bernanke, Mark and Watson (1997), Bernanke and Mihov (1998), Biovin and Gianoni (2002, 2003), Christiano, Eichenbaum and Evans (1996, 1998), Gordon and Leeper (1994), Sims and Zha (1998, 2005), Zha (1998) and so on. This literature has achieved success in estimating the MTMs and the effects of monetary policies.

2.3.2 Dynamic Stochastic General Equilibrium (DSGE) Models

Recent theoretical researches on monetary policy transmission mechanism focus on how the above mentioned transmission channels work within the context of dynamic stochastic general equilibrium (DSGE) models.[30] Today's DSGE models combine the theory of Frischer-Slutsky paradigm (Impulse-propagation-fluctuations), real business cycle (RBC) models, rational expectation, general equilibrium market conditions with classic Keynesian assumptions (nominal rigidities). For detailed discussions on DSGE models refer to Carl E. Walsh (2003), Woodford (2003), Rotemberg and Woodford (1997), Christiano, Eichenbaum and Evans (2001, 2005) and Smets and Wouters (2002).[31]

"DSGE models are not only attractive from a theoretical perspective, but also are emerging as useful tools for forecasting and quantitative policy analysis in macroeconomics. Due to improved

[28] Also often called as random walk, or unit root; with unit root, the time series is non-stationary, to be stationary, difference operations should be applied to $y_t = y_{t-1} + \varepsilon_t$; $\varepsilon_t \in IID$ as $\Delta y_t = \varepsilon_t$.

Several methods can be used to test the unit roots, among which the Phillips-Perron Test and Augmented-Dicker-Fuller test are the most popular.

[29] Hamilton (1994) defined cointegration as follows: if each of time series in an (n x1) vector y_t is individually I(1), say non-stationary with a unit root, while some linear combination of the series $a'y_t$ is stationary, or I(0), for some nonzero (n x 1) vector α , then y_t is said to be cointegrated.

[30] See Peter N. Ireland (2005).

[31] A further detailed overview on DSGE models is made in Chapter 5.

time series fit, these models are gaining credibility in policy making institutions, such as central banks**”.** (Nelgro, Schorheide, Smets, Wouters, 2007).

A DSGE model is a sector-based structure founded on micro-foundation theoretic principles and embraces concepts, variables, markets and relationships which are unlikely to be “nested within” the economy-wide, aggregate models of the VAR/VECM. After a sequence of treatments, including solving the first-order conditions, estimating parameters and linearizing the nonlinear equations, today’s typical DSGE model can be summarized in a benchmark New Keynesian Model (NKM). New Keynesian Models incorporate the microeconomic foundations (rational households and firms) and the nominal rigidities (price and wage stickiness) into contemporary macroeconomic models, in which monetary policy shocks have real effects on the real economy in the short run. Before introducing a basic New Keynesian Model, the nominal rigidities will be discussed.

2.3.2.1 Nominal Rigidities

Generally, there exist two nominal rigidities: price stickiness and wage stickiness assumptions, which mean that wages and prices fail to adjust immediately and completely to changes in the nominal quantity of money. The price stickiness assumption (price was fixed for one period) increase the impact of monetary shocks on the real output but cannot account for persistent real effects of monetary policy. The nominal wage contracts assumption can generate the persistent output responses observed in the data by introducing the models of monopolistic competition (Walsh, 2003). Because the wage stickiness often follows the same models as price stickiness we mainly discuss the price staggering.

Price Staggering assumes that all prices are fixed simultaneously for one period. This stickiness is initially caused by so-called *menu cost* concept. Given the costs of adjusting price, it may not be optimal for the firm to change its price. When this takes place, the price level will adjust slowly. The Calvo model and Taylor model provide the intuition in this field.

Taylor’s Model was developed by Taylor (1979, 1980), it assumes a constant mark up over wage costs. Wages are set for two periods with one half of all contract negotiated each period. The average wage $\overline{w}_t$ at time t can be calculated by

$$\overline{w}_t = 1/2(w_t + w_{t-1}) \qquad (2.16)$$

Given a constant mark up over the wage (no capital in production function), the price level is

$$p_t = \overline{w}_t + \delta \qquad (2.17)$$

δ represents the log mark up, assuming it is equal to zero in convenience. The average expected real wage is assumed to be increasing in the level of economic activity, represented by log output y_t (Taylor, 1979, 1980), then

$$w_t = 1/2(p_t + E_t p_{t+1}) + \gamma y_t \tag{2.18}$$

After a sequence of substitutions and transformations, we have

$$p_t = \frac{1}{2} p_{t-1} + \frac{1}{2} E_t p_{t+1} + \gamma(y_t + y_{t-1}) + \frac{1}{2}(E_{t-1} p_t - p_t) \tag{2.19}$$

And

$$\pi_t = p_t - p_{t-1} = E_t \pi_{t+1} + 2\gamma(y_t + y_{t-1}) + \frac{1}{2}(E_{t-1} p_t - p_t) \tag{2.20}$$

(2.19) implies that the price level is influenced both by expectations of future prices and by the previous price level.

Calvo (1983)'s model assumes that the firms adjust their prices infrequently. Prices once set, are readjusted with probability $1-\omega$ each period (a "Poisson" process). The probability for those firms which cannot adjust their prices is ω. Following Walsh (2003), ignoring the process, the optimal price set at time t by all firms adjusting their prices is a weighted average of current and expected target price p^* as following:

$$\tilde{p}_t = (1-\omega\beta) \sum_{i=0}^{\infty} \omega^i \beta^i E_t p^*_{t+i} \tag{2.21}$$

Then the total price level is

$$p_t = (1-\omega)\tilde{p}_t + \omega p_{t-1} \tag{2.22}$$

The evolution of the optimal price $\tilde{p}_t$ by the firms which can adjust their prices can be expressed as

$$\tilde{p}_t = (1-\omega\beta)(p_t + \gamma y_t) + \omega\beta E_t \tilde{p}_{t+1} \tag{2.23}$$

And the inflation follows (NKM Philips curve):

$$\pi_t = p_t - p_{t-1} = \beta E_t \pi_{t+1} + [\frac{(1-\omega)(1-\omega\beta)}{\omega}]\gamma(y_t + \varepsilon_t) \tag{2.24}$$

Where ε_t is a money supply shock.

2.3.2.2 A Basic New Keynesian Model-DSGE Model

We introduce a basic New Keynesian Model by Gali (2008). Assuming a model economy consists of utility-maximizing same-taste consumers and a continuum of firms in [0, 1] producing differentiated final goods. We ignore the index for goods and firms in the following process.

The consumer solves the following problem

$$\text{Max. } E_0\sum_{t=0}^{\infty}\beta^t U(C_t, N_t) = E_0\sum_{t=0}^{\infty}\beta^t [\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}] \qquad (2.25)$$

Subject to

$$P_tC_t + B_t \leq R_tB_{t-1} + W_tN - T_t \qquad (2.26)$$

Where $0 < \beta < 1, \sigma > 0, \varphi > 1$, β is the discount factor or time preference, σ is the inverse of elasticity of inter-temporal substitution, φ is elasticity of disutility with respect to work; C_t denotes the consumption of the good, N_t represent the work hours provided by consumer; B_t represents the bond holding, R_t is the nominal gross interest rate, W_t is the nominal wage rate, T_t is the lump-sum tax, E_t is the expectation operator.

The first order conditions are

$$\beta E_t[\frac{\lambda_{t+1}}{\lambda_t} R_t] = 1 \qquad (2.27)$$

$$\frac{N_t^{\varphi}}{C_t^{-\sigma}} = \frac{W_t}{P_t} \qquad (2.28)$$

$$\lambda_t = \frac{C_t^{-\sigma}}{P_t} \qquad (2.29)$$

Where λ_t is the Lagrange multiplier.

The technology for the firm is

$$Y_t = A_tH_t \qquad (2.30)$$

Where H_t is the labour demand, A_t is the technology shock, generally assumed to follow AR (1) process:

$$\ln(A_t) = (1-\rho)\ln(A) + \rho\ln(A_{t-1}) + \upsilon_t \qquad (2.31)$$

Where A is the steady value of A_t, $1 > \rho > -1$, υ_t is an innovation of technology normally distributed with *I.I.D.*.

Maximizing-profit firms set price according to Calvo's model. The probability of the firms which can reset their prices is $1-\omega$, and then we can obtain the sequence of equations 2.21-2.24.

The market equilibrium conditions are

$$Y_t = C_t \qquad (2.32) \qquad\qquad N_t = H_t \qquad (2.33)$$

The monetary authority conducts its policy following a simple interest rate rule.

Substituting 2.29 into 2.27 and then log-linearising (2.27), we obtain

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(R_t - E_t \pi_{t+1}) \quad (2.34)$$

Where $\pi_{t+1} = \frac{p_{t+1}}{p_t}$ is inflation rate; for any variable X_t, we have $x_t = \frac{d\log(X_t)}{dt}$.

Substituting (2.32) into (2.34) we obtain the first important equation[32] for the NKM, which is the log-linearized Euler equation (expectation IS curve)

$$y_t = E_t y_{t+1} - \gamma(R_t - E_t \pi_{t+1}) \quad (2.35)$$

Where $\gamma = \frac{1}{\sigma}$ often denotes the inter-temporal elasticity of substitution. This equation describes the optimizing rational household's inter-temporal behaviours. Also we have labour supply equation from 2.28:

$$w_t - p_t = \sigma c_t + \varphi n_t \quad (2.36)$$

Because the firms set their prices following Calvo's model, from (2.21-2.24), the second key equation for NKM, the so-called New Keynesian Philips Curve (NKPC) is

$$\pi_t = \beta E_t \pi_{t+1} + \theta y_t \quad (2.37)$$

This derives from the first-order condition of a profit-maximization firm under nominal sticky environment.

The monetary authority conducts its policy following a simple interest rate rule; the third key equation for NKM represents an interest rate rule for monetary policy, mainly simplified as Taylor's rule

$$R_t = \bar{r} + \pi_t + \delta_1(\pi_t - \bar{\pi}) + \delta_2(y_t - \bar{y}) + \varepsilon_t \quad (2.38)$$

Where $\bar{x}$ represents the steady state value or target equilibrium value of the variable, ε_t is an interest rate shock. This is a monetary policy reaction function. When the inflation rate π_t deviates from the target rate $\bar{\pi}$, or the real output level y_t has a output gap to potential output level $\bar{y}$, the monetary authority will stabilize the economy by increasing or decreasing the interest rate.

Also, if $\pi_t = \bar{\pi}, y_t = \bar{y}$ so $R_t = \bar{r} + \pi_t$ and $\bar{r} = R_t - \pi_t$

Hence $\bar{r}$ represents the long run real interest rate, it is also the marginal product of capital.

Therefore, generally, a DSGE model at least includes a technology shock and a policy shock.

With these three key equations (2.35, 2.37 and 2.38) and estimated values of parameters and market clearing conditions we can simulate the process of monetary policy transmission. Moreover, NKM provides a reasonable and powerful theoretical tool for analysis of monetary

[32] According to Peter N. Ireland (2005) and Clarida, Gali and Gertler (1999), a basic New Keynesian model (DSGE model) consists of three main equations involving output, inflation and short-term interest rate.

policy and the monetary aspects of business cycle by incorporating micro foundations like in Kydland and Prescott (1982) and rational expectation from Lucas and Sargent into the monetary transmission mechanism models.

The VAR model, according to Tao Zha (1998), is not designed to study every detail of the economy. It is designed to capture only essential elements. The VAR model is often small-size with six to eight variables; however it can be closely connected to modern economic theory. Moreover, it can also be readily understood and reproduced to measure the contemporaneous and dynamic interactions among the macroeconomic variables. As mentioned in the above section 2.4.1, much literature has achieved success in estimating the effects of monetary policies by using the VAR approach. Nevertheless, as Sims and Zha (2005) pointed out, substantial differences remain in methods and results. Some macroeconomists find large effects of monetary policy shocks on real output, accounting for a substantial fraction of output variance historically; others estimate weaker effects of policy shocks, accounting for little of historical business cycle fluctuations. Also, the empirical results from VAR approach are ad hoc, they cannot provide intrinsic causes.

By incorporating many concepts, ideas and theories of microeconomics into macroeconomic dynamics the DSGE models make macroeconomic modeling more consistent and effective because its rigorous microfoundations link the development in macroeconomics to the advances in microeconomics. This is its great success and attractiveness; it provides a reasonable and powerful theoretical tool for analysis of monetary policy and the business cycle. Moreover, the DSGE models are not limited by the number of variables; therefore one elegant DSGE model can provide economic intution in several aspects of theoretic and empirical study.

Recently, most of the literature on monetary policy and MTM connects the DSGE models with VAR/VECM specifications such as Rotemberg and Woodford (1997), Christiano, Eichenbaum and Evans (2001), Smets and Wouters (2003), Negro and Schorfheide (2004), Sims and Zha (2005).

Sims and Zha (2005) found that on one hand omitting certain key variables from the list of observable variables in the structural VAR, particularly the information variables in the DSGE models-could undermine the identification of VAR system. On the other hand, many results from VAR literature constitute an implicit criticism of the lack of careful attention to time series fit in most of the DSGE literature.

In summary, the identification problem of VAR models can be improved by the context of explicit DSGE models; DSGE models can fit the data more precisely, referring to the results of VAR literature. Moreover, VAR modellers and DSGE modellers should all pay more attention to detailed links of theory with the time series facts[33].

[33] See Sims and Zha (2005).

Chapter 3 Empirical Evidence of China's Monetary Policy Transmission Mechanism and the Stylized Facts of China's Economy (1996-2006)

Some theoretical and empirical research work has been conducted on the monetary transmission mechanism in China; through this economists recognized that although monetary policy transmission channels did exist in China, the efficiency of the transmission is lower compared with those in developed countries. In what follows, we discuss the theories of monetary policy transmission mechanism identified in China and the relevant empirical research evidence. Also, the stylized facts of China's economy under our study period, particularly those related to the business cycle are demonstrated and reviewed in this chapter.

3.1 Monetary Policy Transmission Mechanism in China: Empirical Evidence

Credit channel and the monetary aggregate channel (Monetarist channel) in China

Over a long time, at least from the foundation of PBC in 1948 until the early 1980s Chinese economy was subject to control planning. The most important channel of monetary policy transmission in China was the credit channel in banking institutions, in which the bank lending channel is the main constituent, the balance sheet channel effect is weak but gradually takes effect. The reason is that no perfect money market could be operated until the 1990s and the bond market and stock market were small and inefficient, therefore the effects of monetary policy during that period took place mainly through banking system by credit channel or loans. Moreover, credit is still the underlying main channel at present because of the imperfect money and capital markets in China. The credit transmission channel in China can be expressed as follows:

$$\textit{Central Bank (PBC)} \Rightarrow \textit{Financial Institutions} \Rightarrow \textit{Firms}$$

$$\textit{Or Reserve (PBC)} \uparrow\downarrow \Rightarrow \textit{Loans (Banking institutions)} \downarrow\uparrow \Rightarrow \textit{Investment} \downarrow\uparrow \Rightarrow \textit{Output} \downarrow\uparrow$$

Historically, most firms in China raised funds by borrowing money from banks rather than issuing bonds or stocks.

Monetary aggregate is another channel of monetary policy transmission and the main targeting instrument of monetary policy in China. By increasing or decreasing money supply the PBC can affect the consumption and investment of households and firms and thereby adjust the price level and output.

Wang Zhiqiang and Wang Zhengshan (2000) conclude that the credit channel dominated the transmission of China's monetary policy during the 1980s and 1990s by employing Granger causality test and cointegration analysis.

Sheng Zhaohui (2006) investigated the transmission channels of China's monetary policy with a quarterly data set from 1994-2004. He selected GDP, CPI, the ratio of total foreign trade volume to GDP, loans, interest rate, monetary aggregate, the Shanghai stock market index and exchange rate to test the effects of monetary policy on the economic variables. The results of Granger causality tests demonstrate that loans, interest rates and monetary aggregate can cause fluctuation of output, stock market index, but exchange rate cannot Granger cause output. The linear regression analysis shows that output increases 0.32%, 0.31%, and decreases 0.26% when the loans rise 1%, monetary aggregate rise by 1% and interest rates reduce 1% respectively. Therefore, the credit channel represented by loans and monetary channel are the main channels of monetary policy transmission, interest rate channel also has important effects but in this case exchange rate and capital price channel are weak due to the fixed exchange rate regime and small infant stock market. On the other hand, Granger causality test demonstrates that the monetary aggregate can influence the price level, but the interest rate cannot. The price level is the Granger cause of interest rate.

Zhou Yingzhang and Jiang Zhensheng (2002) analyzed the credit channel and monetary aggregate channel of China's monetary transmission. They employed three variables: GDP as explained variable, M2, M1 and Loans balance CR as explanatory variables. Granger causality tests show that credit scale is more important than the monetary aggregate (M2) in the course of monetary transmission. Cointegration tests uncover that there exists a long-term relationship between credit loans, monetary aggregate (M2) and economic output (GDP), which implies that monetary policy does influence economic output by the mutual transmission of credit channel and monetary channel. Furthermore, they find that the credit variable can explain 10-20% of variations of GDP, while M2 can explain only 0.019-8.9% of GDP's variation by the variance decomposition technique. The results demonstrate again that the Credit channel dominates the monetary policy transmission in China.

The Interest Rate Channel in China

With the continuing development of a market economy and reform of the economic structure the private sector is emerging as an important component of China's economy. Monetary policy is having a more and more important impact on output though the interest rate transmission channel. Generally, the interest rate channel in China can be expressed as follows:

$$R \uparrow\downarrow \Rightarrow Consumption, C \downarrow\uparrow \Rightarrow Output, Y \downarrow\uparrow$$
$$R \uparrow\downarrow \Rightarrow Investment, I \downarrow\uparrow \Rightarrow Output, Y \downarrow\uparrow$$

David Dickinson and Jia Liu (2005) examined the interaction between the real economy and monetary policy in China by employing the VAR approach. They chose two policy variables: the interest rate and the quantity of credit and two dependent variables: total output and output for different sectors. The results show that the interest rate shocks have an important impact on the output, this confirmed the existence of interest rate channel of monetary policy transmission in China.

Laurens, Bernard J. and Rodolfo Maino (2007) estimated a five-variable VAR model to characterize monetary policy and study the impact of the money on inflation and output for the period 1994–2005, quarterly. The results demonstrate the long-lived persistent effect of a money shock on inflation: confirming the significant influence of money in determining inflation.

Sheng Zhaohui (2006) tested the interest rate channel in China and demonstrated that the elasticity of the interest rate on output is -0.26 by linear regression.

Gao Tiemei and Wang Jingming (2001) investigated the effects of the interest rate channel in China by using a state space technique (Kalman Filter). They found that the elasticity of the interest rate on consumption demand was -0.18 from 1992 to 1994, which means that the consumption level reduces 0.18% if the interest rate rises 1%. From 1996 to 1999, the PBC reduced the interest rate 7 times; the elasticity of the interest rate on consumption demand was about -0.12. After 1999, the elasticity of interest rate was about -0.10, under this condition, PBC decreased interest rate from 3.78% to 2.25% and the consumption level increased about 4.24%; therefore the first interest rate channel did take effect. For the fluctuation of the fixed capital investment caused by volatility of the interest rate, the elasticity of interest rate on the investment was about -0.3-0.2 during the period 1991-1994, this implies that if interest rates increase 1%, the investment will decrease 0.2%. During the 1996-1998 period the elasticity reduced to about -0.1. In 1999 it was about -0.0686. Assuming that the interest rate decreased from 5.85% to 4.85% (17.1% reduction), the investment would increase by 1.173%, and this suggests that the investment effect of interest rate is weaker than that of other monetary instruments in China.

The Asset Price Channel in China

Because the scale of the stock market and bond market are tiny in China compared with that in Europe and North America the Tobin's q effect and the welfare effects of monetary policy transmission in China are small though they began to emerge with the development of capital markets.

Employing cointegration analysis and Granger causality test, Wei Yongfen and Wang Zhiqiang (2002) analyzed the asset price channel of monetary policies in China: determing the welfare effects and q effects of stock prices by investigating the relationships between household's consumption, investment and stock prices. Cointegration analysis uncovers a cointegrating relationship (long run) between stock prices and household's consumption but no such relationship between stock prices and investment. This implies the existence of welfare effect or substitution effect of asset price channel for China's monetary policy transmission and the funds rose though equity markets in China are very limited because of the small capital market. Granger Causality tests furthermore confirm that stock prices can cause an increase in consumption, not the reverse.

The Exchange Rate Channel in China

Prior to 2005, the RMB, the currency of China, was pegged to the US dollar; the fluctuation of exchange rate was managed by the PBC, therefore the effect of exchange rate channel is distorted in China. The results of empirical research in this field are unclear.

Chu Erming (2006) employed Cointegration analysis, Granger causality tests, and VAR with variance decompositions. Two variables were chosen in his paper: the exchange rate (dependent variable) and monetary aggregate (independent variable). Cointegration tests show that there is at least one cointegration equation between the exchange rate and the monetary aggregate but the elasticity of monetary aggregate on exchange rate is very low, which demonstrates the characteristics of a managed fixed exchange rate regime in China. The impulse response function also gave a similar result: the effect of monetary aggregate shock on the exchange rate is very weak. In line with the impulse responses, the monetary aggregate makes very little contribution to the fluctuations of the exchange rate.

Furthermore, Nie Xuefeng and Liu Chuanzhe (2004) pointed out that monetary policy cannot affect international trade and output in China through the exchange rate channel by using Granger causality tests and an auto-regressive-distributed-lag model.

The Expectation Channel in China

Research on the expectation channel in China is rare. Xue Wanxiang (1995) analyzes the effect of monetary policy by bounded rational expectation. Zeng Kanglin (2001) points out that the expectation of the public can offset the effects of expansionary monetary policy on consumption. Xiao Shonghua (2000) discusses how the expectations of different sectors affect the impact of monetary policy in China.

The effects of expectation channel links to the transparency of the policy implementation by PBC, central banks are advised by many economists to increase transparency, accountability and commitments in order to affect and direct the expectations of the public on the monetary policy to reduce the welfare loss.

The empirical research on the MTM in China is summarized in Table 3.1:

Table 3.1 Statistics (Part) for Empirical Research on MTM in China

Authors (Date)	Time Period	Type of Data	Methodology	Findings
Wang and Wang (2000)	1980-1990	Quarterly data	Granger Causality Test Cointegration Test	Credit Channel
Sheng Zhaohui (2006)	1994-2004	Quarterly data	Granger Causality Test Linear Equation	Bank loan channel and monetary channels dominate, weak exchange rate channel and asset price channel
Zhou and Jiang (2002)	1993q1-2001q3	Quarterly data	VAR, Cointegration Test	Credit channel and monetary channel, former dominates
David Dickinson and Jia Liu (2005)	1984-1997	Monthly data	VAR	Interest rate channel
Laurens and Maino (2007)	1994-2005	Quarterly data	VAR	Interest rate channel, monetary channel
Gao and Wang (2001)	1991-1999	Quarterly data	State Space (Kalman-Filter)	Interest rate channel
Wei and Wang (2002)	1992Jan-2001Sep.	Monthly data	Granger causality Test, ECM	No (or very weak) asset price channel
Chu (2006)	2000-2004	Monthly data	VAR, Cointegration test	Real exchange rate channel
Nie and Liu (2004)	1997-2003	Monthly data	ADL, Cointegration test	No exchange rate channel, Credit channel exist
Hasan (1999)	1952-1993	Yearly data	Cointegration Test, ECM	Monetary channel
Qin (2005)	1992-2004	Quarterly data	Polak model	Interest rate and monetary channels.

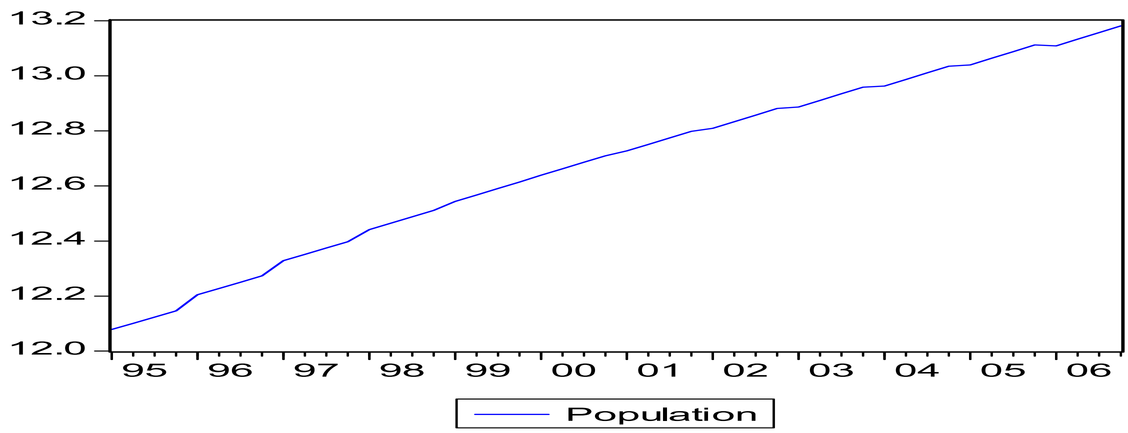
3.2 The Stylized Facts of China's Economy (1995-2006)

For the research periods under our examination the stylized facts of China's economy from 1995 to 2006 are presented in this section. Because we used monthly data from 1996 to 2006 in Chapter 4 to test the transmission mechanism and the roles of monetary variables in China's business cycle with VAR/VECM approach and quarterly data from 1995q1 to 2006 q2 to simulate the effects of monetary policy transmission on the real economy over a business cycle with DSGE models in Chapter 5, we report the stylized facts of China's economy in terms of both monthly and quarterly data here.

Long-term Trend

Population in China evolved as in Figure 3.1 from 1995 to 2006 with a low growth rate compared with the average rate of growth around the world.

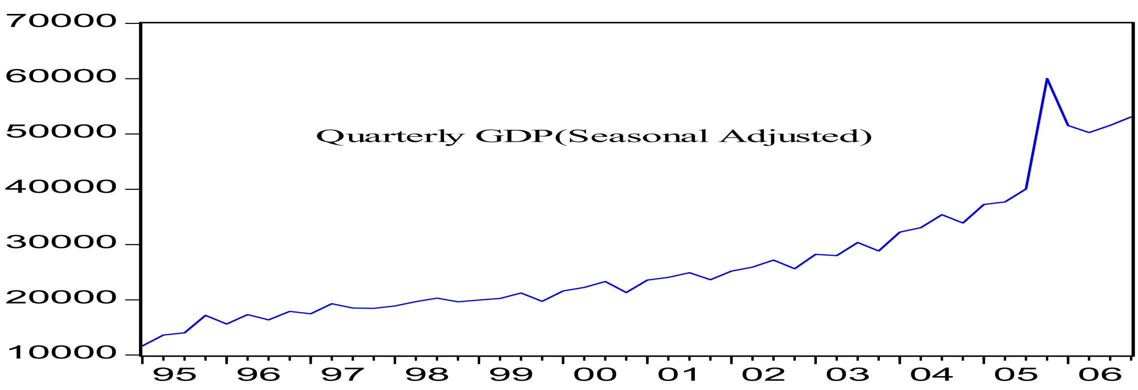
Figure 3.1 Population Statistics for China from 1995-2006(Units: 100 Million)



Source: National Bureau of Statistics of China

Output (Quarterly GDP) illustrated by Figure 3.2 continuously grew from 1995 to 2006 according to its long-term trend. In the first stage of this period, 1995-2002, the economy grew slowly, after 2002, economic growth accelerated.

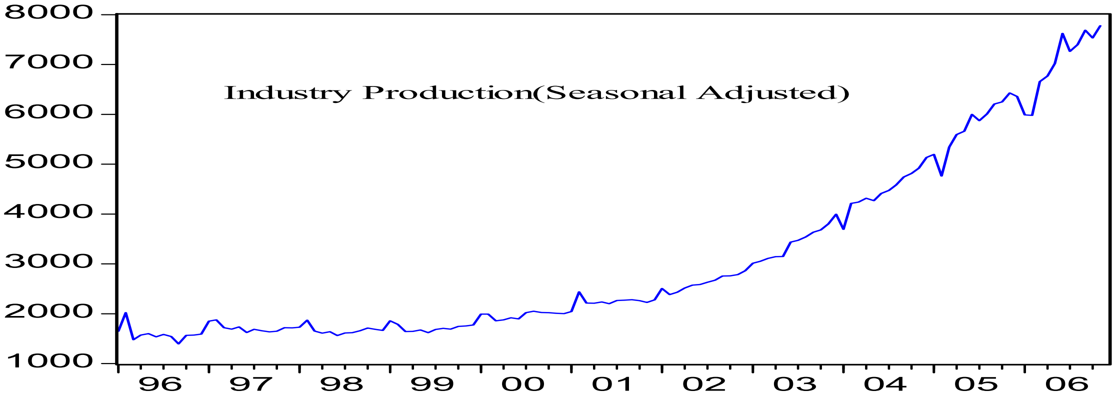
Figure 3.2 Quarterly GDP for China from 1995q1-2006q4 (Unit: 100 Million Yuan)



Source: National Bureau of Statistics of China

Industry production (monthly) with seasonal adjustment increased slowly from 1995 to 2002, after 2002 the speed of growth in industrial production stepped up as shown in Figure 3.3.

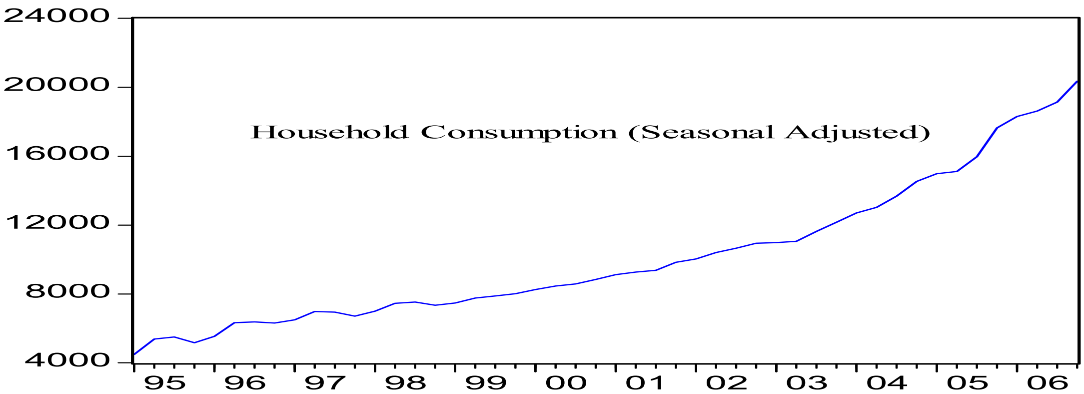
Figure 3.3 Industrial Productions from 1995 to 2006(Monthly. Unit: 100 Million Yuan)



Source: China Economic Network

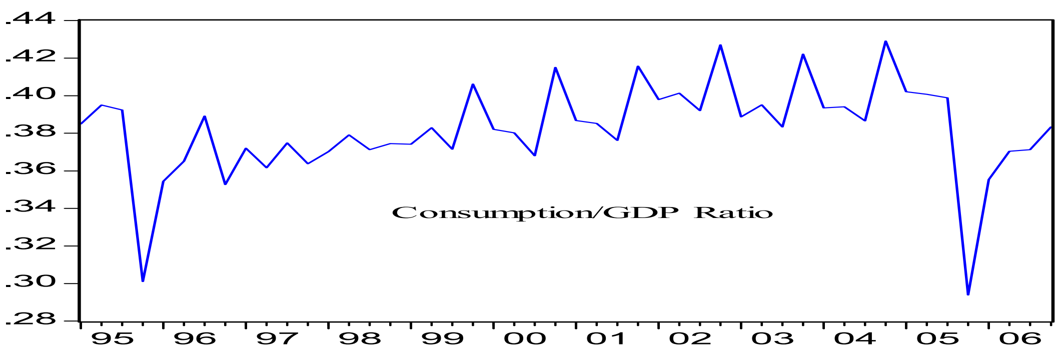
Consumption by households (quarterly) increased steadily during the examined period, as shown in Figure 3.4. Also, the ratio of households consumption to GDP stayed roughly constant between 0.30-0.44 (Figure 3.5).

Figure 3.4 Quarterly Consumption from 1995 to 2006. (Unit: 100 Million Yuan)



Source: National Bureau of Statistics of China

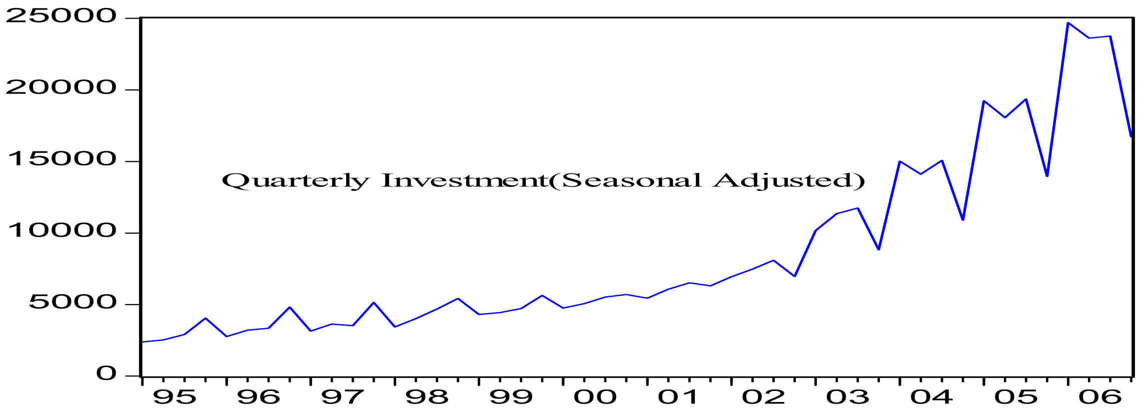
Figure 3.5 Households consumption/GDP ratio



Source: Computed by Author

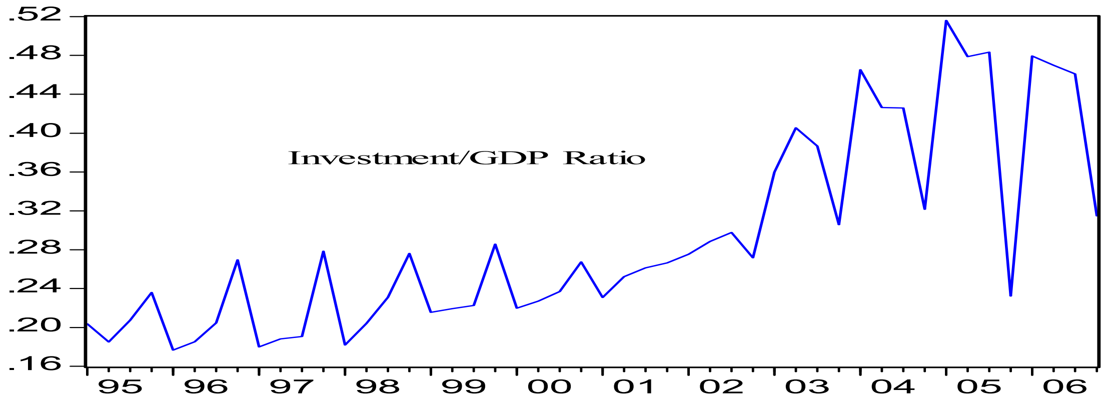
Investments followed similar trend as that in GDP during 1995q1-2006q4 (Figure 3.6); The ratio of investments to GDP fluctuated between 0.18-0.50 (Figure 3.7).

Figure 3.6 Investments in China from 1995 to 2006 (Unit: 100 Million Yuan)



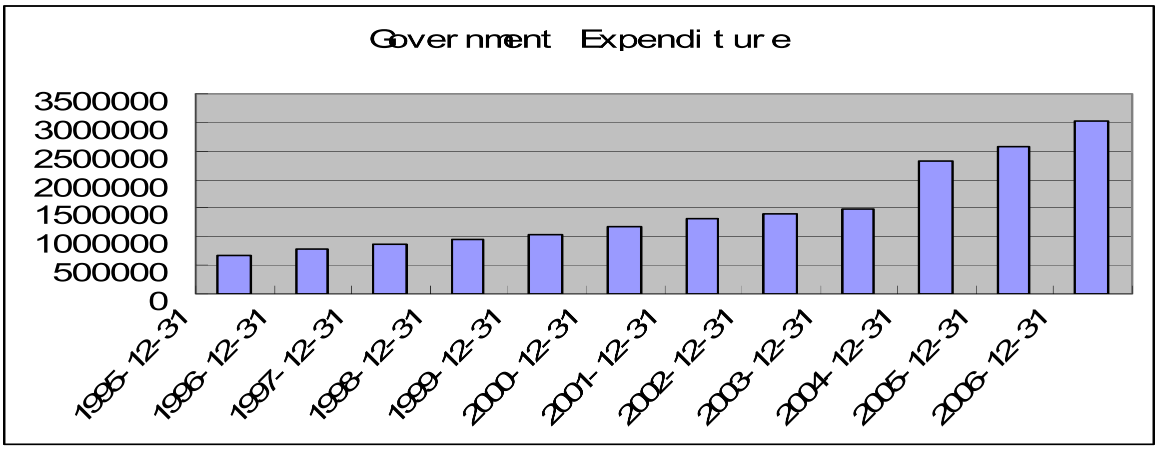
Source: National Bureau of Statistics of China

Figure 3.7 Investment/GDP ratios. (Source: Computed by Author)

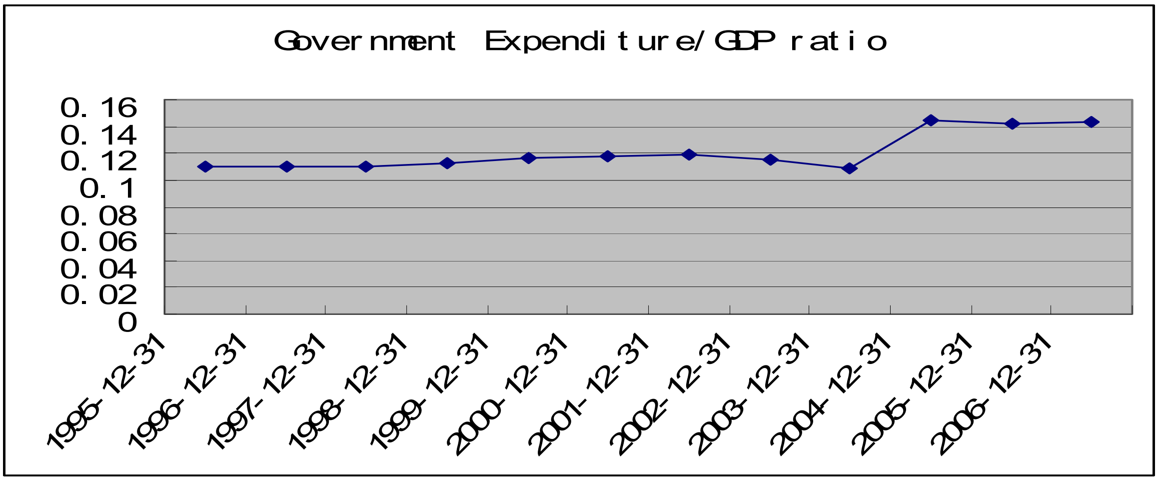


Government expenditure trend is showed in Figure 3.8, increasing steadily from 1995 to 2006, this contributed about one sixth of GDP in China within the examined period.

Figure 3.8 The Government Expenditure and its Ratio to GDP (Unit: Million Yuan)



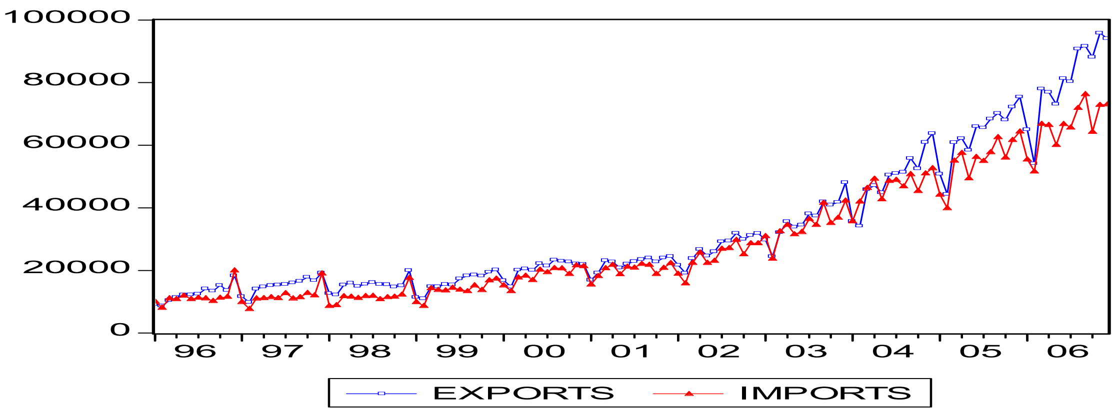
Source: National Bureau of Statistics of China



Source: Computed by Author

Exports and Imports followed a similar trend to GDP, growing slowly between 1995 and 2002, increasing rapidly after 2002 (Figure 3.9).

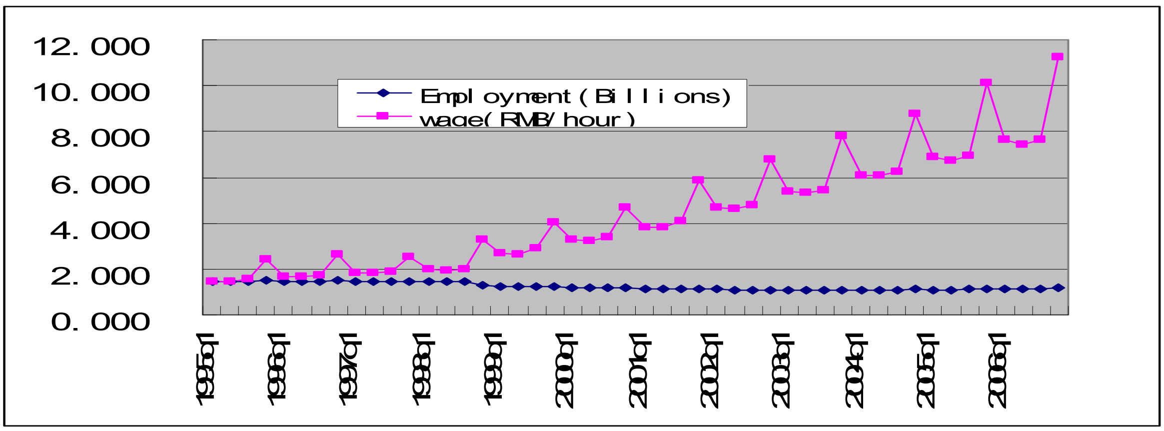
Figure 3.9 Exports and Imports in China (1995-2006)



Source: National Bureau of Statistics of China

Wage per hour increased gradually following the trend of output. *Employment* number of labours in cities dropped during this period (Figure 3.10).

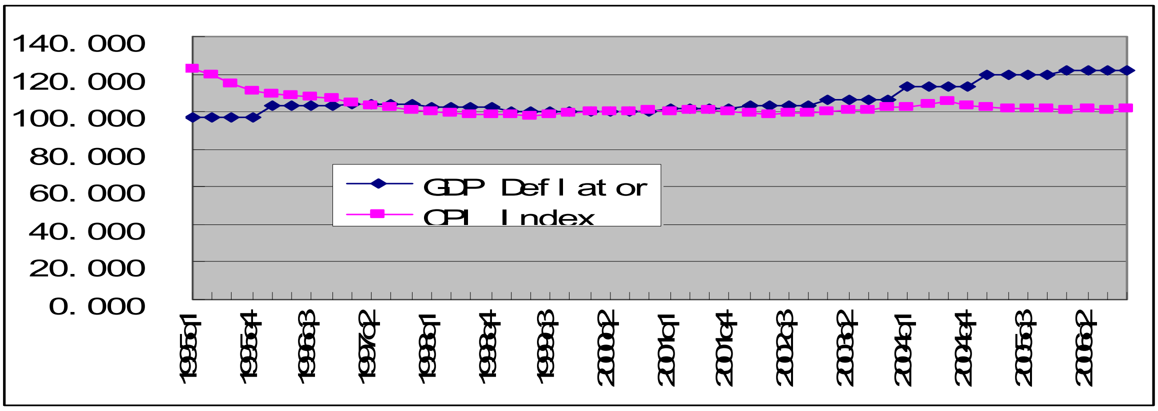
Figure 3.10 The Wage and Employment



Source: National Bureau of Statistics of China

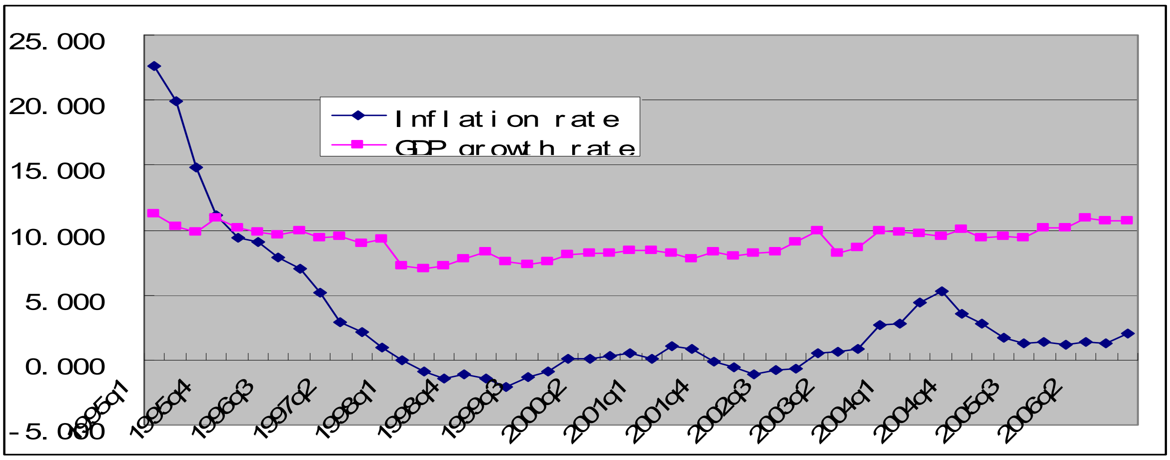
Price level decreased before fourth quarter 2002, then rose gradually, showing a cycle from deflation to inflation during 1995-2006. (Figure 3.11, Figure 3.12).

Figure 3.11 Price Level during 1995-2006



Source: National Bureau of Statistics of China

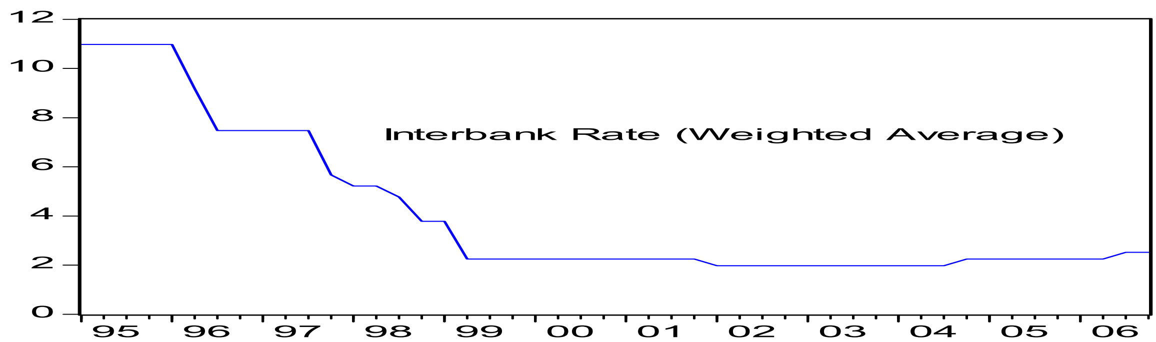
Figure 3.12 Growth Rates of GDP and Inflation



Source: National Bureau of Statistics of China

Interbank rate (weighted average) was very high at the beginning of this period because the interest rate was raised to reduce the rate of inflation in 1995; it then fell rapidly against the risk of deflation after 1997, shown in Figure 3.13.

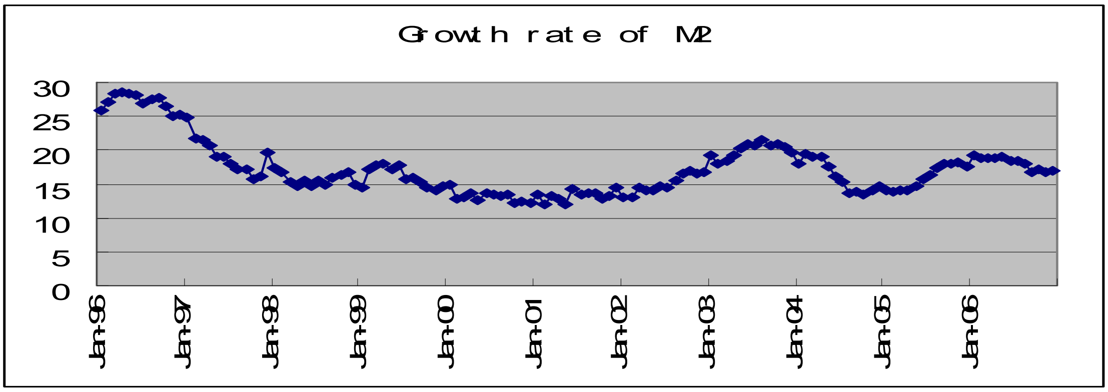
Figure 3.13 Interbank Weighted Average Rate



Source: China Economic Networks

Money supply is the intermediate target of China's monetary policy. The *growth rate of M2* fluctuated around 20% during 1996-2006. (Figure 3.14)

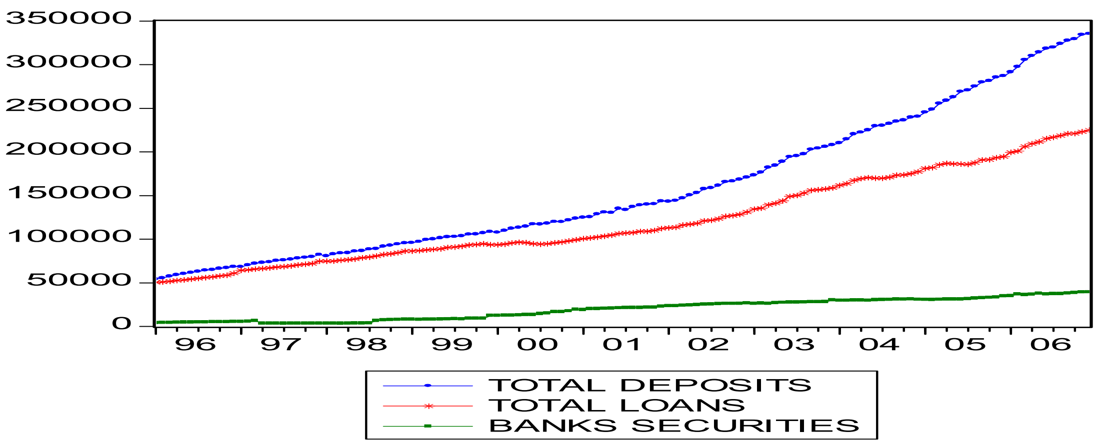
Figure 3.14 The Growth Rate of M2



Source: China Economic Networks

Total Deposits, Total Loans and Securities owned by banks are described in Figure 3.15. Total deposits and loans increased rapidly, but banks Securities added up slowly.

Figure 3.15 The Variables in Balance Sheet of Banks



Source: China Economic Networks

In summary, as the economy of China overheated during 1992-1995 the central government and monetary authority conducted tighter policies to decrease the growth rate of GDP (14.2% in 1992, 14% in 1993, and 13.1% in 1994) and the rate of inflation (14.7% CPI inflation in 1992, 24.1% in 1993, and 17.1% in 1994). In 1996, the above control measures took effect: CPI inflation rate fell to 8.3% and the growth rate of GDP stayed at about 10%. Since 1997, the economic situation of China changed dramatically because of the Asian Financial Crisis and the precedent strict contractionary policies, the deflation and recession became main threats. From 1998 to 2002 CPI fell continuously, the growth of GDP stayed at a low level (about annual 8%, lower than long-term equilibrium). Moreover, the actual rate of unemployment rose dramatically, it is estimated that the average rate of unemployment was above 8% during this period. To stimulate the economy, the central government undertook positive fiscal policy, providing vast capital in infrastructure projects by issuing treasury bonds. PBC reduced rates of deposits and lending 5 times, the interest rate for 1 year time deposit decreased from 5.67% to 1.98%, the growth rate of M2 remained above 15% annually. Facing the pressure of depreciation of RMB because of the Asian Financial Crisis China maintained the exchange rates of RMB, providing a stable anchor for money in Asia. After 2002, China's economy recovered to its long term equilibrium level. From 2003 to 2006, the growth rate of GDP hovered around the interval 10%-11% while the rate of inflation fluctuated between 1% and 4%. Given the above facts, we can see that in the long run the ratios of consumption, government expenditure and investment relative to GDP were constant and steady. The growth rate of GDP and the growth rate of M2 fluctuated around their long-term trend, which reflected the steady state of China's economy and the persistent trends.

Business Cycle Fluctuations

In contrast to long-term patterns, short-term and medium-term fluctuations are related to macro economic policies and other exogenous shocks, especially monetary policy, which aims to promote the stable sustainable economic growth and control the rate of inflation over business cycles through the monetary transmission channels. In what follows, we describe the fluctuations with the observable data during 1995-2006 by using Hodrick-Prescott Filter.[34]

Figure 3.16 illustrates trend and cycle of quarterly GDP. Figure 3.17 shows the growth rates of real GDP per person, consumption and investment per person.

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[34] The filter was first applied by economists Robert J. Hodrick and Edward Prescott to obtain a smoothed non-linear representation of a time series variable in macroeconomics, which is more sensitive to long-term than to short-term fluctuations. Let y_t denote the logarithms of a time series variable for $t = 1, 2, \ldots T$. Given an adequately chosen value of λ, which represents the adjustment of the sensitivity of the trend to short-term fluctuations, there is a "trend component", denoted by τ , that minimizes

$$\sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} ([(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

The first term of the equation is the sum of the squared deviations $d_t = y_t - \tau_t$. The second term is a multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component. The larger the value of λ, the higher is the penalty. Hodrick and Prescott advise that, for quarterly data, a value of λ = 1600 is reasonable

Figure 3.16 Fluctuations of Quarterly GDP

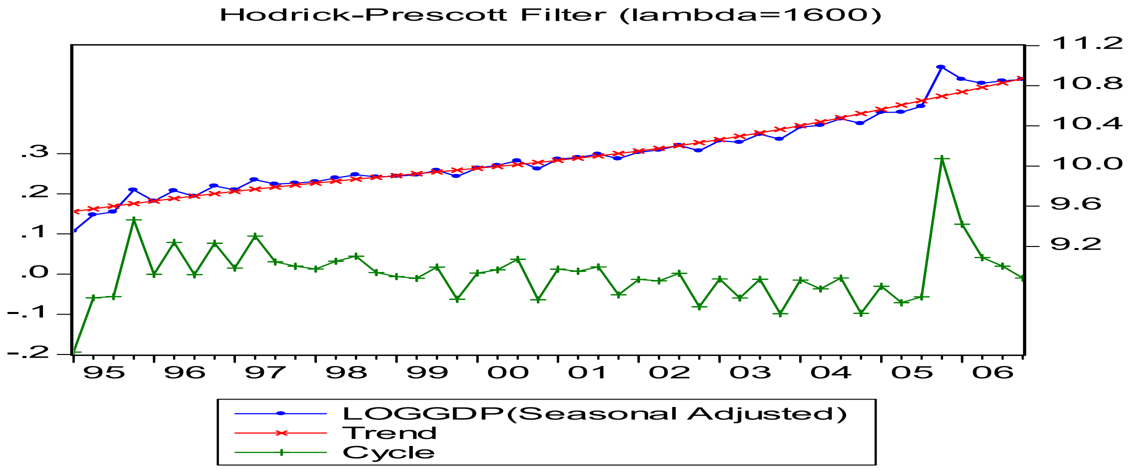
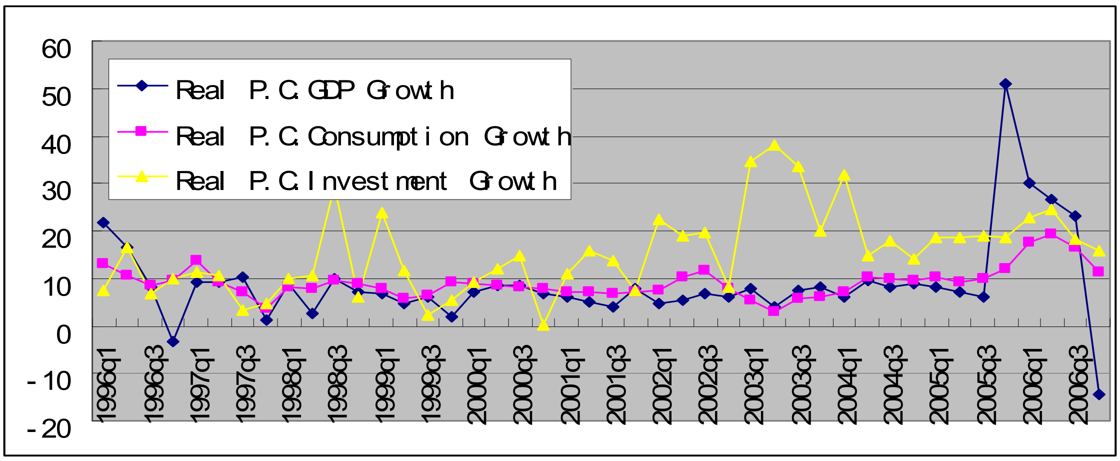


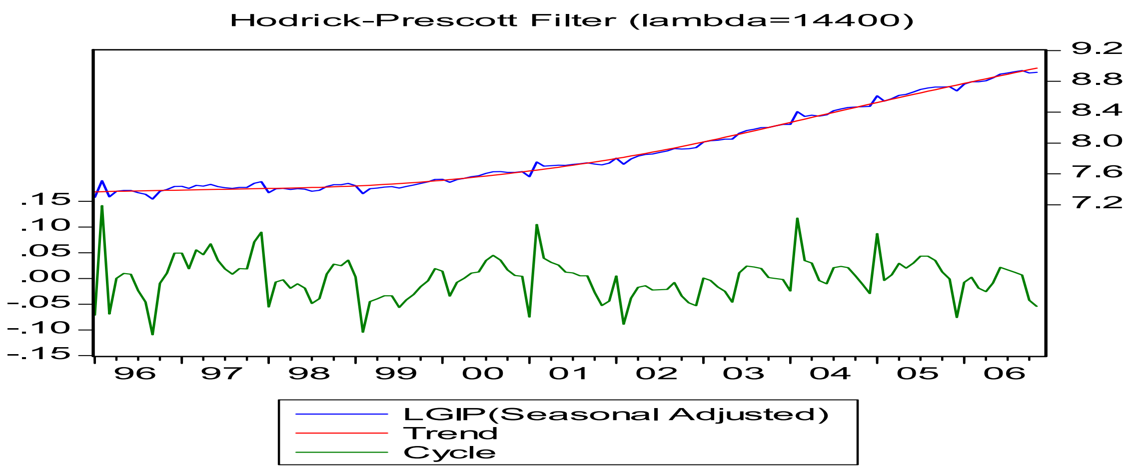
Figure 3.17 Fluctuation of Growth in Real P.C. GDP, Consumption, and Investment



Source: China Economic Networks

Industrial Production fluctuations are reported in Figure 3.18.

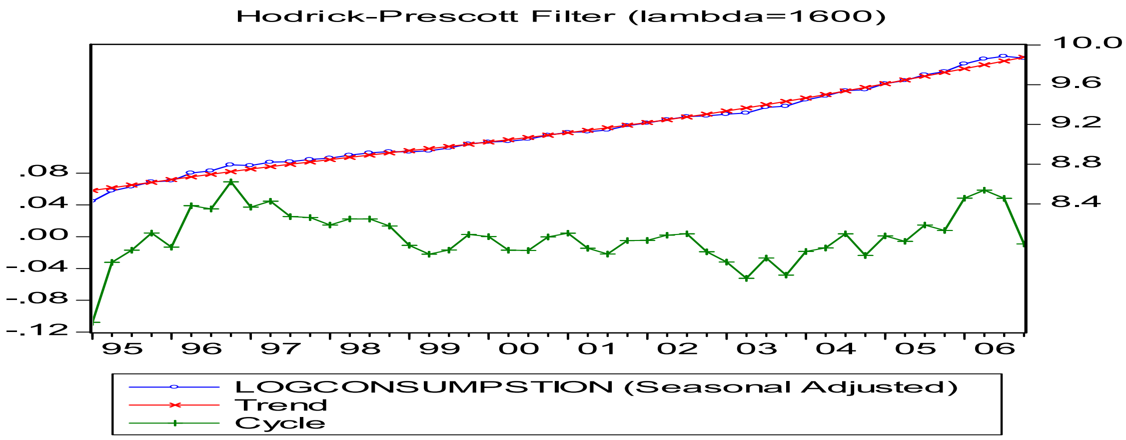
Figure 3.18 The trend and cycle of industrial production (monthly data)



The fluctuations of consumption and investment are demonstrated in Figure 3.19. We can see the co-movements of consumption and investment with GDP in China from Figure 3.16 and 3.19.

Also that the fluctuations of investment are significant.

Figure 3.19 The Fluctuations of Consumption and Investment



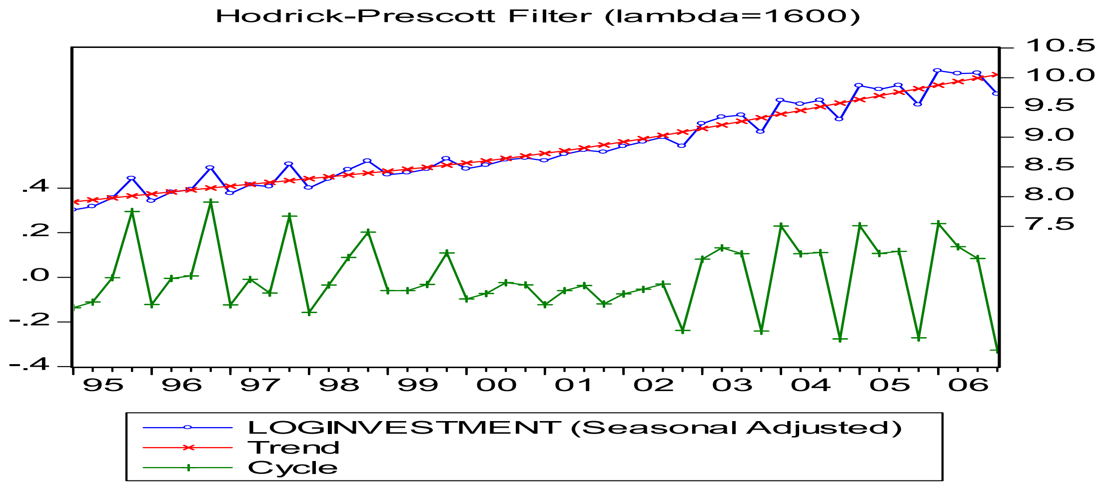
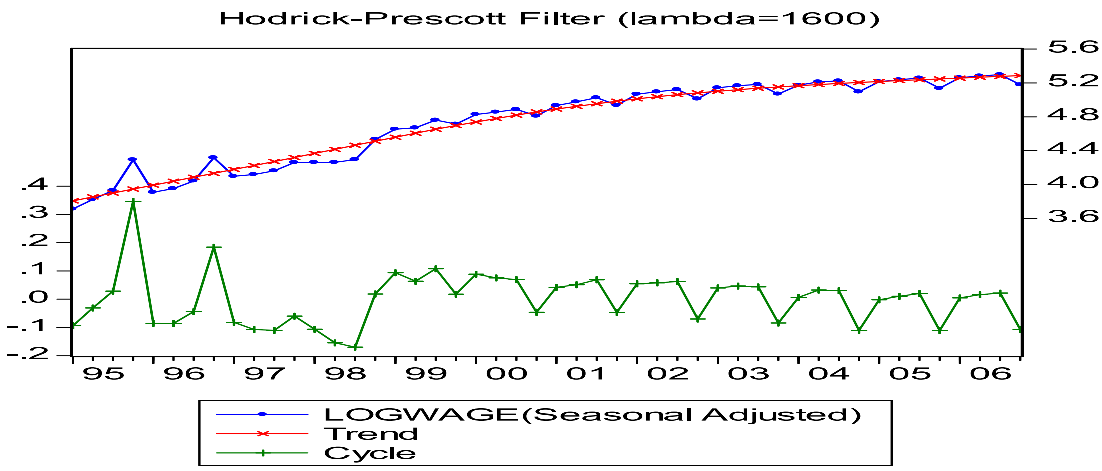
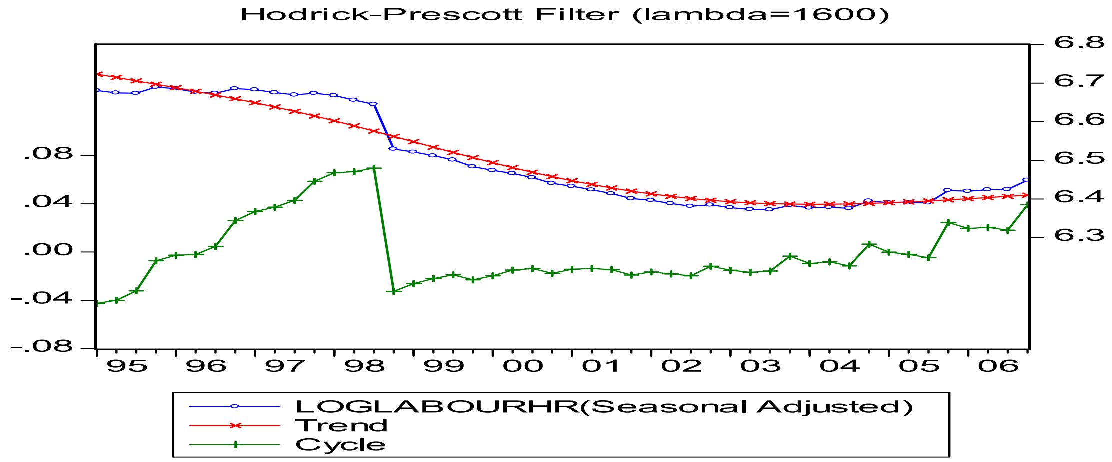


Figure 3.20 illustrates the trends and cycles of wages and working hours. From figure 3.20, the wage per hour is pro-business cycle of GDP in China.

Figure 3.20 Fluctuations of Wage and Labour Hours

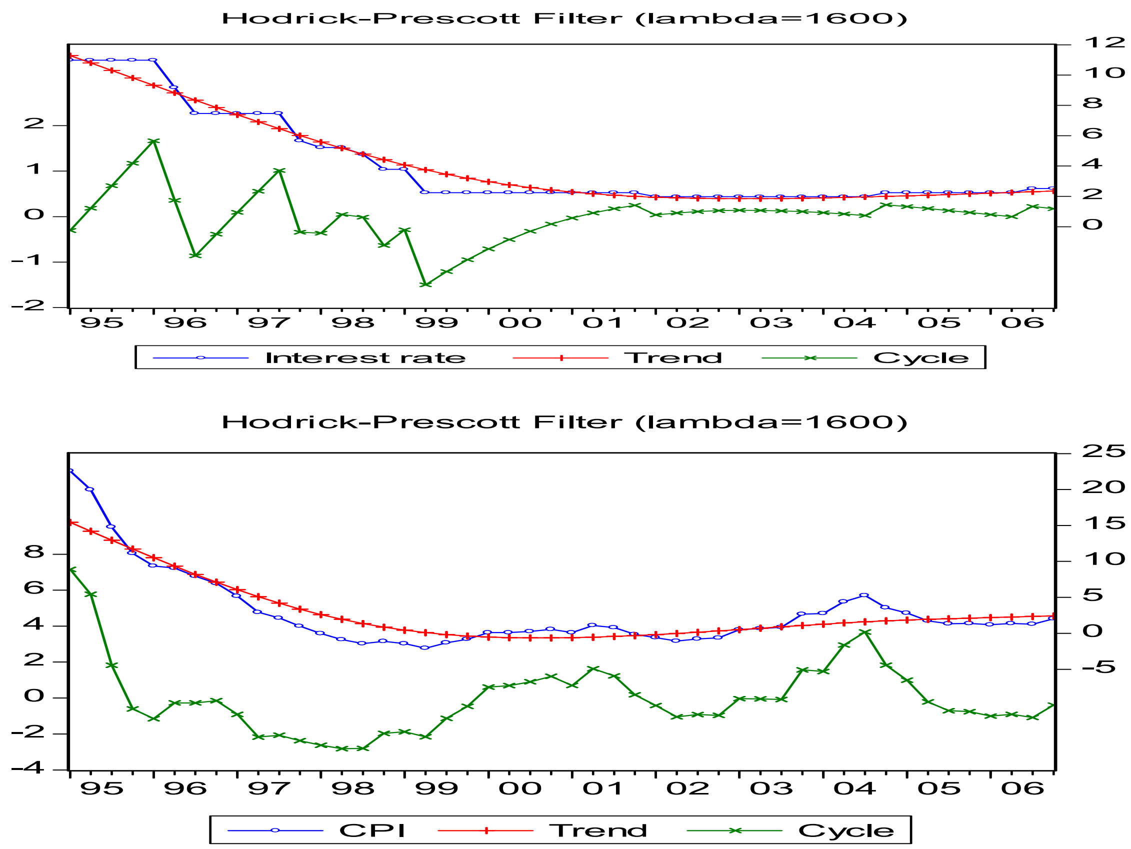




The wage is pro-cycle in China. The abrupt decline (discontinuity) of labour hours in 1998 was because China adopted a 5-day-work weekly system in 1998.

The interest rate volatility and CPI fluctuations are shown in Figure 3.21. The fluctuation of the interest rate complies with the so-called "leaning against winds" monetary policy in China.

Figure 3.21 The Cycles of Interest Rate and CPI Inflation



On the basis of the above observable time series data, we employed a VAR/VECM approach to identify the transmission channels of China's monetary policy and thereby uncover the effects of monetary policy on China's macroeconomy in Chapter 4. We estimated a benchmark DSGE model for China's macroeconomy to test the transmission channels of monetary policy and measure the contributions of China's monetary policy shocks and other shocks to China's business cycle in Chapter 5.

Chapter 4 Bank Loans and China's Monetary Policy Transmission Mechanisms: A VAR/VECM Approach

4.1 Introduction

As we discussed in Chapter 2, the following transmission channels of monetary policy are identified and employed to measure the effects of monetary policy on economic activities. The 'money view' works through the interest rate channel and exchange rate channel. The 'credit view' works through the bank lending channel and the balance sheet channel. The asset price channel works through wealth effects due to monetary policy, and the expectation channel is determined by the rational expectations of the public. Due to China's fixed exchange rate regime prior to 2005, we ignore the exchange rate channel. However, we still discuss the effects of monetary policy on exports, imports, total foreign exchange reserves and aggregate output. The interest rate channel reflects the fact that, when the central bank increases (decreases) the money supply or reduces (raises) the nominal interest rate, if prices are sticky, the real interest rate will decline (rise), commercial banks will create more (less) money by issuing deposits, and the demand for consumption and investment will increase (decrease) the aggregate output (GDP). The bank lending channel dominates the credit channels, which assumes that the banking system plays a significant role in the transmission of monetary policy to the real sector, and, thereby, the business cycle. It focuses on the asset side of banks' balance sheets, assuming that contractionary monetary policy not only reduces the capital and the assets of the banks, but also causes a decline of the supply of bank loans. It also focuses on the extent of reduction in loans diverse across banks of varying size. This implies that the type of borrower matters given asymmetric information and friction in the loan market. The balance sheet channel is similar to the bank lending channel; in a monetary contraction, the decline of net worth of firms (borrowers) will raise the cost of external finance and thereby reduce the demand for loans and investments.

Following Ford et al. (2003) and Bernanke and Blinder (1992), we have tested for, and identified the existence of transmission channels of monetary policies, giving particular attention to *the money channels* and *the credit channels* in China and to the long-run relationships between macroeconomic variables and monetary policy parameters by employing VAR/VEC Models with Cointegration. First, we use aggregate time series monthly data, namely total loans and total deposits, from 1996 through 2006 to examine the relationships between bank loans and macroeconomic variables to identify the existence of the *interest rate channel* and *bank lending channel*. Second, we test the differential effects of China's monetary policy across the banks by employing two categories, state owned banks (big banks), which dominate the capital structure of banking system lend to state-owned enterprises (large and medium firms), and non state banks (small banks), which lend to private and small firms. By doing this, we can further test the evidence of credit channels because recent studies (e.g., Kashyap and Stein, 1995; Ford et al, 2003) indicate that results from disaggregated bank data can reflect a theoretical base on which the bank lending channel was developed: asymmetric information and the possibility of financial frictions in loan markets. Third, we explore the distributional effects of monetary policy across sectors by disaggregating the loans to different economic sectors (industry, commercial, construction), which is also an important aspect caused by the *bank lending channe*l. Fourth, we determine the effects of monetary policies on international trade (exports and imports) in China under the fixed exchange rate regime that existed before May 2005. Finally, based on the results of cointegration tests, we identify the cointegrating vectors among these variables and set up VEC Models to uncover the long-run relationships that connect monetary policy, bank balance sheet variables and macroeconomic variables in China.

The data used are monthly observed from January 1996 to December 2006. They are collected from China's central bank, PBC, IFS, China's National Statistics, National Planning and Development Committee and Data companies. The detail on the data and the notation used are given and explained in Appendix 4.1.

It is difficult to choose the indicators of China's monetary policy in a VAR approach because the accuracy of the estimates of the effects of monetary policy depends crucially on the validity of the measure of monetary policy that is used. Use of an inappropriate measure may obscure a relationship between monetary policy and other economic variables that actually exists, or it may create the appearance of a relationship where there is no true causal link.[35] Here we use the inter-bank weighted average rate, *CIBR*, as the indicator of China's monetary policy. Also, we provide another avenue by which to test the transmission channels of China's monetary policy by employing the growth rate of M2 as the indicator of China's monetary policy because, according to some Chinese economists, PBC targets the growth rate of broad money.

All variables are in logarithms except for the indicators of monetary policy and CPI inflation. We seasonally adjust all variables by the X12 approach[36] and find that industrial production, exports, and imports have distinguished seasonal characteristics. Therefore, in our system, the above three variables are seasonally adjusted prior to estimation, and other variables remain unchanged.

[35] See Romer and Romer (2004).
[36] In Eviews 5.0, the X12 approach can be found in Proc menu.

There are both advantages and drawbacks to using a VAR. The fact that the VAR/VECM technique has produced many fruitful and consistent results motivates our study. On the other hand, critics, especially Rudebusch (1998), are concerned by the difficulty of identifying policy innovations and accounting for exogenous structural innovations to monetary policy. Also, according to Romer and Romer (2004), *endogenous and anticipatory movements* caused by some indicators of monetary policy, which are generally employed in the VAR/VECM technique, may lead to underestimates of the effects of monetary policy. An example of this can be seen in the federal funds rate, which is used as indicator of American monetary policy: the federal funds rate in non-Greenspan periods often moved endogenously with changes in economic conditions. In Section 3.2 and Appendix 4.4, we will discuss this issue and offer evidence to connect structural innovations to *cibr* and growth rate of M2, the indicators of China's monetary policy, with the exogenous monetary policy actions by monetary authority.

The remainder of this chapter is organized as follows. Section 2 describes the methodology. Section 3 specifies the VAR/VECM Model for China's monetary policy transmission. The empirical results of MTMs by VARs are presented in section 4. Section 5 discusses the VEC Models and the Cointegrating Vectors and. Section 6 summarizes and concludes.

4.2 Vector Autoregression (VAR) Approach and Vector Error Correction (VEC) Model

Sims (1980) developed the Vector Autoregression (VAR) in macro-econometrics. According to him, a VAR is an ad hoc dynamic multivariate model, treating a simultaneous set of variables equally, in which each endogenous variable is regressed on its own lags and the lags of all other variables in a finite-order system. The objective of the approach is to examine the dynamic response of the system to the shocks without having to depend on "incredible identification restrictions" inherent in structural models.

Following Christiano, Einchbaum, and Evans (1998), Bernanke and Blinder (1992) and Ford et al. (2003), a representative VAR can be expressed as

$$By_t = C(L)y_t + D(L)x_t + \varepsilon_t \tag{4.1}$$

where y_t is a (*m* x 1) vector of endogenous variables, x_t is an n vector of exogenous variables, B, C and D are matrices of the estimated coefficients, L is the lag operator, and i is the number of lag or the order of the VAR. The error term ε_t is a vector of innovations that are *I.I.D.*.

Excluding the vector of exogenous variables, as we do in this chpter by estimating, we can obtain the reduced form of the VAR by rearranging

$$y_t = A(L) y_t + \nu_t \tag{4.2}$$

where $A(L) = B^{-1}C(L) = A_1 L + A_2 L^2 + \ldots + A_i L^i$

$$\nu_t = B^{-1}\varepsilon_t$$

(4.2) can be rewritten as a MA representation

$$y_t = \frac{1}{[I - A(L)]}\nu_t = K(L)\nu_t \tag{4.3}$$

(4.3) gives a structural form (an estimated VAR) from which we can estimate the *impulse response functions* and *variance decomposition functions* assuming that the estimated VAR is stationary or non-stationary. However, all variables are integrated as I (1) with cointegrations, and can be simulated by the VEC model.

To simulate the process of dynamic responses of variables to a shock by using (4.3), it is generally assumed that the shocks should be orthogonal (uncorrelated), because the shocks usually come at the same time. For the structural form (4.3), the requirement is then that the structural error term $\nu_t = B^{-1}\varepsilon_t$ should have the following property:

$$E(\nu_t \nu_t^{'}) = (B^{-1}\varepsilon_t)(B^{-1}\varepsilon_t)' = (B^{-1})\varepsilon_t\varepsilon_t'(B^{-1})' = (B^{-1})(B^{-1})', \quad E[\varepsilon_t\varepsilon_t^{'}] = I_n$$

This process uses the *Choleski decomposition,* with which the structural residuals can be identified through the matrix B by decomposing the covariance matrix of the residuals. To achieve this, according to Sims (1980), the B^{-1} should be a lower-triangular.

Thus, the system of (4.3) becomes a recursive model in which the variables have an impact on each other according to their order. The innovation in the first variable in the system influences the other variables in sequence. The innovations in the other variables cause the changes in all those below them in order and in none of those variables above them in the chain. The order of variables in the vector, therefore, affects the recursive chain of causality among the shocks in any given period. Sims (1992) and other researchers follow the recursive assumption made by Christiano et al (1998), which says that the non-policy variables do not react contemporaneously to the policy variables. Thus, it is assumed that the policy decisions are made without considering the simultaneous evolution of economic variables. If we want to measure the contemporaneous effects of policy variables on economic variables, the policy variables should be ordered last. If the correlations across the residuals are very small, the position of variables in the VAR is irrelevant. In this study, we follow the recursive assumption because the high-frequency monthly data are employed.

If all variables in our VARs are integrated with order 1 [*I* (1)] and if the cointegration relationships among them exist, we can use Vector Error Correction Model (VECM) to identify the long runrelationships among the variables.

According to Hamilton（1994）, if each time series in an (n x 1) vector y_t is individually I(1), say non-stationary with a unit root, while some linear combination of the series $a'y_t$ is stationary, or I(0) for some nonzero (n x 1) vector α, then y_t is said to be cointegrated.

Rewriting 4.2 as

$$y_t = (A_1 + A_2 + ...)y_{t-1} - (A_2 + A_3 + ...)(y_{t-1} - y_{t-2}) - (A_3 + A_4 + ...)(y_{t-2} - y_{t-3}) - ... + \varepsilon_t \quad (4.4)$$

and applying the B-N decomposition[37] $A(L) = A(1) + (1-L)A^*(L)$ to 4.4

we obtain

$$y_t = (A_1 + A_2 + ...)y_{t-1} - \sum_{j=1}^{\infty} A_j^* \Delta y_{t-j} + \varepsilon_t \quad (4.5)$$

Subtracting y_{t-1} from both sides of 4.5, we then get

$$\Delta y_t = A y_{t-1} - \sum_{j=1}^{\infty} A_j^* \Delta y_{t-j} + \varepsilon_t \quad (4.6)$$

The matrix A controls the cointegration characters. There are three cases[38] for this system (4.6):

Case 1: A is full rank, and any linear combination of y_{t-1} is stationary. In this case, we run a normal VAR in levels.

Case 2: The rank of A is between 0 and full rank, and there exist some linear combinations of y_t that are stationary; thus, y_t is cointegrated, and the VAR in differences is misspecified in this case. With the rank of A being less than full, A can be expressed as

$$A = \alpha\beta';$$

4.6 then becomes the *error correction representation form*

$$\Delta y_t = \alpha\beta' y_{t-1} - \sum_{j=1}^{\infty} A_j^* \Delta y_{t-j} + \varepsilon_t \quad (4.7)$$

where β is the vector of cointegrating coefficents. When we know the variables are cointegrated by pre-test with matrix of β, we need to run an error-correction VAR (VEC).

Case 3: The rank of A is zero, and Δy_t is stationary with no cointegration. In this case, we can run normal VAR in first difference.

[37] Beveridge-Nelson decomposition provides measures of trend and cycle for an integrated time series. See Beveridge and Nelson (1981).

[38] See, for example, Cochrane (1997)

Recalling the reduced form of VAR Model in 4.2, we partition the vector of y_t into two groups: the vector of monetary policy indicator variables MT_t and the vector of economic (non-policy) variables V_t. Then the estimated VAR can be expressed as

$$\begin{bmatrix} MT_t \\ V_t \end{bmatrix} = A_0 + A(L)\begin{bmatrix} MT_{T-1} \\ V_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_t^{MT} \\ \mu_t^{V} \end{bmatrix} \tag{4.8}$$

where MT_t denotes the vector of indicators of China's monetary policy, inter-banks weighted average rates or growth rate of M2; V_t is the macro variables block, which includes industrial production, CPI, exports, imports, the stock market index, foreign exchange reserves, and banking loans and deposits. A_0 is the constant vector, and $A(L)$ is the parameters vector. $\mu_t = \begin{bmatrix} \mu_t^{MT} \\ \mu_t^{V} \end{bmatrix}$ is the error vector that are *i.i.d.,* where μ_t^{MT} can be used to represent the monetary policy shock, μ_t^{V} is an error vector to denote shocks from other economic activities.

Given that the variables are cointegrated with cointegration parameters matrix β and adjustment parameters matrix α, then the long-run relationships (cointegration equations) can be expressed as

$$MT_t = \beta V_t \tag{4.9}$$

The corresponding VEC Model is

$$\Delta MT_t = A_0^1 + \alpha_1(MT_t - \beta V_t) + \sum_{i=1}^{p}(c_{1i}\Delta MT_{t-i} + c_{2i}\Delta V_{t-i}) + u_t^{MT} \tag{4.10}$$

$$\Delta V_t = A_0^2 + \alpha_2(MT_t - \beta V_t) + \sum_{i=1}^{p}(d_{1i}\Delta MT_{t-i} + d_{2i}\Delta V_{t-i}) + u_t^{V} \tag{4.11}$$

where the first part in 4.10 and 4.11 is constant vector, the second part represents the error correction term and the third part is dynamic process in the short run.

Given the importance of cointegration and unit roots of variables, in the next section the unit root tests and the cointegration tests will be conducted.

4.3 VAR Models Specification for China's Monetary Policy Transmission

By choosing the inter-bank weighted average rate and growth rate of broad money as the indicators of China's monetary policy, we can investigate the transmission process of monetary policy in a contractionary or an expansionary operation respectively.

The VAR models are summarized in Table 4.1. The lag number choice will be discussed later.

First, following Ford et al. (2003) and Wibowo (2005), we develop VARs with seven variable using the following ordering: inter-bank weighted average rate for money (*cibr)* or growth rate of M2, bank deposits, bank loans, bank Securities, stock market index, industry production (proxy for output) and CPI (consumer price index) inflation. Using the aggregate data in VARs, the total bank loans transmission effects of China's monetary policy can be examined.

Second, by disaggregating the total bank loans into loans from state-owned banks (big banks whose main borrowers are big, state-owned firms) and loans from non-state banks (small–and medium banks who lend money to small companies and private firms), we specify a VAR model to examine the different behaviours across bank type and firm size under a tight or an expansionary monetary policy. This possibly provide the empirical evidence for whether or not the bank lending channel in China's monetary policy transmission exists.

Table 4.1 The Summary of Groups and the Lags Choices.

Group Name.	**Sub group**	**Lag Number in VARs[39]**	**Variables**
Total loans (Aggregate banks)	**Model I** CIBR as indicator	6	CIBR, total deposits, total loans, total Securities, stock market index, industrial production, CPI inflation
	Model II Growth rate of M2 as indicator	8	Growth rate of M2, total deposits, total loans, total Securities, stock market index, industrial production, CPI Inflation
Bank type (State banks and non state banks loans)	**Model III** CIBR as indicator	6	CIBR, total deposits, state banks loans, non-state banks loans, total Securities, stock market index, industrial production, CPI Inflation
	Model IV Growth rate of M2 as indicator	6	Growth rate of M2, total deposits, state banks loans, non-state banks loans, total Securities, stock market index, industrial production, CPI Infaltion
Borrower type (Loans to different sectors, borrow sectors)	**Model V** CIBR as indicator	4	CIBR, total deposits, loans to industry, loans to commercial sector, Loans to construction, total Securities, stock market index, industrial production, CPI Inflation
	Model VI Growth rate of M2 as indicator	4	Growth rate of M2, total deposits, loans to industry, loans to commercial sector, Loans to construction, total Securities, stock market index, industrial production, CPI Inflation
International trade (The effects on International trade)	**Model VII** CIBR as indicator	4	CIBR, total deposits, total loans, total Securities, stock market index, exports, imports, foreign exchange reserves, industrial production, CPI Inflation
	Model VIII Growth rate of M2 as indicator	4	Growth rate of M2, total deposits, total loans, total Securities, stock market index, exports, imports, foreign exchange reserves, industrial production, CPI Inflation

Third, we partition the bank loans by economic sector-industry sector, commercial, or construction to estimate the distribution and growth effects of a tight or expansionary monetary

39 The lag number choice is discussed at the outset of the section 4.4--the diagnostic tests.

policy operation.

Finally, we test the effects of monetary policy on international trade by employing similar VAR system. However, the exchange rate is not included in the model because of the fixed exchange rate regime in China. In this case, exports, imports and foreign exchange reserves are placed before industrial production in ordering.

Details of the data are discussed in Appendix 4.1. All the variables are in log levels except the indicators of monetary policy and CPI inflation. Industrial production, exports and imports are seasonally adjusted; other variables are kept unchanged according to the seasonal analysis in section 4.3.1.

4.3.1 Seasonal Adjustment, Unit Roots Tests and Cointegration Tests

To avoid the seasonality problem, all variables are adjusted by the X12 approach. The results of the seasonal analysis are presented by Figure 1 in which the "_(X12)" represents the variable seasonally adjusted by the X12 approach. From Figure 4.1, we can see that only industrial production, exports, and imports have distinguished seasonal characters. As such, in our system, the seasonally adjusted values of these three variables are used, and other variables are kept unchanged.[40]

To test if the variables are stable and to explore the possibility of the existence of cointegration equations, we conduct Augmented-Dickey-Fuller and Philips-Perron tests to determine the order of integration of all variables. The results are shown in Appendix 4.2 (see Tables 4.20 and 4.21).

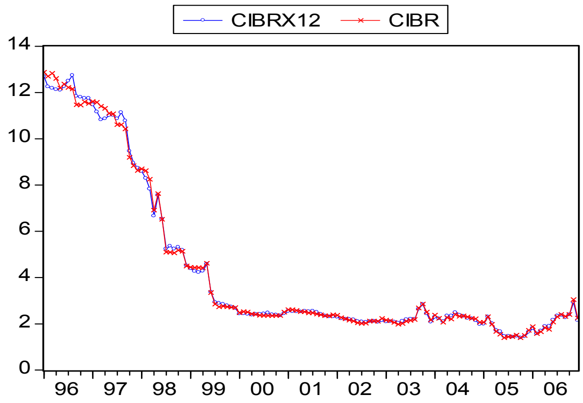
Hamilton (1994, page 501) address whether or not constants and trends should be included in unit root tests.

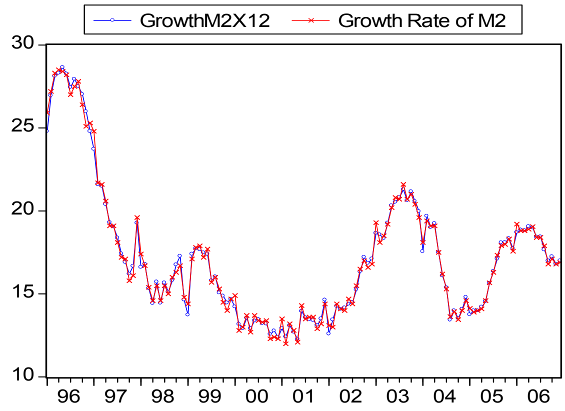
The results of the ADF unit roots tests (see Tables 4.20-21 in Appendix 4.2) show that only the total deposit causes concern because it is I(2) by ADF test. However, Philips-Perron tests suggest that it is I (1). Other variables are all I (1) according to the two tests.

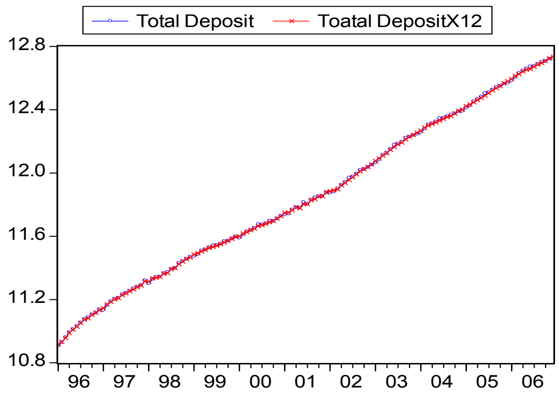
Combining the results of unit roots tests from Appendix 4.2, we can confirm that all the variables are found to be integrated with I (1); therefore, there may exist some cointegration between the employed variables. Thus, we conduct cointegration tests using Johansen's technique later in Section 4.5. We will use VARs to test and identify the possible monetary policy transmission mechanisms in China in Section 4.4, and then we will discuss the cointegrations tests, Cointegrating Vectors and VEC models in Section 4.5.

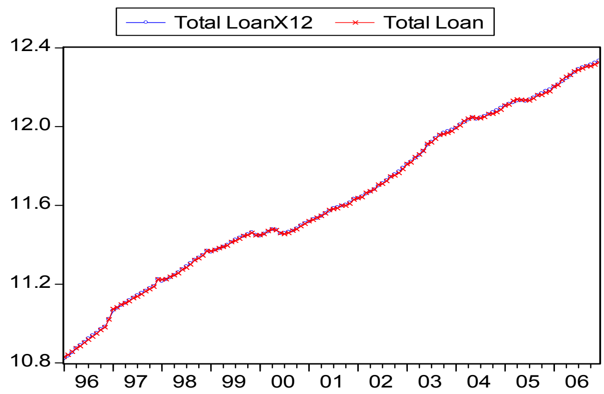
Figure 4.1 The Seasonal Analysis of the Variables

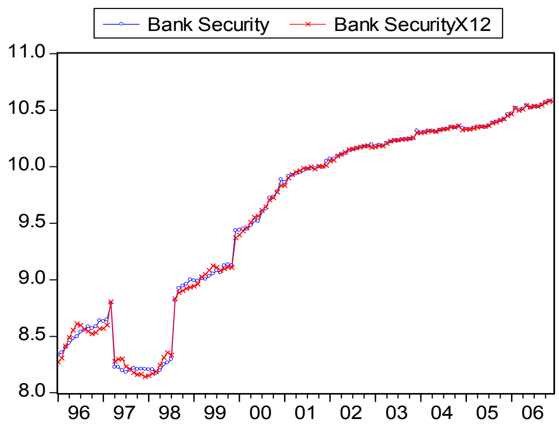
[40] We seasonally adjusted all variables by using the X12 approach. Compare the results, we find that the means and other mamematichal statistics are same after adjustments as that prior to seasonal adjustments for most varibles except the above three variables.


CIBRX12
CIBR
0 2 4 6 8 10 12 14
96 97 98 99 00 01 02 03 04 05 06

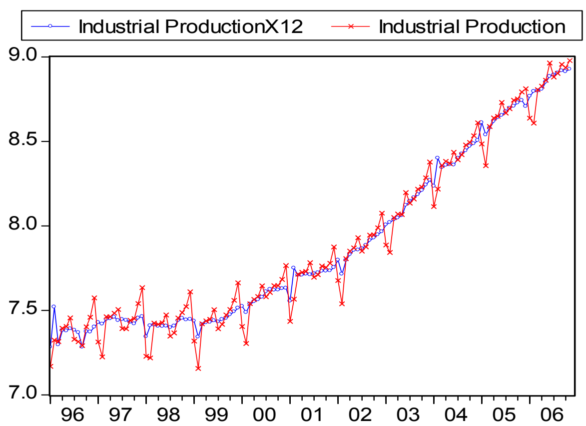

GrowthM2X12
Growth Rate of M2
10 15 20 25 30
96 97 98 99 00 01 02 03 04 05 06

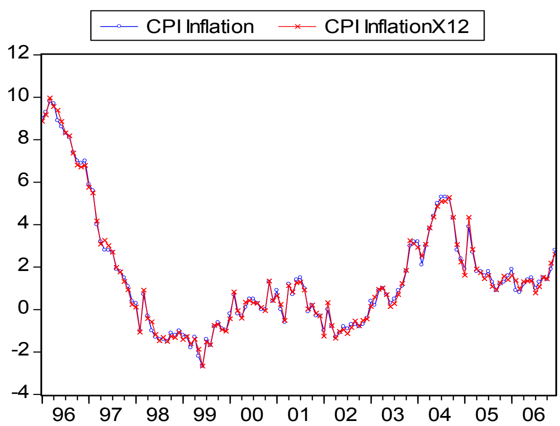

Total Deposit
Toatal DepositX12
10.8 11.2 11.6 12.0 12.4 12.8
96 97 98 99 00 01 02 03 04 05 06

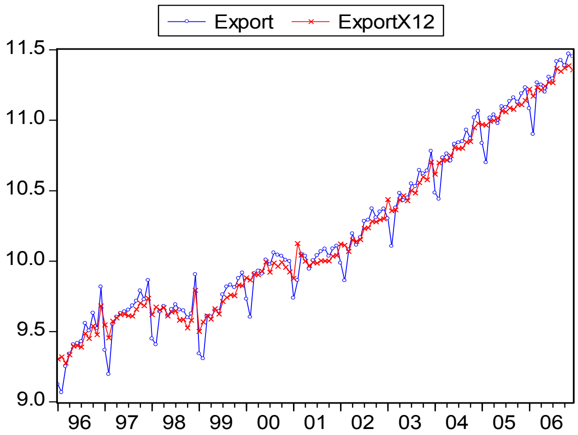

Total LoanX12
Total Loan
10.8 11.2 11.6 12.0 12.4
96 97 98 99 00 01 02 03 04 05 06

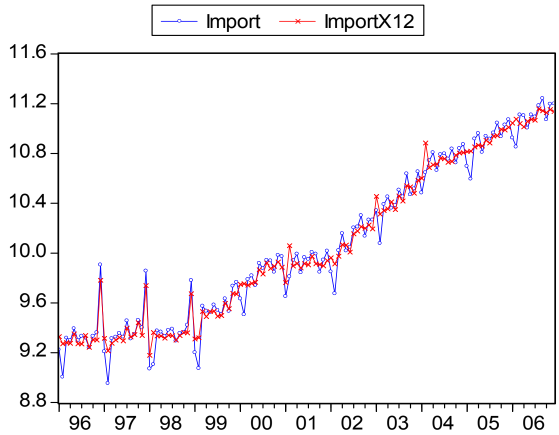

Bank Security
Bank SecurityX12
8.0 8.5 9.0 9.5 10.0 10.5 11.0
96 97 98 99 00 01 02 03 04 05 06

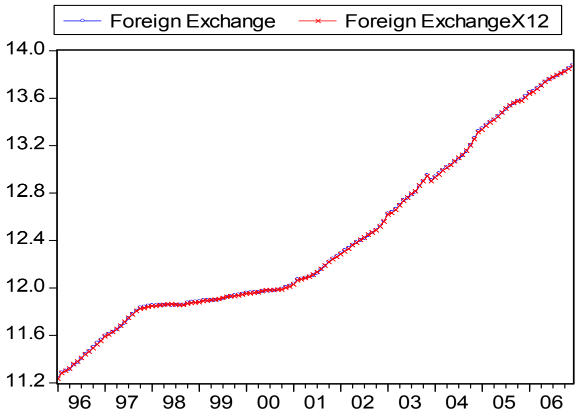

Shanghai Stock Index
Shanghai Stock IndexX12
6.0 6.4 6.8 7.2 7.6 8.0
96 97 98 99 00 01 02 03 04 05 06

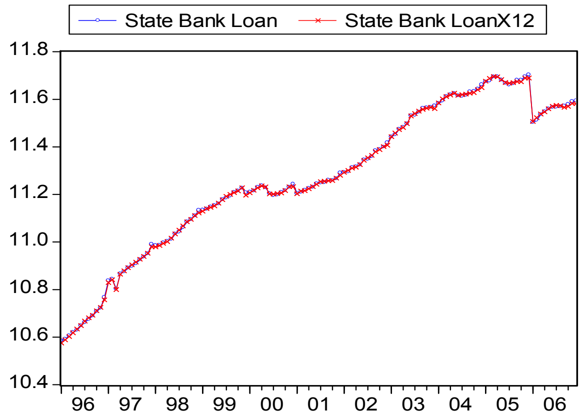

Industrial ProductionX12
Industrial Production
7.0 7.5 8.0 8.5 9.0
96 97 98 99 00 01 02 03 04 05 06

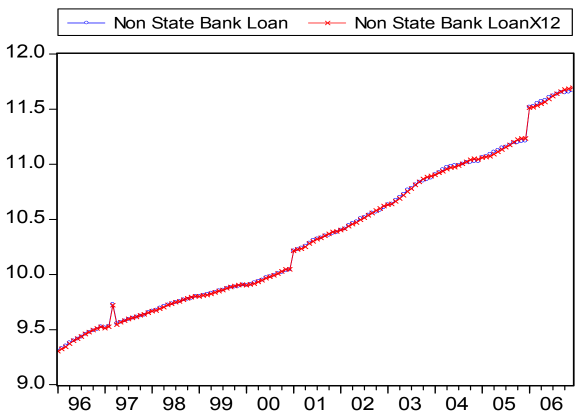

CPI Inflation
CPI InflationX12
-4 -2 0 2 4 6 8 10 12
96 97 98 99 00 01 02 03 04 05 06

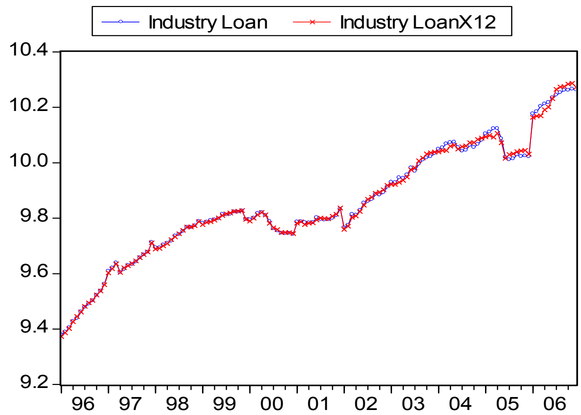

Export
ExportX12
11.5
11.0
10.5
10.0
9.5
9.0
96 97 98 99 00 01 02 03 04 05 06

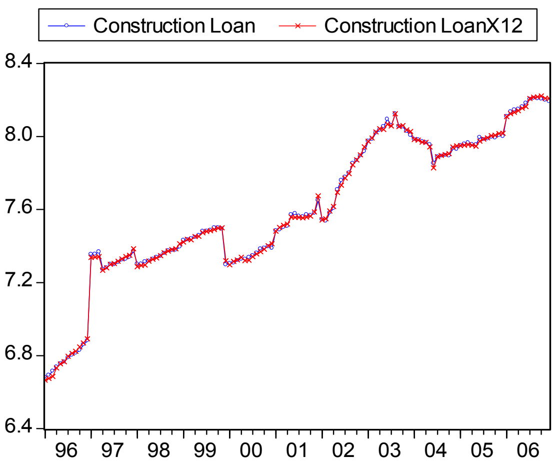

Import
ImportX12
11.6
11.2
10.8
10.4
10.0
9.6
9.2
8.8
96 97 98 99 00 01 02 03 04 05 06

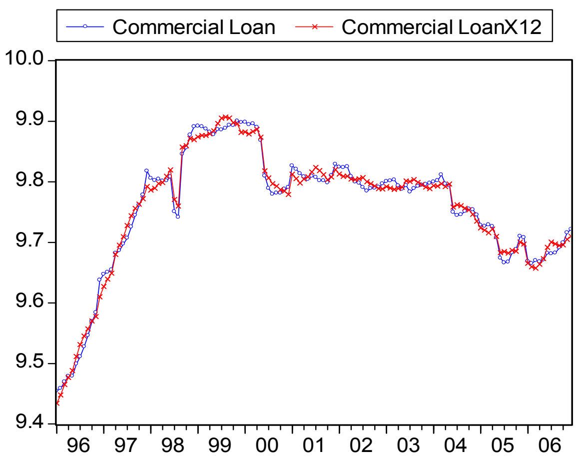

Foreign Exchange
Foreign ExchangeX12
14.0
13.6
13.2
12.8
12.4
12.0
11.6
11.2
96 97 98 99 00 01 02 03 04 05 06


State Bank Loan
State Bank LoanX12
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
96 97 98 99 00 01 02 03 04 05 06


Non State Bank Loan
Non State Bank LoanX12
12.0
11.5
11.0
10.5
10.0
9.5
9.0
96 97 98 99 00 01 02 03 04 05 06


Industry Loan
Industry LoanX12
10.4
10.2
10.0
9.8
9.6
9.4
9.2
96 97 98 99 00 01 02 03 04 05 06


Construction Loan
Construction LoanX12
8.4
8.0
7.6
7.2
6.8
6.4
96 97 98 99 00 01 02 03 04 05 06


Commercial Loan
Commercial LoanX12
10.0
9.9
9.8
9.7
9.6
9.5
9.4
96 97 98 99 00 01 02 03 04 05 06

4.3.2. Identification of the Indicators for China's Monetary Policy

As mentioned above, we use CIBR (inter-bank weighted average rate) and the growth rate of M2 as the indicators of China's monetary policy.

In a VAR system, the structural innovations of the monetary policy variable are generally taken as the monetary policy shocks, which are often referred to represent the changes in monetary policy stance, as Sims (1992) and Bernanke and Blinder (1990) did. We take note of critiques of this methodology, especially those raised by Rudebusch (1998). According to him, the VARs that are employed to test the effects of monetary policy shocks might provide impulse responses that are inconsistent with other exogenous indicators of monetary policy (based on US data). Sims (1998), in his reply, conceded that the point is worth of considering and checking seriously, although he did not provide concrete measures to deal with this problem. He did, however, insist that VAR/VECM could provide good descriptions of economy's responses to exogenous monetary policy shocks.

Having considered this issue, we examine the structural innovations from the CIBR (inter-bank weighted average rate) and the growth rate of M2 against some indicators of exogenous monetary policy in China. Recalling the framework of China's monetary policy in Chapter 1, which takes the monetary aggregate as intermediate targets by controlling monetary base, we employ the unanticipated changes in monetary base and required rate of reserves as the changes in *exogenous* monetary policy due to the alterations in direct monetary policy instruments. Thus, we need to investigate the associations which connect the innovations in our VAR models with the unanticipated actions of China's monetary policy, such as the unanticipated changes in monetary base and required rate of reserves. The abrupt changes in money base via open market operations by the PBC can cause the adjustments of growth rate of M2 and the CIBR. Also, the abrupt alternations in required rate of reserves, which is the most useful tool in the implementation of China's monetary policies, can introduce the changes in CIBR and the growth rate of M2.

To estimate the unanticipated components in monetary base (MB) and required rate of reserves (RR), we use the state space technique (Kalman Filter) based on the assumptions of rational expectations following Wibowo (2005).

Assuming that:

$$MB_t = MB_t^* + \varepsilon_t$$

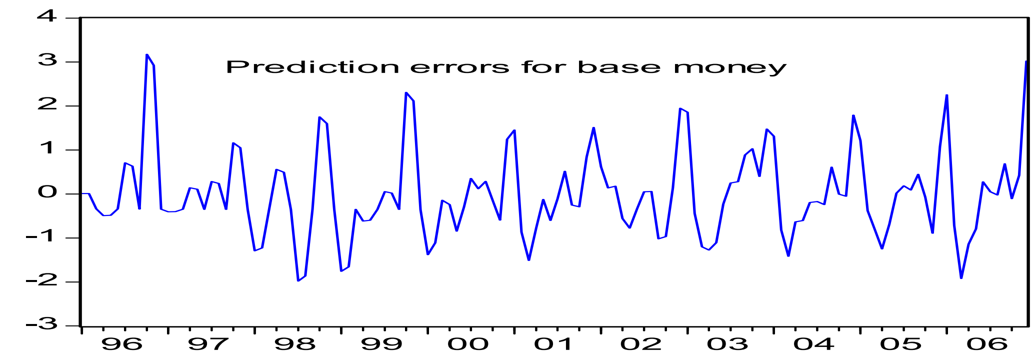
and $$RR_t = RR_t^* + \sigma_t$$

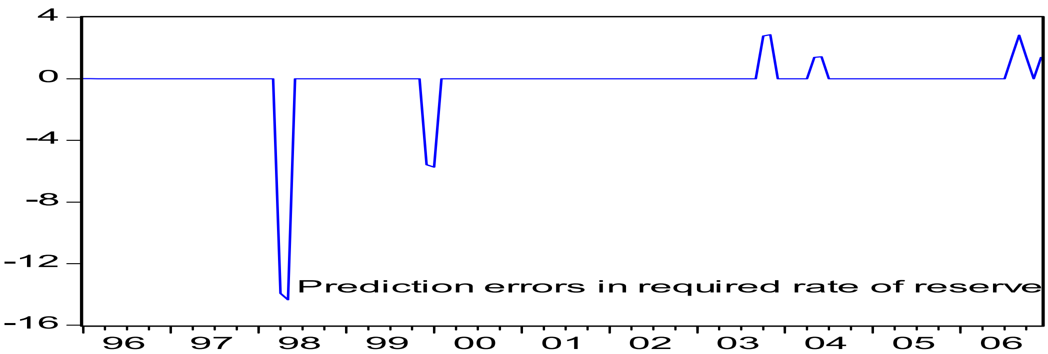
where MB_t is the base money at time t, MB_t^* is the expected value of base money at t, and ε_t is the unanticipated change in base money at t. Similarly, RR_t represents the required rate of reserve at t, RR_t^* denotes the expected value of required rate of reserve at t, and σ_t is the unanticipated change in required rate of reserve.

The prediction errors for MB (logarithm form) and RR are shown in Figure 4.2.

Having estimated the prediction residuals[41] for the base money and the required rate of reserve, we regress the structural innovations to CIBR and growth rate of M2 against them and their lags. For all of our VAR models, the regression results are reported in Appendix 4.4.

Figure 4.2 the prediction errors in base money and required rate of reserve





From Appendix 4.4, we observe in sum that, when we use the CIBR as the indicator of the china's monetary policy, the results of the regressions for all groups provide overall reasonable fits; the goodness of fit is 20.99% for the total loans group, 20.84% for the bank type group, 30.93% for the borrow type group, and 33.66% for the international trade group. Furthermore,

[41] The State space equations for estimation the prediction errors for RR in Eview5.0:

@signal RR = sv1

@state sv1 = c(3)*sv1(-1) + c(4)*sv2(-1) + [var = exp(c(2))]

@state sv2 = sv1(-1)

Here sv1 represents the expected value of RR.

the coefficients for prediction errors of RRR are significant at the 5% level. The growth rate of M2 as the indicator provides weak fits, with goodness of fits, with goodness of fits that are 15.38%, 6.9%, 7.7% and 7.4% respectively.

On the basis of above results and discussions, we conclude that the structural innovations to the indicators of China's monetary policy in our study can be suggested as the responses to changes in exogenous monetary policy in China.

4.4 The Empirical Results on MTMs from VARs

As mentioned above, the variables are partitioned into 8 groups in order to investigate the possible transmission channels in terms of aggregate data and disaggregated data (bank types and loan types). In each group of VAR Models, the indicator of China's monetary policy is inter-bank weighted average rate (CIBR) or growth rate of broad money; deposits, loans, and securities are variables in the balance sheets of banks; stock market index is a variable to reflect wealth or asset price; other important macro variables include industrial production, CPI inflation, exports, imports and foreign exchange reserves.

Lag Choices and the Diagnostic Tests

As mentioned earlier, the number of lags for VARs, and therefore for VECM is determined by several criteria:

· It must meet the requirement of mathematical stability or stationary condition, this means that all roots of the companion matrix lie inside the unit circle in absolute value.

·It should meet the LR criterion or SIC criterion.[42] Ivanzov and Kilian (2005) suggested six criteria for lag order selection: the Schwarz Information Criterion (SIC), the Hannan-Quinn Criterion (HQC), the Alkaike Information Criterion (AIC), the general-to-specific sequential Likelihood Ratio test (LR), a small-sample correction to that test (SLR), and the Lagrange Multiplier (LM) test. Some econometricians argue that the SIC should be applied to small sample and the AIC should be used for large sample, but other econometricians' empirical works come to opposite conclusions. In our study, we first let the VARs meet the stationary conditions and then choose the number of lags referring to the LR standard. on choosing the better lag number, we follows the 2 steps as (1) to evaluate the signficance of the included lags, for a given lag length; and, (2) to determine what might be the optimum lag length, that is, they test for omitted lags.

[42] See, for example, Lutkepohl 1993) made the detailed discussion on lag choice.

·It must pass the misspecification tests such as normal distribution, autocorrelation, ARCH and heteroscedasticity.

All our VARs are mathematically stable. Table 4.2 displays the results of misspecification tests of AR, normality and heteoscedasticity for the total loans group when *CIBR* is used to be the indicator of monetary policy. The results of the diagnostic tests indicate that there are no AR, heteoscedasticity in the model, but the normality test cannot meet the requirements.

Table 4.3 summarizes the diagnostic test results for all groups. Most of our test results meet the requirements. However, there are few failures, particularly with the normality tests. However, according to Juselius[43] the residuals in the VARs/VECs need not be normally distributed if this is caused by excess kurtosis, some of failures are because of the excees kurtosis in our system. Also, as pointed out by Johansen (1995, p29),

"*The methods derived are based upon the Gaussian likelihood but the asymptotic properties of the methods only depend on the i.i.d. assumption of the errors. Thus the normality assumption is not so serious for the conclusion, but the ARCH effect may be.*"

Therefore, provided there is no (or hardly any) AR or heteroscedasticity, the VAR models can be accepted even if the residuals are not normally distributed. Based on the above tests and analysis, our VAR/VECM system can perform well, although some fluctuations may take place.

[43] See Juselius (2006), the Cointegrated VAR Model-Methodology and Applications. Oxford: Oxford University Press.

Table 4.2 Diagnostic Test Results for Total Loans Group (Cibr as indicator)

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
H0: residuals are multivariate normal
Sample: 1996M01 2006M12
Included observations: 125

Component	Kurtosis	Chi-sq	Df	Prob.
1	2.544469	1.080773	1	0.2985
2	1.839438	7.015129	1	0.0081
3	1.574638	10.58155	1	0.0011
4	2.948404	0.013865	1	0.9063
5	1.265049	15.67738	1	0.0001
6	2.092750	4.286991	1	0.0384
7	1.649797	9.495045	1	0.0021
Joint		48.15073	7	0.0000

Component	Jarque-Bera	Df	Prob.
1	4.634407	2	0.0985
2	8.774062	2	0.0124
3	10.74321	2	0.0046
4	1.184321	2	0.5531
5	15.81865	2	0.0004
6	4.290353	2	0.1170
7	10.52234	2	0.0052
Joint	55.96733	14	0.0000

VAR Residual Serial Correlation LM Tests
H0: no serial correlation at lag order h
Sample: 1996M01 2006M12
Included observations: 125

Lags	LM-Stat	Prob
1	56.77310	0.2079
2	54.74271	0.2658
3	57.67533	0.1852
4	57.73778	0.1837
5	48.96375	0.4746
6	52.68345	0.3335
7	49.51766	0.4525

Probs from chi-square with 49 df.

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Sample: 1996M01 2006M12
Included observations: 125

Joint test:

Chi-sq	Df	Prob.
2489.680	2408	0.1203

Table 4.3 Summary of diagnostic tests for all VAR models (groups)

Group Name.	**Sub group**	**AR Test** (H0: no serial correlation at lag order) Probability	**Hetero Test** (H0: no cross terms) Probability	**Normality Test** (H0: residuals are multivariate normal) Probability
Total loans	Cibr as indicator	0.1837-0.4746	0.1203	0.0-0.55
	Growth rate of M2 as indicator	0.018-0.56	0.3263	0.0
Bank type (State Banks and Non State Banks Loans)	Cibr as indicator	0.11-0.69	0.2450	0.0-0.07 (there are some excess kurtosis)
	Growth rate of M2 as indicator	0.26-0.90	0.5478	0.00-0.14
Borrower Type (Loans to different sectors)	Cibr as indicator	0.002-0.52	0.5541	0.0-0.68 (there are some excess kurtosis)
	Growth rate of M2 as indicator	0.07-0.34	0.9637	0.0-0.55 (there are some excess kurtosis)
The effects on International trade	Cibr as indicator	0.01-0.38	0.1474	0.0-0.36 (there are some excess kurtosis)
	Growth rate of M2 as indicator	0.08-0.64	0.6702	0.0-0.15 (there are some excess kurtosis)

In sum, on the basis of the stationary and diagnostic tests, especially the key mathematical and statistical tests, our VAR Models are acceptable tools which can be used to investigate the transmission mechanism of China's monetary policy.

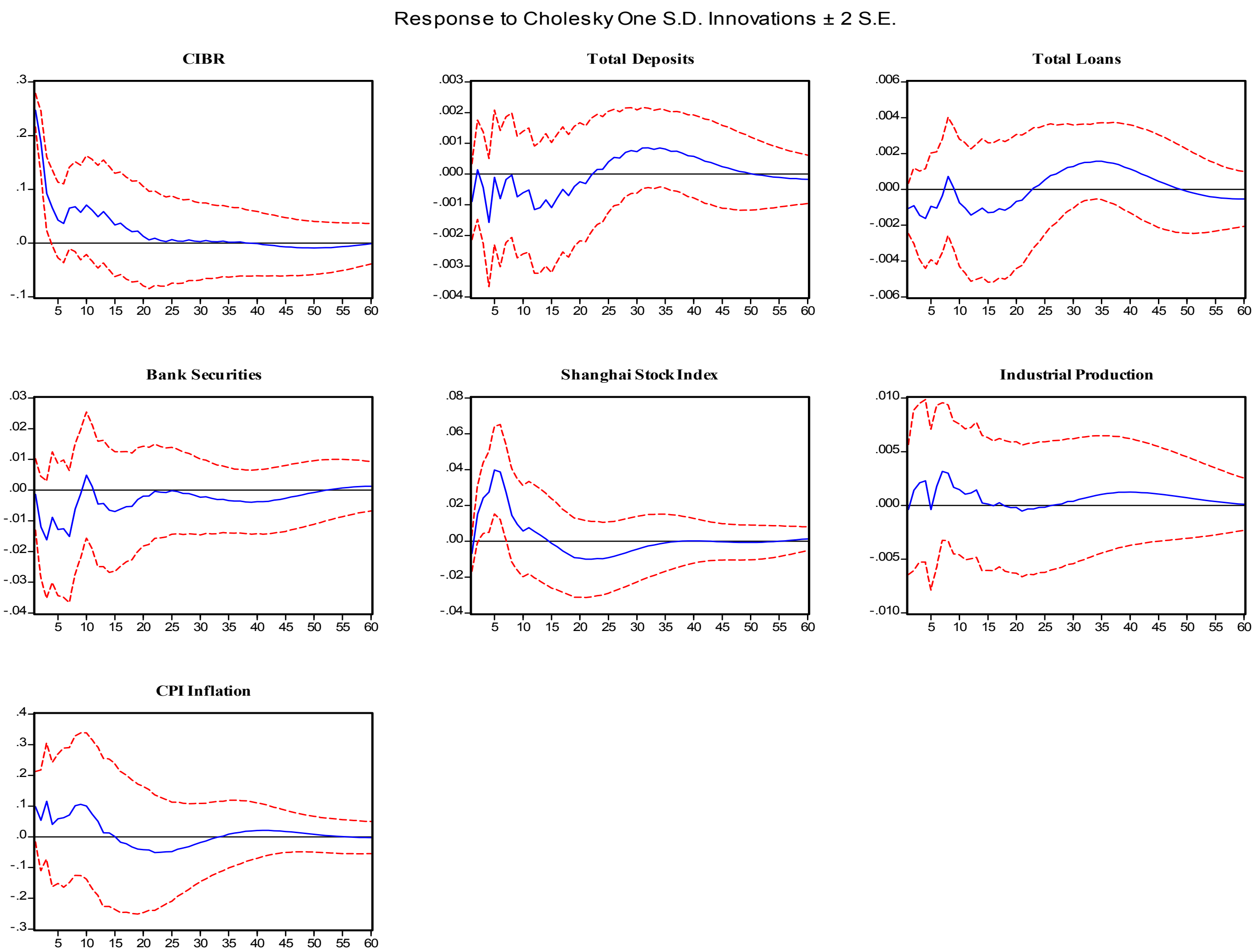
We present the impulse response graphs and variance decompositions for 60 months (5 years). The detailed variance decompositions for each model are attached in Appendix 4.5.

4.4.1 The VAR Results for the Aggregate Banks (Total Loans Group)

We estimate the effects of one S.D. innovation to CIBR (a contractionary monetary policy shock) on the total deposits, total loans and total securities (aggregate components of banks balance sheets), stock market index, industrial production and CPI inflation by employing the seven variables VAR Model.

The impulse response functions are presented in Figure 4.3 (the dotted line represents the 68% confidence interval). The results of our 60-step variance decompositions forecast are presented in Table 4.4.

Figure 4.3 Impulse Responses of All Variables for Aggregate Banks to CIBR



From Figure 4.3, following a contractionary monetary policy shock (an innovation in CIBR), the bank balance sheet variables (total deposits, total loans and bank securities) decline immediately (negative change rate), the output immediately declines slightly and declines again 15 months later, the stock market index falls immediately, and the CPI inflation declines after 15 months. The immediate decrease of output following a contractionary monetary policy shock (an innovation to CIBR) implies a weak effect of the *interest rate channel*. As a result of the increase in the inter-bank rates, deposits and loans decline immediately, while industrial production (output) and prices (CPI) decline one year later. This suggests the existence of *the bank lending channel* in China's monetary policy transmission: the fall in output is caused by the fall in the supply of loans (deposits), not by the fall in demand for loans. The later decline of output may also be the direct effect of monetary policy through the *interest rate channel* by reducing investment and thereby reducing industrial production. Therefore, we should conclude that the effects of the contractionary monetary policy shocks are transmitted through the mutual effects of the *bank lending* channel and the *interest rate channel* based on the above results in this case. The immediate fall of the Shanghai Stock Market Index after the interest rate shock indicates possible evidence of an *asset price channel* in China's monetary policy transmission.

The variance decompositions in Table 4.4 provide some support for our above arguments: the total deposits and loans contribute 10% to the variance decompositions of industrial production in the long run. The short-term and medieum-term effects of deposits and loans on the variation of industrial production can refer to Table 4.30 in Appendix 4.5. Initially deposits contribute about 12.42%, gradually decline to 10%. Loans' contributions from 0.19% in the short run to 1.16% in the medieum-term to the variations of industrial production.

From the impulse responses in Figure 4.3, although the bank lending and interest rate channels of monetary policy transmission in China in a tight monetary operation can be traced out, the effects of monetary policy shock on the real economy are weak. Furthermore, the response of Shanghai Stock Market Index suggests evidence of the asset price channel.

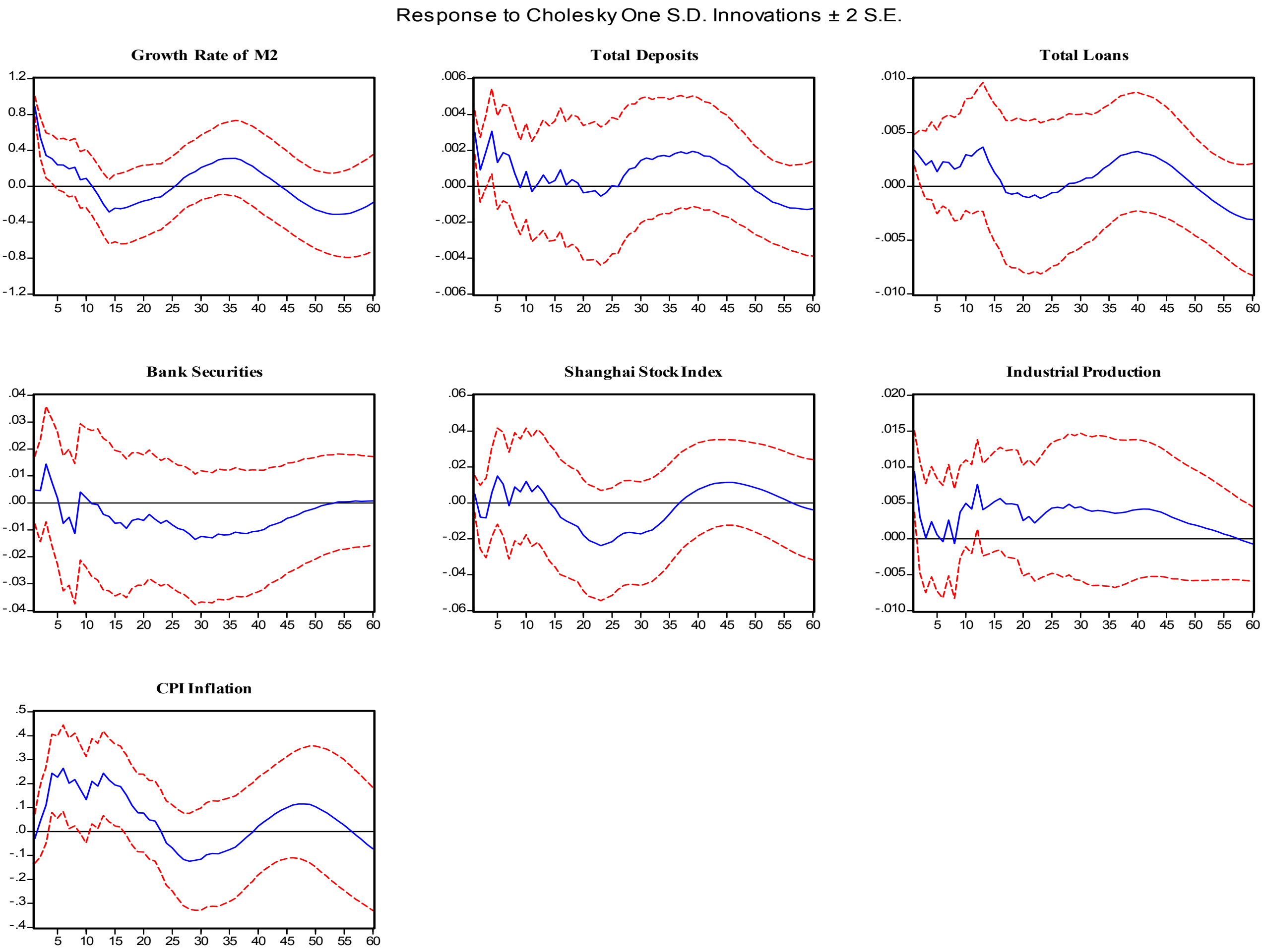
Table 4. 4 (Cholesky) Variance Decompositions for Total Loans Groups (CIBR as Indicator) (60 Steps)

			Forecasted	**Variables**	
Shock	**Deposits**	**Total Loans**	**Stock Index**	**Industrial Production**	**CPI Inflation**
Inter-Bank Rate	5.36	4.84	14.77	1.31	2.94
Deposits	31.76	14.82	5.34	9.83	1.93
Total Loans	14.71	26.72	8.09	3.58	1.55
Securities	11.65	8.38	16.26	13.47	14.95
Stock Index	23.26	26.44	38.75	7.63	5.84
Industrial Production	3.56	12.21	8.36	28.06	8.07
CPI Inflation	9.69	6.58	8.43	36.11	64.71

Growth of M2 as Monetary Policy Indicator

As mentioned in Chapter 1, the PBC, China's central bank, takes the growth of broad money (M2) as the intermediate target. Thus we can employ the growth rate of M2 as an alternative indicator of China's monetary policy. Figure 4.4 presents the impulse responses of variables to an expansionary policy shock (An innovation in growth of M2). The variance decompositions for this case are reported in Table 4.5.

Figure 4.4 Impulse Responses of All Variables for Aggregate Banks Group to Growth of M2



Generally, following a positive monetary policy shock (an innovation in growth rate of M2), the deposits and loans rise and hence increase the industrial production as well as the price level. The total deposits, total loans and the industrial production increase immediately after the expansionary monetary policy shock; thus the same loan supply story about the bank lending channel-the rise in output could be caused by the rise in loans and deposits appears again in monetary expansionary operation as it did in monetary contractionary operation. Certainly, the rise in output could also be attributed to the rise in investment: the demand for loans, and therefore the effects of monetary policy shocks on the real economy, combines the transmissions effects through the *bank lending* and *interest rate channel* mutually. We still cannot split the roles played by the bank lending channel and the monetarist channel (i.e., liquidity effects of money supply) in China's monetary policy transmission. The impulse responses results also confirm that changes in the money supply do influence the changes in output, and money supply precedes inflation.[44] The increase in Shanghai Stock Index again indicates evidence of the *asset price channel.*

Table 4.5 shows that deposits and loans contribute much to the forecasted variance of industrial production (8.09% and 24.84% respectively), supporting the evidence for the bank lending channel; they also contribute to the forecasted variance decomposition of the Stock Index, which helps to trace the effects of asset price channel. The short-term and medieum-term effects of deposits and loans on the variations of industrial production and the Stock Index are shown in Table 4.31 for this case in Appendix 4.5. Initially deposits contribute about 9.15%, increase to 10.57% in the mediuem term. Loans' contributions from 0.27% in the short run to 12.33% in the medieum-term to the variations of industrial production.

In sum, by computing the impulse responses functions and variance decompositions (Cholesky decompositions) in the VAR Models for the aggregate banks data, we can identify the existence of the *bank lending channel*, the *interest rate channel* and the *asset price channel* in China's monetary policy transmission process. Furthermore, we can conclude that the effects of a monetary policy shock on economic activity through the bank lending and the interest rate channels are different when we use a quantity tool and a price tool respectively. Our study supports the argument that the monetary policy does have influences on the real economic activities (output) in the short run, especially in an expansionary monetary operation. Moreover, the growth rate of M2 contributes about 26.51% of the forecasted variance decomposition of CPI inflation, which empirically indicates the correlation between the money supply and the rate of inflation.

[44] See, for example, the discussions on the empirical evidences between money supply and inflation in Chapter 1 in Carl E. Walsh (2003).

Table 4.5 (Cholesky) Variance Decompositions for Total Loans (Growth rate of M2 as Indicator) (60 Steps)

	Forecasted Variables				
Shock	**Deposits**	**Total Loans**	**Stock Index**	**Industrial Production**	**CPI Inflation**
Growth Rate of M2	9.74	7.76	11.05	9.77	26.51
Deposits	19.39	16.50	8.94	8.09	6.36
Total Loans	32.72	40.45	28.73	24.84	17.38
Securities	12.51	12.43	11.75	14.53	7.30
Stock Index	10.78	9.97	22.92	11.60	14.84
Industrial Production	5.94	6.78	8.37	17.69	7.73
CPI Inflation	8.93	6.12	8.24	13.48	19.87

4.4.2 The VAR Results for the Disaggregated Banks Data (Bank Type Group)

By disaggregating the total loans into loans from state-owned banks loans, which go to large, state-owned companies, and loans from non-state banks, which go to small and medium private firms, we can investigate the different behaviors of banks across the various sizes, and seek more evidence for the existence of the bank lending channel and other channels in China's monetary policy transmission.

As we did above, we choose CIBR and the growth rate of M2 as indicators of China's monetary policy, alternatively, to examine the effects of monetary policy shocks in expansionary and contractionary operations through different channels. In this subsection, we put the results of China's monetary policy transmission in either indicator together.

Figure 4.5 presents the impulse responses of the balance sheet variables (deposits, loans, and securities) of the two types of bank (state banks and non-state banks) as well as that of the macroeconomic variables (stock market index, industrial production and CPI). Following an innovation in CIBR, state bank loans decrease immediately then increase one year later; non-state bank loans rise initially then fall in the medium-long run. A shock in broad money supply increases both state and non-state bank loans immediately, but the non-state banks respond quickly. The impulse response functions indicate that the state and non-state banks behave differently in both situations, which supports the theoretical base on which the bank lending channel was developed: asymmetric information and the possibility of financial frictions in loan markets. The heterogeneous behaviors across banks and firms confirm again that the bank lending channel does exist and has effects in China. We find that both types of banks adjust their loans quickly. Moreover, the state banks react quickly to a contractionary monetary policy shock (an innovation in CIBR), and non-state banks respond rapidly to an expansionary monetary policy shock (an innovation in growth of M2). The possible reason for this may be because most state banks often follow the signals of central banks quickly because of the political factors.[45] Another possibility is that, to cool the heat economy, the non-state banks care more about their market shares and profits. Other explanations include that the underdevelopment of financial markets and frictions in the loan markets distort the normal transmission of policy signals in the loan markets for banks.

The 60-step variance decompositions in this case are displayed in Tables 4.6 and 4.7 respectively.

The variance decompositions for bank type loans in Tables 4.6 and 4.7 reflect that deposits and banks loans (in expansionary monetary operation) contribute much to the forecasted variance decomposition of output in the long term, which supports the effects of monetary policy through the bank lending channel in China. The short-term and medieum-term effects of bank type loans in the variations of industrial production are presented in Tables 4.32 and 4.33 in Appendix 4.5. Both state bank loans and non state bank loans gradually increase their contributions to the variance decompositions of industrial production.

Table 4.6 (Cholesky) Variance Decompositions for Bank Type Loans(CIBR as Indicator) (60 Steps)

	Forecasted Variables				
Shock	**Deposits**	**State Bank Loans**	**Non-State Bank Loans**	**Securities**	**Industrial Production**
Inter-Bank Rate	3.51	2.02	3.45	6.37	1.77
Deposits	28.69	7.24	4.73	16.14	8.09
State Bank Loans	6.99	20.13	28.56	3.98	2.72
Non-State Bank Loans	15.53	21.89	23.79	3.92	3.91
Securities	12.97	7.64	4.46	30.91	20.29
Stock Index	13.46	6.45	4.03	4.47	3.30
Industrial Production	6.08	23.18	17.44	6.22	23.20
CPI Inflation	12.79	11.45	13.54	27.99	36.72

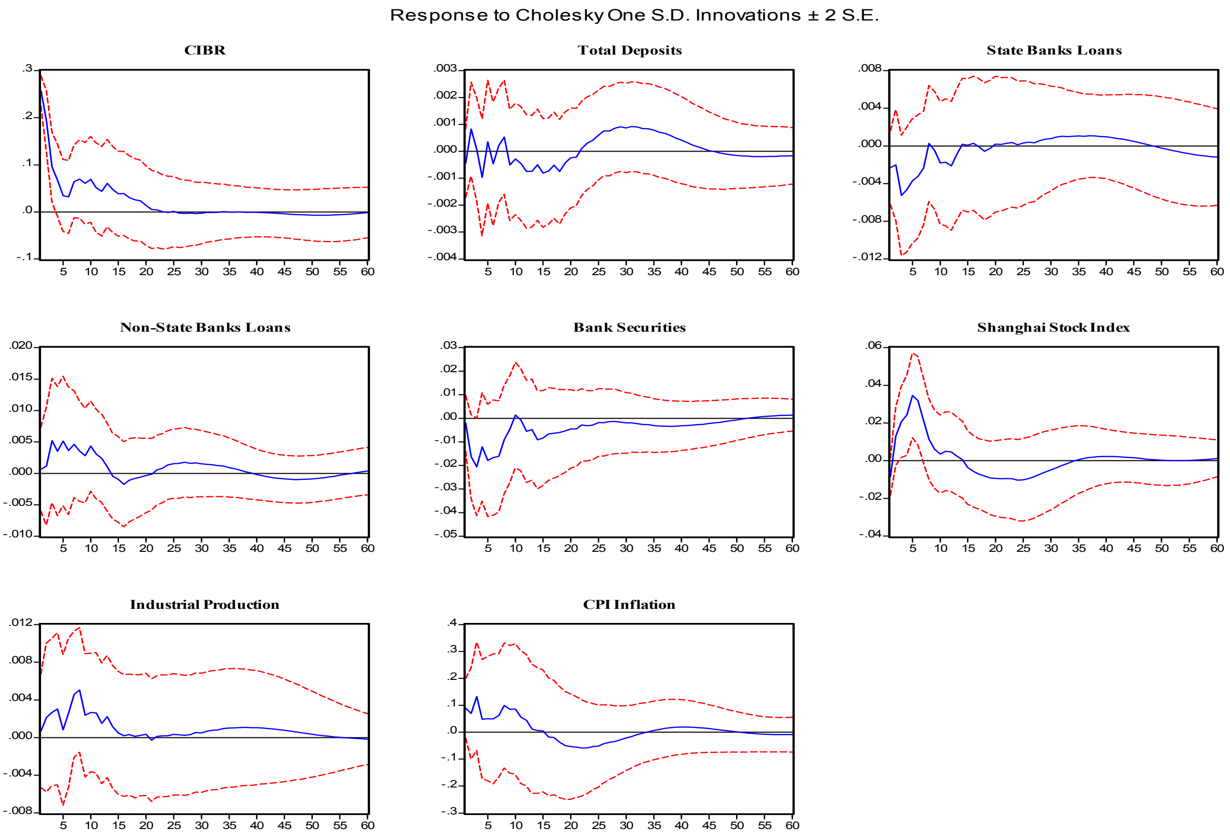
Table 4.7 (Cholesky) Variance Decompositions for Bank Type Loans (Growth rate of M2 as Indicator) (60 Steps)

	Forecasted Variables				
Shock	**Deposits**	**State Bank Loans**	**Non-State Bank Loans**	**Securities**	**Industrial Production**
Growth Rate of M2	21.91	26.70	15.99	16.14	19.08
Deposits	13.82	2.87	2.86	7.11	4.39
State Bank Loans	7.24	15.13	25.27	6.51	6.83
Non-State Bank Loans	30.75	30.60	26.21	26.02	21.35
Securities	4.50	3.07	5.47	25.86	5.40
Stock Index	14.64	7.80	9.97	9.27	34.20
Industrial Production	4.09	11.96	7.95	3.87	5.18
CPI Inflation	3.04	1.89	6.28	5.22	3.57

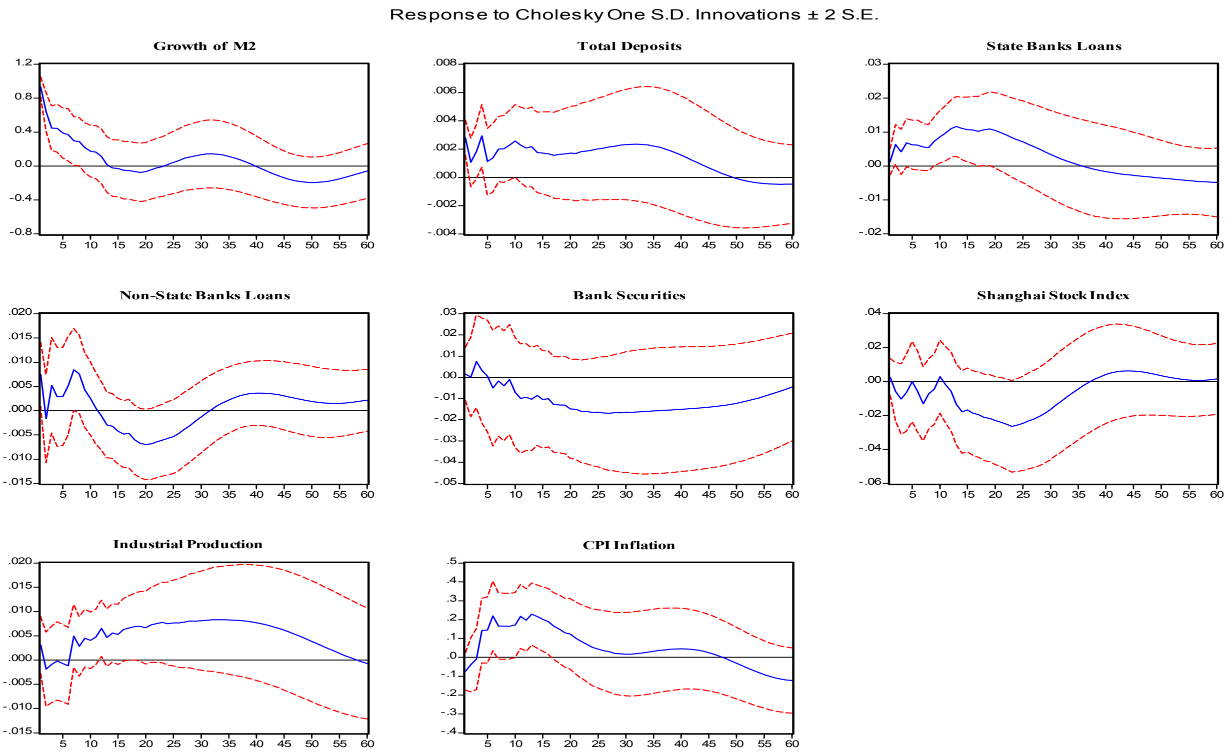
45 In the operation of China's monetary policy, window guidance still has an important influence and the top leaders in state banks are appointed by the government.

Figure 4.5 Impulse Responses of All Variables for Bank Type Group

Panel A. An Innovation in CIBR



Panel B. An Innovation in Growth of M2



4.4.3 The Discussion on Loans Based on Loans to Different Sectors

Our study's third investigation examines the effects of monetary policy shock on loans to different sectors, such as the industrial sector (industry excluding construction), the commercial sector (i.e., the service sector), and the construction sector. The different responses of loans made on these sectors to the monetary policy shock may explain some distribution and growth effects of China's monetary policy.

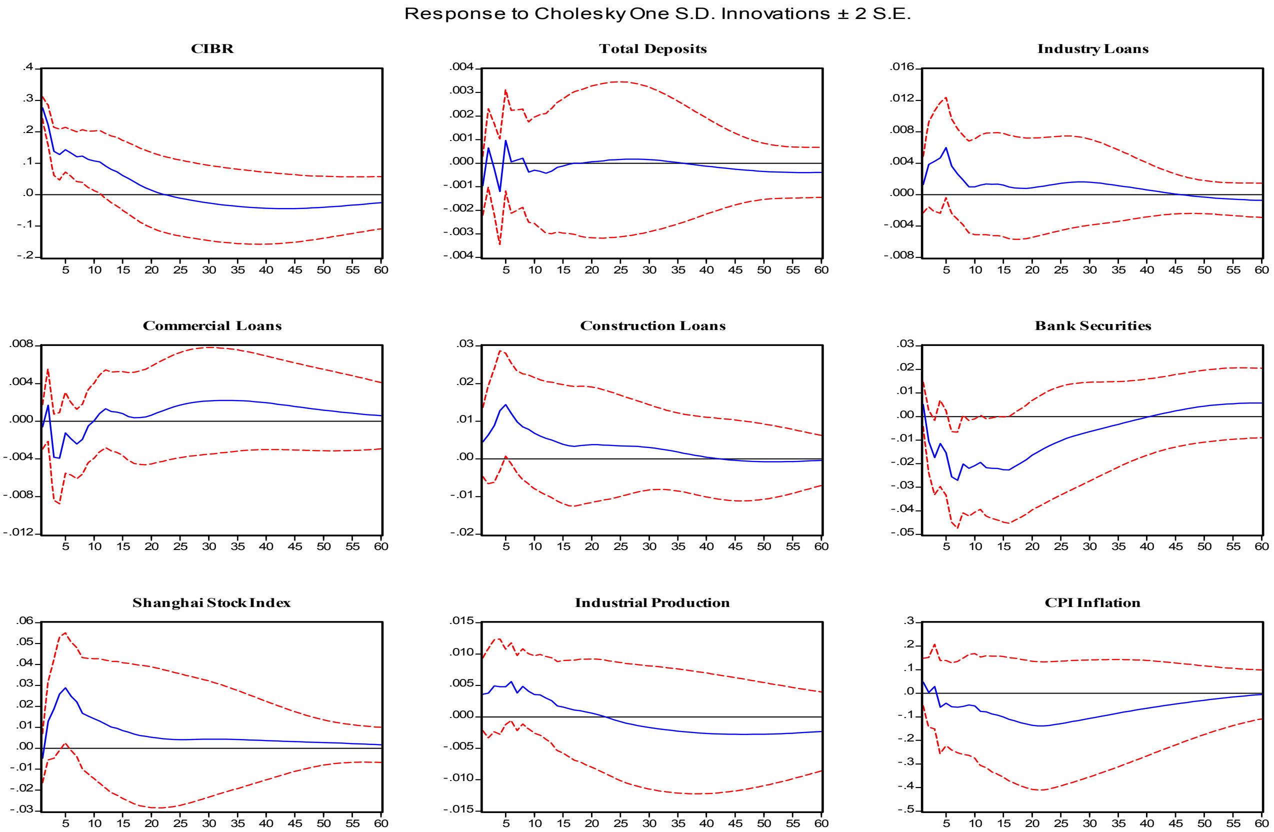
As we did in the above subsection, we display the impulse responses of all variables following a contractionary or an expansionary monetary policy shock in one figure, Figure 4.6. The variance decompositions (Cholesky decompositions) are presented in Tables 4.8 and 4.9.

Reviewing Figure 4.6, loans to different sectors react diversely following a monetary policy shock; the heterogeneous responses in loans to different sectors imply the distribution effects and growth effects of monetary policy. In a contractionary monetary policy operation that increases the interest rate, a monetary policy shock causes aggregate bank balance sheets variables (deposits and securities) to decline. Total deposits decline immediately and then again 5 months later. Bank securities fall dramatically to offset the decline of total deposits in order to meet the demand for loans; this is because loans to the construction and industry sectors do not decline, and the loans to commercial industry only fall three months later. CPI falls 12 months later, and then, after 24 months, output (industry production) falls. This shows that the Chinese service sector is more sensitive to contractionary monetary policy shocks. This is because the working capital in most service businesses severely depends on bank loans. Panel B of Figure 4.6 shows that, after an expansionary monetary policy shock that increases money supply, deposits, securities and loans to different sectors, except the commercial sector, increase immediately (referring to the error band, this may not the case for the commercial sector). Industrial production rises immediately, and the price level rises after 3 months, possibly due to the effects of interest rate channel. However, the real rise in output begins 3 months later, which could be attributed to the bank lending channel. The different magnitudes of growth (positive or negative) in loans to different sectors reflect the distribution and growth effects of China's monetary policy.

The results of variance decompositions in Table 4.8 and 4.9 also support the existence of the distribution and growth effects of monetary policy because loans to different sectors provide diverse contributions to the variance decompositions of industry production. The short-term and medieum-term effects of loans to different sectors on the variations of industrial production are presented in Tables 4.34 and 4.35 in Appendix 4.5. The contributions of these loans to the variance decompositions of industrial production increase by different magnitude.

Figure 4.6 The Impulse Responses of All Variables for Loans to Different Sectors

Panel A. An Innovation in CIBR



Panel B. An Innovation in Growth of M2

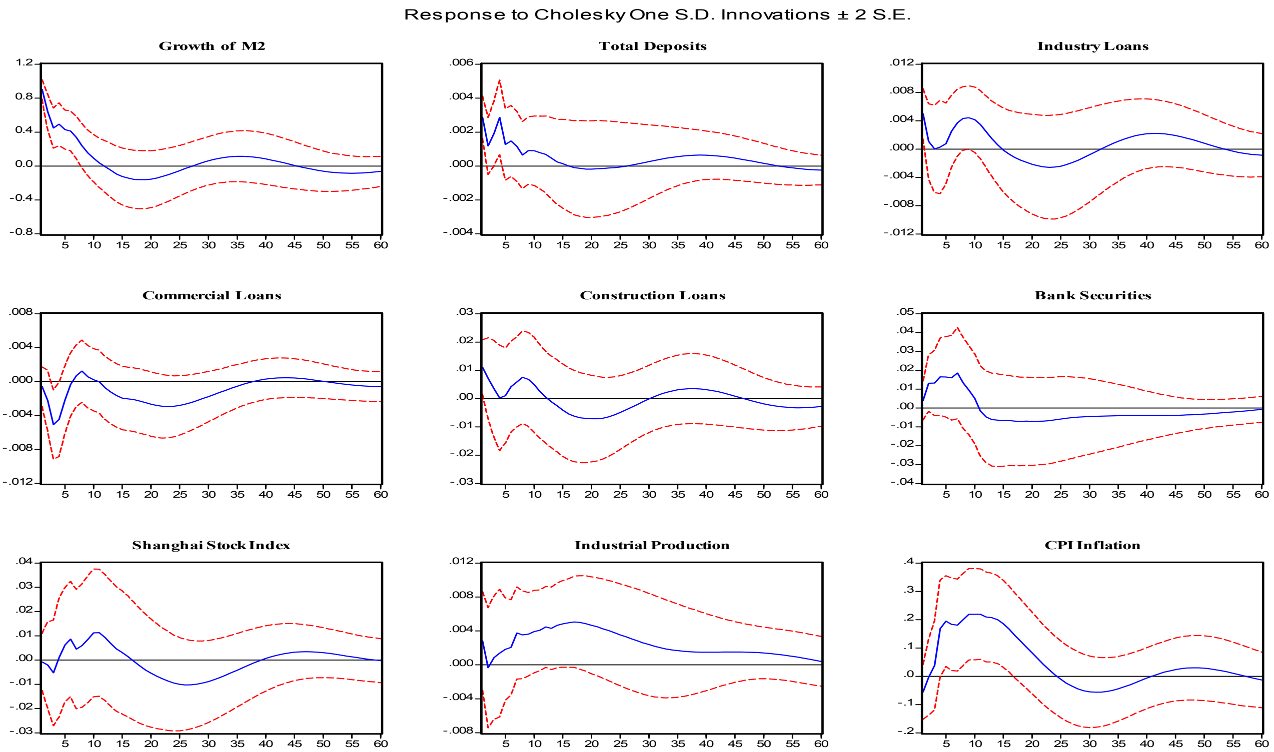


Table 4.8 (Cholesky)Variance Decompositions for Loans Type(CIBR) (60 Steps)

	Forecasted Variables					
Shock	**Deposits**	**Loans to Industry**	**Loans to commercial industry**	**Loans to Construction**	**Securities**	**Industrial Production**
CIBR	1.30	5.11	6.57	6.59	22.28	6.94
Deposits	40.88	12.36	5.72	16.71	8.64	14.41
Loans to industry	8.44	45.56	5.38	13.24	8.08	**6.71**
Loans to commercial sec.	2.14	2.87	28.19	0.96	17.84	**8.65**
Loans to construction	16.76	11.57	8.56	30.35	5.16	**4.92**
Securities	1.02	1.90	2.62	1.00	12.38	0.77
Stock Index	26.26	14.50	10.26	16.40	2.95	9.87
Industrial Production	0.89	0.73	4.77	3.88	5.96	22.04
CPI Inflation	2.31	5.40	27.93	10.86	16.72	25.70

Table 4.9 (Cholesky) Variance Decompositions for Loans Type(Growth rate of M2) (60 Steps)

	Forecasted Variables						
Shock	**Deposits**	**Loans to Industry**	**Loans to commercial industry**	**Loans to Construction**	**Securities**	**Industrial Production**	**CPI**
Growth rate of M2	4.67	4.66	9.86	3.73	4.41	8.29	21.15
Deposits	31.82	15.39	9.93	10.80	15.95	11.08	6.42
Loans to industry	6.90	26.19	8.20	10.24	7.10	**5.38**	**4.16**
Loans to commercial sec.	2.43	1.76	20.41	2.74	3.95	**3.07**	**1.04**
Loans to construction	28.56	26.71	26.62	52.06	35.95	**11.38**	**18.87**
Securities	1.44	2.01	8.17	1.91	12.53	2.06	7.05
Stock Index	15.22	15.16	5.84	12.14	8.54	18.01	12.28
Industrial Production	0.62	0.42	5.15	1.68	4.72	24.82	2.49
CPI Inflation	8.35	7.69	5.82	4.70	6.85	15.92	26.55

4.4.4 The VAR Results for Measuring the Effects of China's monetary Policy on International Trade

Given the fixed exchange rate regime in China prior to May of 2005, we cannot employ the exchange rate as an endogenous variable to test the exchange rate channel in a VAR Model, but we still can examine the effects of monetary policy on international trade variables (exports, imports, foreign exchange reserves) by using a similar VAR Model.

The impulse responses of all variables are shown in Figure 4.7. Panel A illustrates those for a contractionary monetary policy, and Panel B shows those for expansionary monetary policy operations.

From Panel A in Figure 4.7, we see that a contactionary monetary policy shock immediately decreases the aggregate bank balance sheet variables (total loans, total deposits and bank securities), stock index (asset price channel), and the exports and imports. The magnitude of fall in the imports is larger than that of exports, and the exports recover soon and begin to rise. However, the imports decline in the medium and long run ten months later. Because the fixed exchange rate regime of China prevents the appreciation of the China's currency, the prices of foreign goods are higher than that of domestic goods, and the demand for foreign goods declines (under a floating exchange rate system, the increase in interest rates appreciates the home currency and thereby makes the foreign goods more attractive than home goods.). The rise in net trade increases the foreign exchange reserves and economic output in the short run, but the output finally declines three years later due to the contractionary monetary policy.

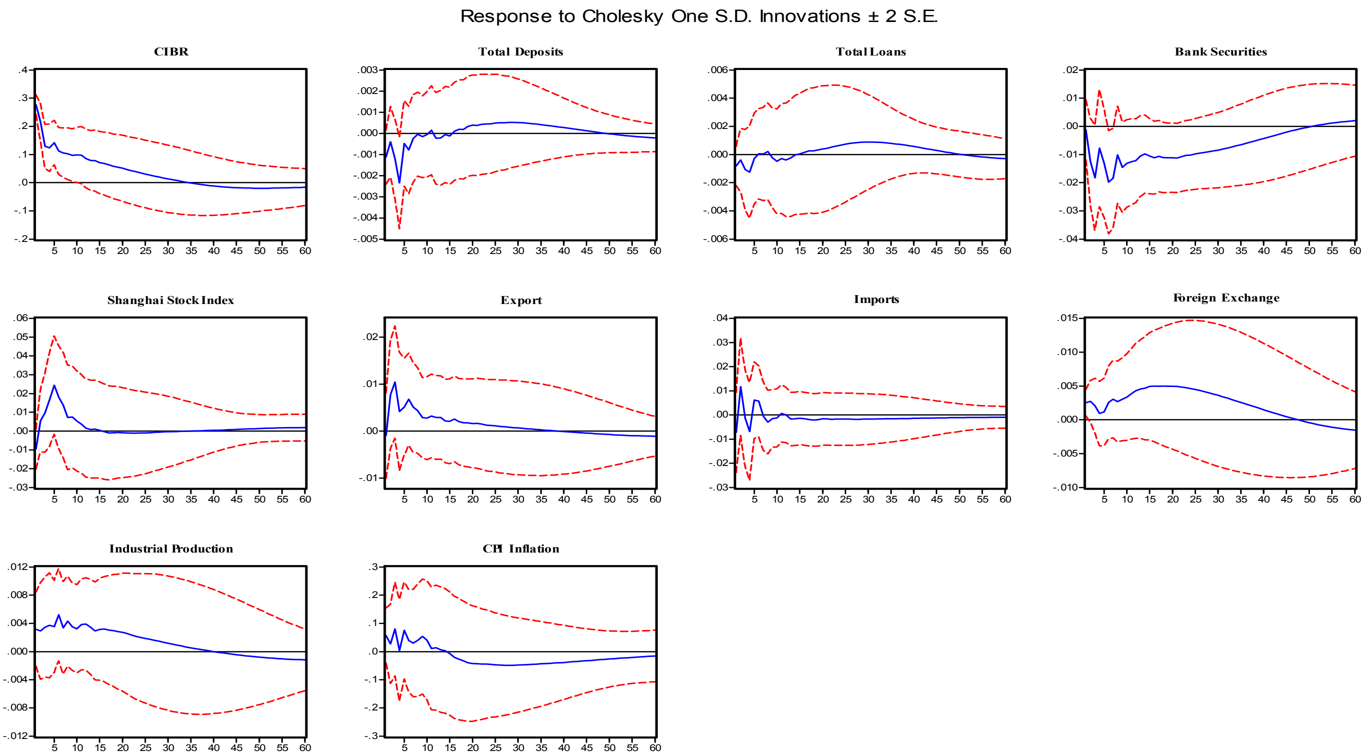
In Panel B, following an expansionary monetary policy, bank sheet variables, exports, and imports rise, which should be caused by the demand (wealth) effects rather than the exchange rate effects because of the fixed exchange rate regime: expansionary monetary policy increases the income of a household and thereby increases the aggregate demand for the international trade and industry production. At the outset, the imports rise more than the exports do. Ten months later, the rise in exports is larger than that in imports and thus increases the foreign exchange reserves.

Tables 4.10 and 4.11 show the (Cholesky) variance decompositions for all variables in this group under contractionary monetary policy and expansionary monetary policy, respectively. If we focus on the variance decompositions of exports, imports, foreign reserves and output, we can find the following properties. 1) Deposits and loans play a great role in the variance decompositions of exports and imports, because, in China, the working capital of international trade business depends on bank loans. 2) Exports dominate the variance decomposition of the forecasted foreign reserves; this provides an explanation for the huge accumulation of foreign reserves in China since the 1990s. 3) Deposits play significant roles in accumulation of foreign exchange reserves, which supports the theory of balance payments: China's high rate of saving causes the current account surplus. 4) Exports contribute largely to the variance decomposition of output (industrial production), reflecting the significant role of foreign trade in the economic growth of China. The short-term and medieum-term effects of deposits and loans on the variations of industrial production, exports and imports are presented in Tables 4.36 and 4.37 in Appendix 4.5.

Given the effects of monetary policy on international trade and the ratio of foreign trade in China's aggregate economic activities implied by above results, China's monetary policy not only targets economic stability (price level), but also aims to promote international trade and thereby to achieve sustainable economic growth.

Figure 4.7 The Impulse Responses of All Variables in International Trade Group

Panel A CIBR as the Indicator



Panel B Growth of M2 as the Indicator

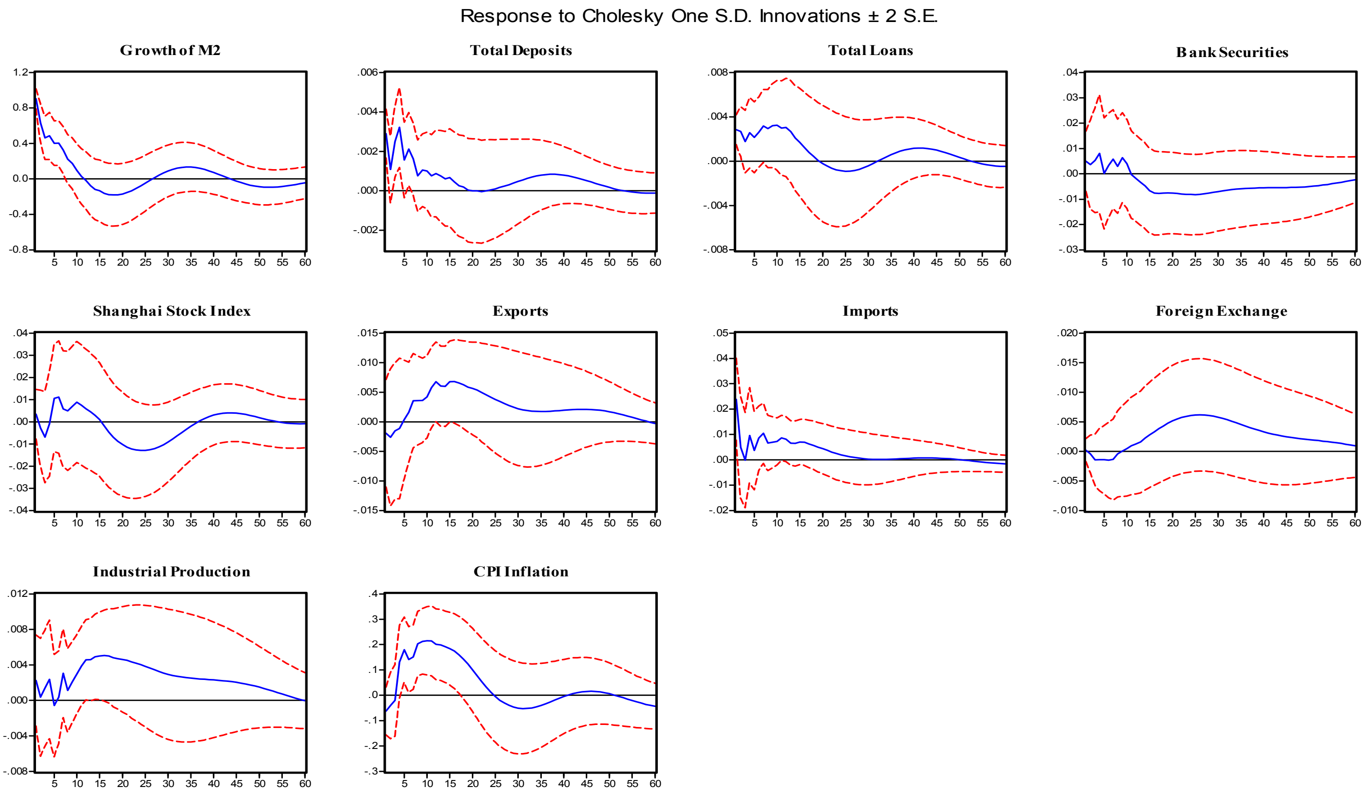


Table 4.10 (Cholesky)Variance Decompositions for International Trade Group(CIBR) (60 Steps)

	Forecasted Variables					
Shock	**Deposits**	**Total Loans**	**Exports**	**Imports**	**Foreign Exchange Reserve**	**Industrial Production**
CIBR	3.00	1.19	12.72	2.12	6.36	3.81
Deposits	35.48	19.99	**13.71**	**11.60**	**20.06**	16.72
Total Loans	16.60	29.63	**3.16**	**11.74**	**17.90**	16.92
Stock Index	6.15	5.66	16.93	3.45	3.59	3.78
Exports	24.01	18.96	38.95	14.48	**22.26**	**19.49**
Imports	6.77	15.52	1.41	35.02	**5.44**	**12.33**
Foreign Exchange Reserve	1.42	1.37	3.26	15.35	3.26	2.47
Industrial Production	3.40	1.67	0.75	0.87	9.41	2.51
CPI Inflation	1.12	3.21	5.64	0.65	2.50	10.98

Table 4.11 (Cholesky) Variance Decompositions for International Trade Group (Growth rate of M2) (60 Steps)

	Forecasted Variables						
Shock	**Deposits**	**Total Loans**	**Exports**	**Imports**	**Foreign Exchange Reserve**	**Industrial Production**	**CPI**
Growth rate of M2	7.45	5.95	5.96	8.20	5.45	7.22	18.19
Deposits	21.93	13.91	**7.04**	**6.65**	**10.58**	7.81	5.35
Total Loans	26.50	33.43	**17.28**	**11.88**	**27.99**	19.39	10.59
Stock Index	13.80	15.20	6.66	4.40	13.77	8.96	6.80
Exports	14.92	9.99	20.16	14.86	**23.36**	**27.23**	22.84
Imports	6.00	11.99	33.52	34.33	**2.49**	**6.32**	14.56
Foreign Exchange Reserve	1.01	0.83	1.91	16.18	2.12	4.02	1.73
Industrial Production	5.97	4.99	5.98	1.34	12.35	5.90	2.74
CPI Inflation	0.94	2.39	0.49	0.55	0.52	11.24	2.39

4.5 Cointegrating Vectors and the VEC Models (Long Run Relationships)

Recalling the results of unit roots tests from Appendix 4.2, we can confirm that all the variables are found to be integrated with I (1); therefore, there may exist some cointegration between the employed variables. Thus, we conduct cointegration tests using Johansen's technique.

Because the industrial production (seasonally adjusted), exports (seasonally adjusted), imports (seasonally adjusted), and bank balance sheet variables (total loans, total deposits, bank Securities) are trending series by checking, we use Model 3 of Johansen's technique[46] to conduct the cointegration tests.

For each group of variables mentioned in Section 4.3 (see Table 4.1), we present the results of cointegration tests in the Tables 4.22-4.29 in Appendix 4.3, which are summarized in Table 4.1A as follows. The results of the cointegration tests reflect that the variables in each group or

[46] See, Johansen (1995) and the guide of Eviews 5.0.

the estimated VARs system have long-run relationships. Therefore, we can employ Johansen's technique to identify the cointegrating vectors and discuss the long-run relations by setting up the VEC models.

Table 4.1A The Summary of Groups and the Cointegration Tests Results

Group Name	Total loans (Aggregate banks)		Bank type (State banks and non state banks loans)		Borrower type (Loans to different sectors, borrow sectors)		International trade (The effects on International trade)	
Sub group	**Model I** CIBR as indicator	**Model II** Growth rate of M2 as indicator	**Model III** CIBR	**Model IV** Growth rate of M2	**Model V** CIBR	**Model VI** Growth rate of M2	**Model VII** CIBR	**Model VIII** Growth rate of M2
Cointegration Equation No. [47]	4	4	5	4	5	5	6	7

By imposing restrictions, we can identify all cointegrating vectors for Model 1-8 to explore and identify the long run relationships among the indicators of China's monetary policy, bank balance sheet variables (total deposits, total loans and bank securities) and the real economic variables (output, CPI, stock index, exports, imports and foreign exchange reserves). In what follows, we will present the identified cointegrating vectors for each model. Before discussing the cointegrating vectors and VEC models, I quote some sentences from Johansen (1995, p9) as follows:

"*It must be emphasized that a cointegration analysis cannot be the final aim of an econometric investigation, but it is our impression that as an intermediate step a cointegration analysis is a useful tool in the process of gaining understanding of the relation between data and theory, which should help in building a relevant econometric model.*"

4.5.1 Cointegrating Vectors and the VEC Models for Total Loans Group

By imposing restrictions on the cointegrating coefficients, the cointegrating vectors can be identified and the VEC models can be obtained.

Table 4.12 presents the four identified cointegrating vectors for the total loans group (Model I) when CIBR is used as the indicator of China's monetary policy.

[47] For Cointegration test results for each model (group), See Appendix 4.3

Table 4.12 The Identified Cointegrating Vectors for Total Loan Group (Model I, Cibr)

Vector Error Correction Estimates
Sample (adjusted): 1996M07 2006M11
Included observations: 125 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,2)=1,B(1,3)=0,B(1,4)=0,B(1,7)=0
B(2,2)=0,B(2,3)=1,B(2,5)=0,B(2,6)=0
B(3,2)=0,B(3,1)=1,B(3,6)=0,B(3,7)=0
B(4,1)=0,B(4,4)=1,B(4,5)=0,B(4,6)=0,B(4,7)=0
Maximum iterations (500) reached.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 4):
Chi-square(1) 2.078937
Probability 0.149344

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4
CIBR(-1)	0.042991 -0.00235 [18.2597]	-0.176204 -0.01666 [-10.5746]	1	0
Total Deposit(-1)	1	0	0	-14.37232 -1.93207 [-7.43880]
Total Loan(-1)	0	1	-9.438307 -0.72951 [-12.9379]	16.95281 -2.37841 [7.12779]
Bank Securities(-1)	0	-1.588739 -0.10906 [-14.5675]	13.91445 -1.07269 [12.9715]	1
Stock Index(-1)	-0.09468 -0.0235 [-4.02932]	0	2.274005 -0.67407 [3.37356]	0
Industry Production(-1)	-0.744853 -0.01316 [-56.5944]	0	0	0
CPI Inflation(-1)	0	0.042455 -0.00873 [4.86204]	0	0
C	-5.4673	4.31969	-44.67041	-36.47845

From Table 4.12, we can obtain the following equations for the long term:

1. Total deposits, interest rate, stock index and industry production:

$$\log(Totaldeposit) = 0.745\log(Industrialproduction) + 0.0947\log(Stockindex) - 0.043CIBR + 5.467 \quad (4.12)$$

This long run equation can be interpreted as a total deposit demand function, which shows, the total deposit demand depends on the output level(+), asset price (+) and market interest rate(-). Also, *ceteris paribus*, a rise in the total deposits could increase industrial production and the stock index, decrease the interest rate in the long term..

2. Total loans, interest rate and CPI:

$$\log(Totalloan) = 1.5887\log(Security) - 0.042455CPIInflation + 0.176204CIBR - 4.32 \quad (4.13)$$

This equation represents the demand function of total loans in the long run. Total loans are positively related with market interest rate and bank securities, negatively related with CPI inflation. (4.13) indicates that, *ceteris paribus,* the rise in the interest rate can cause the rise in total loans and bank securities, reduces the CPI inflation in the long term.

3 The interest rate, total loans and Shanghai Stock Index:

$$CIBR = 9.438\log(Totalloan) - 13.914\log(Security) - 2.274\log(Stockindex) + 44.67 \quad (4.14)$$

This equation could be interpreted as a interest rate reaction function, which demonstrates that a increase in the total loans can cause an increase in the interest rate to stabilize the economy, the fall in the interest rate may increase the asset price and bank securities.

4. The relationships between the bank balance sheet variables:

$$\log(securities) = 14.37232\log(totaldeposit) - 16.9528\log(Totalloan) + 36.47845 \quad (4.15)$$

This equation can be interpreted as an total demand supply function, which suggests that the liabilities of the banks (deposits) are the sources of the assets of the banks (loans and securities).

The above equations show that the bank balance sheet variables (total deposits, total loans, and bank securities) have important effects on the real Chines economy. These cointegrating relationships connect the monetary policy variables with the macroeconomic variables (industry production, CPI inflation, and stock market index), supporting the existence of the the interest rate channel, the bank lending channel and the asset price channel in the monetary policy transmission process in China. Figure 4.8 shows these cointegrating relationships.

Figure 4.8 The Cointegrating Graphs for Total Loans Model I (CIBR as indicator)

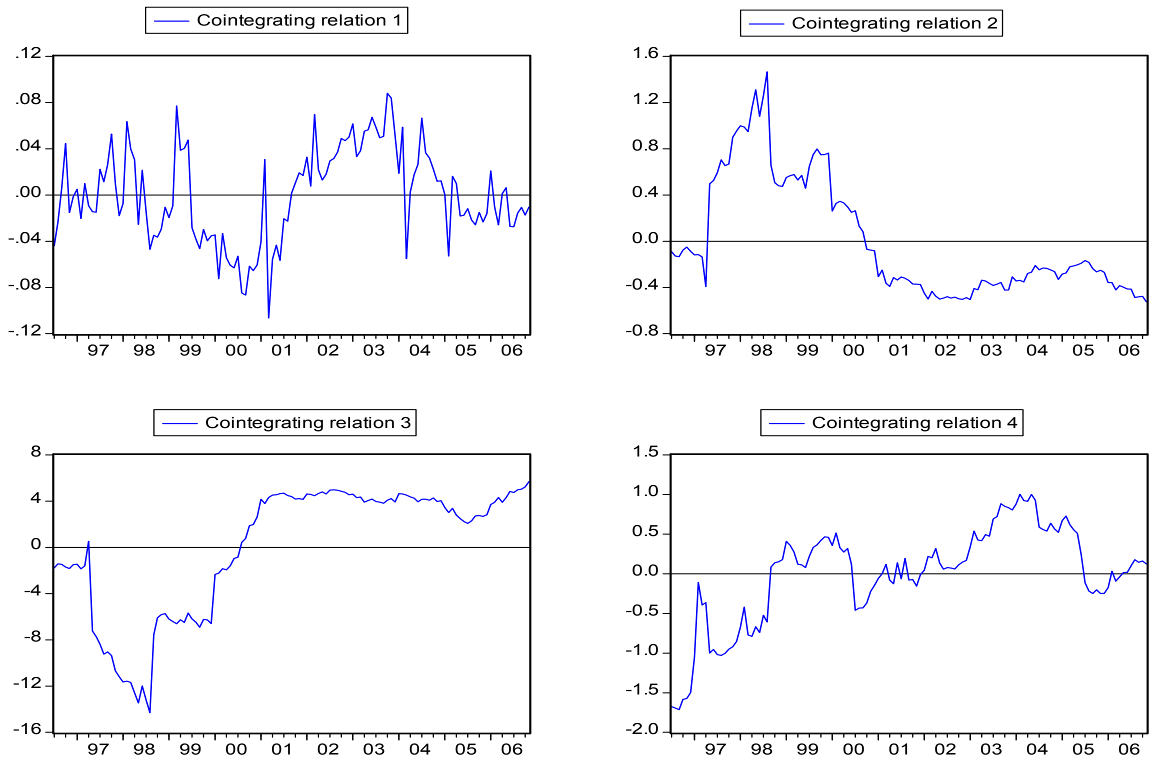


Table 4.13 demonstrates the identified cointegrating vectors for the total loans group when the growth of M2 is used as the indicator of China's monetary policy (Model II, M2).

Table 4.13 The Identified Cointegrating Vectors for Model II (Growth of M2 as the indictor)

Vector Error Correction Estimates
Sample (adjusted): 1996M09 2006M11
Included observations: 123 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1,B(1,2)=0,B(1,3)=0,B(1,4)=0
B(2,1)=0,B(2,2)=1,B(2,3)=0,B(2,4)=0
B(3,1)=0,B(3,3)=1,B(3,2)=0,B(3,4)=0
B(4,4)=1,B(4,3)=1.5,B(4,5)=0,B(4,6)=0,B(4,7)=0
Convergence achieved after 131 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 4):
Chi-square(1) 3.477419
Probability 0.062212

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4
GROWTH_RATE_OF_M2(-1)	1	0	0	0.219911
				-0.01863
				[11.8023]
Total Deposit(-1)	0	1	0	-2.072114
				-0.19795
				[-10.4678]
Total Loan(-1)	0	0	1	1.5
Bank Securities(-1)	0	0	0	1
Stock Index(-1)	5.186019	-0.128144	0.04065	0
	-0.80091	-0.04216	-0.04158	
	[6.47514]	[-3.03931]	[0.97759]	
Industrial Production(-1)	0.615764	-0.836498	-0.665833	0
	-0.45453	-0.02194	-0.01919	

	[1.35472]	[-38.1224]	[-34.6879]	
CPI Inflation(-1)	-0.347387	0.034312	0.031502	0
	-0.08448	-0.0045	-0.00449	
	[-4.11186]	[7.63262]	[7.02169]	
C	-58.82623	-4.369633	-6.718784	-6.182485

From Table 4.13, we also can obtain the identified long run relationships when the growth of broad money is chosen as the indicator of China's monetary policy as follows:

5. The indicator of monetary policy, Shanghai Stock Index Industrial Production and, CPI:

$$GrowthofM2 = 0.347CPI - 0.6158\log(Industrialproduction) - 5.186\log(Stockindex) + 58.83 \quad (4.16)$$

This equation shows that, *ceteris paribus,* the increase in the money supply can increase the CPI inflation rate, but cannot increase the output and stock values in the long run.

6. Total deposits, stock index, output and CPI:

$$\log(Totaldeposit) = 0.8365\log(Industrialproduction) + 0.128\log(Stockindex) - 0.0431CPI + 4.37 \quad (4.17)$$

This equation confirms that the increase in saving (total deposits) makes the output, stock market value rise in the long run.

7. Total loans, stock index, output and CPI

$$\log(Totalloan) = 0.6658\log(Industryproduction) - 0.0407\log(Stockindex) - 0.0315CPI + 6.719 \quad (4.18)$$

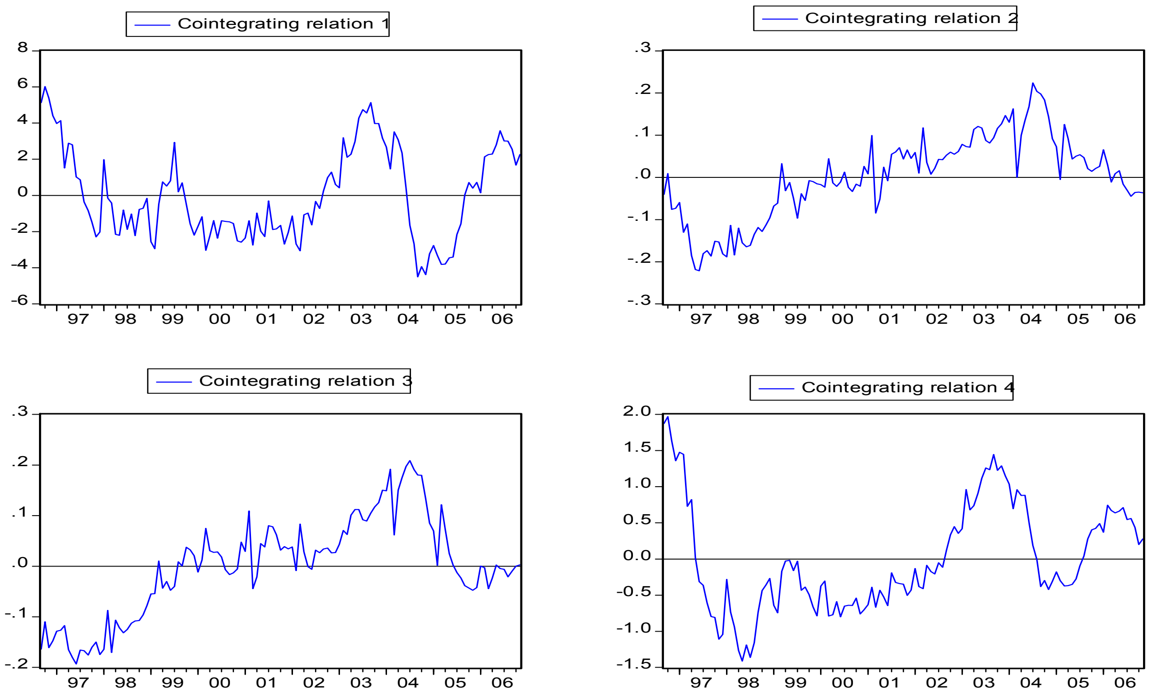
8. The bank balance sheet variables and the growth of M2:

$$\log(Securities) = 2.072\log(Totaldeposit) - 1.5\log(Totalloan) - 0.2199GrowthofM2 + 6.1825 \quad (4.19)$$

These equations also confirm that the deposits and the bank loans play significant roles in Chines real economy, connecting the monetary policy indicators with the macroeconomic variables, implying the existence of the bank lending channel.

Figure 4.9 presents the above four cointegrating relationships against the indicators of China's monetary policy, the bank balance sheet variables (total deposits, total loans, and bank securities), stock market index and macro economy variables (industrial production, CPI inflation) in the long term.

Figure 4.9 The Cointegrating Graphs for Total Loans Model II (Growth of M2 as indicator)



4.5.2 Identified Cointegrating Vectors for Bank Type Group (Model III-IV)

The identified cointegrating vectors for Bank Type Group (Model III CIBR and Model IV for Growth of M2 are reported in Table 4.14 and 4.15 as follows:

In Table 4.14, there are five long term relations in this model. The first relation shows that the total deposits have positive correlations with the industry production. The second relation demonstrates that the positive correlations between the state bank loans and the CPI inflation rate. The rise in state bank loans may cause the rise in the inflation. The third equation shows a “price puzzle”. The fourth relationship connects the balance sheet variables of the banks with the stock index. The final equation is the relation between the banks balance sheet variables.

Table 4.14 Identified Cointegrating Vectors for Bank Type Group (Model III, CIBR)

Vector Error Correction Estimates
Sample (adjusted): 1996M07 2006M11
Included observations: 125 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,2)=1,B(1,4)=0,B(1,6)=0,B(1,8)=0
B(2,1)=0,B(2,3)=1,B(2,4)=0,B(2,6)=0,B(2,7)=0
B(3,1)=1,B(3,2)=0,B(3,3)=0,B(3,4)=0,B(3,5)=0,B(3,7)=0
B(4,1)=0,B(4,4)=0,B(4,5)=1,B(4,7)=0,B(4,8)=0
B(5,1)=0,B(5,4)=1,B(5,6)=0,B(5,7)=0,B(5,8)=0
Convergence achieved after 10 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 5):

Chi-square(1)	0.006562				
Probability	0.935435				
Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5
CIBR(-1)	0	0	1	0	0
Total Deposit(-1)	1	-0.251076 -0.03453 [-7.27207]	0	3.17633 -0.30866 [10.2908]	-1.644948 -0.07968 [-20.6438]
State Bank Loan(-1)	3.255114 -0.12109 [26.8819]	1	0	-10.19783 -0.19102 [-53.3875]	0.018773 -0.12658 [0.14832]
Non State Bank Loan(-1)	0	0	0	0	1
Bank Securities(-1)	-1.103009 -0.04275 [-25.8040]	-0.197687 -0.00586 [-33.7495]	0	1	0.099037 -0.03204 [3.09137]
Shanghai Stock Index(-1)	0	0	-8.104953 -1.32378 [-6.12260]	-1.427715 -0.24372 [-5.85807]	0
Industrial Production(-1)	-1.190124 -0.08511 [-13.9834]	0	0	0	0
CPI Inflation(-1)	0	-0.008726 -0.00087 [-10.0839]	-0.814401 -0.05903 [-13.7967]	0	0
C	-28.59068	-6.396708	55.76031	78.17836	7.980578

Table 4.15 presents the long term relations when growth of M2 is used to be the indicator of China's monetary policy.

The first relation shows the rise in the total deposits could increase the rises in the output in the long term.

The second relation demonstrates the positive correlation between the state bank loans, total deposit and the CPI inflation.

The third equation shows that the rise in the growth of broad money could increase the rise in the output in the long term.

The fourth relation connects the banks balance sheet variables with the growth of money supply (The rise in money supply will cause the rises in the state banks and non state banks loans.

Table 4.15 Identified Cointegrating Vectors for Bank Type Group (Model IV, M2)

Vector Error Correction Estimates
Sample (adjusted): 1996M07 2006M11
Included observations: 125 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,2)=1,B(1,4)=0,B(1,6)=0,B(1,8)=0
B(2,1)=0, (B(2,2)=-0.5376), B(2,3)=1,B(2,4)=0,B(2,6)=0,B(2,7)=0
B(3,1)=1,B(3,2)=0,B(3,3)=0,B(3,4)=0,B(3,5)=0,B(3,8)=0
B(4,1)=1,B(4,6)=0,B(4,7)=0,B(4,8)=0
Maximum iterations (500) reached.

Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 4):
Chi-square(4) 9.839663
Probability 0.079908

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4
GROWTH_RATE_OF_M2(-1)	0	0	1	1
Total Deposit(-1)	1	-0.537604 -0.05883 [-9.13839]	0	119.9541 -18.1997 [6.59101]
State Bank Loan(-1)	0.438667 -0.0896 [4.89609]	1	0	-59.50714 -10.1518 [-5.86171]
Non State Bank Loan(-1)	0	0	0	-63.94794 -9.34601 [-6.84227]
Bank Securities(-1)	-0.052719 -0.04632 [-1.13815]	0.172795 -0.04168 [4.14573]	0	0.552083 -1.5758 [0.35035]
Stock Index(-1)	0	0	8.075385 -1.13842 [7.09347]	0
Industry Production(-1)	-0.911567 -0.05327 [-17.1113]	0	-0.649536 -0.7562 [-0.85895]	0
CPI Inflation(-1)	0	-0.021133 -0.0028 [-7.55597]	0	0
C	-9.107573	-6.549472	-70.30409	-110.3539

4.5.3 Identified Cointegrating Vectors for Borrow Type Group (Model V-VI)

Following the above procedure, in this subsection, we identify the cointegrating vectors for Loans to the different sectors group (Model V-VI).

In Table 4.16, when the CIBR is used, five cointegrating relations can be found. The first is the positive relationship between the industry loans with the industrial production. The second shows the rise in the loans to the industry production could cause the rise in the CPI inflation. The third connects the loans to different sectors with the stock market. The fourth shows that the rise in the interest rate could depress the output and increase the CPI, a “price puzzle”. The fifth demonstrates the total deposits have positive relationships with the loans to different sectors, this confirms that the total deposits are the sources of the loans.

Table 4.16 Identified Cointegrating Vectors for Borrow Type Group (Model V, CIBR)

Vector Error Correction Estimates
Sample (adjusted): 1996M05 2006M11
Included observations: 127 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,2)=0,B(1,3)=1,B(1,6)=0,B(1,7)=0,B(1,9)=0
B(2,1)=0,B(2,2)=0,B(2,4)=1,B(2,6)=0,B(2,7)=0,B(2,8)=0

B(3,1)=0,B(3,5)=1,B(3,6)=0,B(3,8)=0,B(3,9)=0
B(4,1)=1,B(4,2)=0,B(4,3)=0,B(4,4)=0,B(4,5)=0,B(4,6)=0
B(5,1)=0,B(5,2)=1,B(5,7)=0,B(5,8)=0,B(5,9)=0
Maximum iterations (500) reached.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 5):
Chi-square(3) 6.193792
Probability 0.102553

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5
CIBR(-1)	0	0	0	1	0
Total Deposit(-1)	0	0	-0.828184	0	1
			-0.04099		
			[-20.2033]		
Industry Loan(-1)	1	-0.379702	0.08174	0	-0.240525
		-0.13155	-0.0922		-0.10867
		[-2.88644]	[0.88654]		[-2.21338]
Commercial Loan(-1)	-4.388777	1	-1.099567	0	1.272139
	-0.3884		-0.152		-0.17799
	[-11.2996]		[-7.23389]		[7.14708]
Construction Loan(-1)	1.566254	0.42414	1	0	-0.854003
	-0.10228	-0.06629			-0.0674
	[15.3135]	[6.39789]			[-12.6710]
Bank Securities (-1)	0	0	0	0	-0.266067
					-0.01392
					[-19.1091]
Shanghai Stock Index(-1)	0	0	-0.04077	-1.955989	0
			-0.03676	-0.82597	
			[-1.10923]	[-2.36812]	
Industry Production(-1)	-1.526799	0	0	1.069844	0
	-0.07893			-0.59875	
	[-19.3427]			[1.78679]	
CPI Inflation(-1)	0	0.032367	0	-0.579563	0
		-0.00389		-0.06542	
		[8.32292]		[-8.85923]	
C	33.1184	-9.296915	12.42455	2.327289	-12.84006

Table 4.17 Identified Cointegrating Vectors for Borrow Type Group (Model VI, M2)

Vector Error Correction Estimates
Sample (adjusted): 1996M05 2006M11
Included observations: 127 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,2)=0,B(1,3)=1,B(1,6)=0,B(1,7)=0,B(1,9)=0
B(2,1)=0,B(2,2)=0,B(2,4)=1,B(2,6)=0,B(2,7)=0,B(2,8)=0
B(3,1)=0,B(3,5)=1,B(3,6)=0,B(3,8)=0,B(3,9)=0
B(4,1)=1,B(4,2)=0,B(4,3)=0,B(4,4)=0,B(4,5)=0,B(4,6)=0,B(4,8)=0
B(5,1)=0,B(5,2)=1,B(5,7)=0,B(5,8)=0,B(5,9)=0
Maximum iterations (500) reached.

Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 5):
Chi-square(4) 8.388429
Probability 0.078342

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5
GROWTH_RATE_OF_M2(-1)	0	0	0	1	0
Total Deposit(-1)	0	0	-6.141529	0	1
			-0.82569		
			[-7.43807]		
Industry Loan(-1)	1	0.069207	5.863545	0	0.568296
		-0.15033	-2.00294		-0.34193
		[0.46036]	[2.92747]		[1.66205]
Commercial Loan(-1)	-4.417117	1	-16.38288	0	0.666062
	-0.32548		-2.39108		-0.31133
	[-13.5710]		[-6.85168]		[2.13941]
Construction Loan(-1)	0.882379	0.105623	1	0	-1.450695
	-0.11223	-0.08382			-0.15611
	[7.86196]	[1.26019]			[-9.29262]
Bank Securities(-1)	0	0	0	0	-0.351353
					-0.03456
					[-10.1671]
Shanghai Stock Index(-1)	0	0	-0.472015	6.288258	0
			-0.25477	-1.24472	
			[-1.85269]	[5.05195]	
Industrial Production(-1)	-1.266923	0	0	0	0
	-0.08288				
	[-15.2862]				
CPI Inflation(-1)	0	0.036654	0	-0.117067	0
		-0.00383		-0.14578	
		[9.57513]		[-0.80306]	
C	36.55344	-11.30192	170.7639	-62.41786	-9.530172

In Table 4.17, there are also five cointegrating relations. The fourth relation connects the growth of broad money with CPI (positive correlation). Other relations are similar as those in Table 4.16.

4.5.4 Identified Cointegrating Vectors for International Trade Group (Model VII-VIII)

For the international trade group, by imposing restrictions on the cointegrating coefficients like above, we obtain the identified cointegrating vectors among the indicator of China's monetary policy, the balance sheet variables, the output and CPI and the international trade variables (exports, imports, and foreign exchange reserves).

Table 4.18 shows the identified cointegrating vectors for International trade group when CIBR is used to be the indicator of China's monetary policy.

Table 4.18 The Identified Cointegrating Vectors for International Trade Group (CIBR)

Vector Error Correction Estimates
Sample (adjusted): 1996M05 2006M11
Included observations: 127 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,2)=1,B(1,5)=0,B(1,6)=0,B(1,7)=0,B(1,8)=0,B(1,10)=0

B(2,1)=0,B(2,5)=1,B(2,6)=0,B(2,7)=0,B(2,8)=0,B(2,9)=0,B(2,10)=0
B(3,1)=1,B(3,2)=0,B(3,3)=0,B(3,4)=0,B(3,6)=0,B(3,7)=0,B(3,8)=0
B(4,1)=0,B(4,3)=1,B(4,5)=0,B(4,6)=0,B(4,7)=0,B(4,8)=0,B(4,9)=0
B(5,1)=0,B(5,5)=0,B(5,6)=1,B(5,8)=0,B(5,9)=0,B(5,10)=0
B(6,1)=0,B(6,2)=1,B(6,5)=0,B(6,6)=0,B(6,7)=0,B(6,9)=0,B(6,10)=0

Maximum iterations (500) reached.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 6):

Chi-square(5)	21.70066
Probability	0.000597

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5	CointEq6
CIBR(-1)	0	0	1	0	0	0
Total Deposit(-1)	1	-17.40894	0	-0.928767	-0.725381	1
		-1.2527		-0.032	-0.2621	
		[-13.8972]		[-29.0239]	[-2.76760]	
Total Loan(-1)	-0.802299	20.69184	0	1	0.557509	0.431675
	-0.02573	-1.54604			-0.27164	-0.09456
	[-31.1870]	[13.3837]			[2.05239]	[4.56520]
Bank Securities(-1)	-0.176568	1.22763	0	0.194128	0.096722	-0.312706
	-0.01077	-0.28539		-0.01567	-0.02625	-0.02704
	[-16.3948]	[4.30152]		[12.3864]	[3.68493]	[-11.5634]
Stock Index(-1)	0	1	-0.835064	0	0	0
			-0.57737			
			[-1.44633]			
Export(-1)	0	0	0	0	1	0
Import(-1)	0	0	0	0	-0.940232	0
					-0.05094	
					[-18.4573]	
Foreign Exchange (-1)	0	0	0	0	0	-0.630031
						-0.03556
						[-17.7187]
Industrial Production(-1)	-0.186384	0	0.755522	0	0	0
	-0.01199		-0.64262			
	[-15.5476]		[1.17569]			
CPI Inflation(-1)	0	0	-0.719313	0.009068	0	0
			-0.06667	-0.00098		
			[-10.7894]	[9.26710]		
C	0.648121	-53.38295	-3.120028	-2.501789	0.442484	-6.044489

In Table 4.18, the interesting relations are those connecting the exports, imports and foreign exchange reserves with the macroeconomic variables. For example, the positive relation between the total deposits, total loans with the exports (Cointegrating equation 5). The sixth long run relation connects the total deposits with foreign exchange reserves, the higher the total deposits (saving), the higher the foreign exchange reserves.

Similarly, by imposing restrictions, the identified cointegrating vectors for international trade group Model VIII (the growth of M2 as the indicator of China's monetary policy) are reported in Table 4.19. Seven long run relationships between the indicator of China's monetary policy, bank balance sheet variables and the international trade variables can be found as follows in Table 4.19.

Table 4.19 The Identified Cointegrating Vectors for International Trade Group (M2)

Vector Error Correction Estimates
Sample (adjusted): 1996M05 2006M11
Included observations: 127 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=0,B(1,3)=1,B(1,4)=0,B(1,5)=0,B(1,6)=0,B(1,7)=0,B(1,8)=0,B(1,10)=0
B(2,1)=0,B(2,2)=1,B(2,4)=0,B(2,6)=0,B(2,7)=0,B(2,8)=0,B(2,9)=0,B(2,10)=0
B(3,1)=0,B(3,3)=1,B(3,4)=0,B(3,5)=0,B(3,6)=0,B(3,7)=0,B(3,8)=0,B(3,9)=0
B(4,1)=1,B(4,2)=0,B(4,3)=0,B(4,4)=0,B(4,6)=0,B(4,7)=0,B(4,8)=0,B(4,9)=0
B(5,1)=0,B(5,4)=0,B(5,5)=0,B(5,6)=1,B(5,8)=0,B(5,9)=0,B(5,10)=0
B(6,1)=0,B(6,3)=1,B(6,4)=0,B(6,5)=0,B(6,6)=0,B(6,7)=0,B(6,9)=0,B(6,10)=0
B(7,1)=0,B(7,3)=0,B(7,4)=1,B(7,5)=0,B(7,6)=0,B(7,7)=0,B(7,9)=0,B(7,10)=0
Maximum iterations (500) reached.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 7):
Chi-square(6) 25.93494
Probability 0.000229

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5	CointEq6	CointEq7
GROWTH_RATE_OF_M2(-1)	0	0	0	1	0	0	0
Total Deposit(-1)	0.151312	1	-0.825716	0	-0.260459	-0.230048	-5.551513
	-0.05744		-0.0375		-0.13186	-0.02795	-0.22172
	[2.63432]		[-22.0212]		[-1.97526]	[-8.22978]	[-25.0386]
Total Loan(-1)	1	-1.265064	1	0	-0.106925	1	0
		-0.02246			-0.12586		
		[-56.3335]			[-0.84953]		
Bank Security(-1)	0	0	0	0	0	0	1
Stock Index(-1)	0	-0.155383	0	5.280139	0	0	0
		-0.0138		-1.61847			
		[-11.2579]		[3.26242]			
Export(-1)	0	0	0	0	1	0	0
Import(-1)	0	0	0	0	-0.849431	0	0
					-0.04058		
					[-20.9338]		
Foreign Exchange(-1)	0	0	0	0	0	-0.310734	2.675326
						-0.01251	-0.13279
						[-24.8306]	[20.1475]
Industrial Production(-1)	-0.737042	0	0	0	0	0	0
	-0.03811						
	[-19.3389]						
CPI Inflation(-1)	0	0	-0.03858	-0.919337	0	0	0
			-0.00357	-0.17739			
			[-10.8156]	[-5.18255]			
C	-7.60652	3.9877	-1.792023	-54.01917	2.677219	-5.046487	22.96695

Also, in Table 4.19, we can find the similar interesting relations between the exports, imports and foreign exchange reserves with the macroeconomic variables as in Table 4.18.

The most important relation is that the rise in the deposits can increase the foreign exchange reserves. From Table 4.18 and the long run relationship between the deposit and the foreign exchange reserves (CointeEq. 7), the sixth relation should be spurious.

4.6 Summary and Conclusions

In this chapter we have examined the differential effects of monetary policy shock on banks balance sheets variables (deposits, loans, securitises) across bank categories (aggregate banks, state banks, non-state banks) and on macro economic activities (output, consumer price index, exports, imports, foreign exchange reserves) by estimating VAR Models to uncover the transmission mechanism of China's monetary policy. Our study identifies and tests the existence of the *bank lending channel,* the *interest rate channel* and the *asset price channel* by using the aggregate and disaggregated banks data in term of bank and loans types. Furthermore, we explore and discuss the distribution and growth effects of China's monetary policy by using data on bank loans to different sectors. Thirdly, we investigate the effects of China's monetary policy on China's foreign trade in contractionary and expansionary policies, respectively. Finally, we identify the cointegrating vectors among these variables and set up VEC Models to uncover the long run relationships that connect the monetary policy, bank balance sheet variables, and macroeconomic variables in China. The results of this study reveal many implications for implementations of China's monetary policy.

The study covers more than a 10-year period (January 1996 to December 2006), which includes a weak recession period (1996-2001) with a deflation threat and a rapid recovery period with a high economic growth rate and low inflation rate. The reshaping of China's economic structure and financial regulations (or deregulations) has taken place during this period with the development and openness of China.

First, we have presented significant results from aggregate bank data, bank type data, and loan type data that comply with the asymmetric-information-based and finance-friction-based monetary transmission theories. Both the impulse response functions from the aggregate bank data and the disaggregated data simulations confirm the existence of the *bank lending channel,* the *interest rate channel and* the *asset price channel* in China's monetary policy transmission for both contractionary and expansionary activities. In particular, a monetary policy shock influences the bank behaviors across the bank and loans types. The heterogeneous behaviour across bank and loans types (borrowers) reflect asymmetric information and frictions in the loan market, supporting the theoretical base on which the bank lending channel was developed. This empirical evidence implies that China's monetary policy can affect macroeconomic activities by constraining or augmenting the loan supply through the bank lending channel. Moreover, given the immature and tiny scale of China's capital market, in which the direct capital raising is rationed and difficult, most of China's firms obtain external capital mainly depend on the banks loans. The bank lending channel does and will play a great role in the implementation of China's monetary policy to achieve its multiple goals. The identification of *the asset price channel* in China's monetary transmission can contribute significantly to the development of China's financial markets.

Second, the diversity in the responses from bank loans to different sectors to China's monetary policy shocks in both expansionary or contractionary operations qualitatively and quantitatively show that China's monetary policy play a role in economic distribution and growth and not just in stabilization. This can provide some possible explanations for the rapid economic growth in China since 1978. It also implies the importance of improving the effects and efficiency of China's monetary policy's transmission.

Third, we find that China's monetary policy did affect exports and imports; thus it did influence foreign reserves and output by impacting the terms of trade even before 2005 when China maintained a fixed exchange rate system. Given the current long-term account surplus, the huge accumulation of foreign exchange reserves and the recent adoption of a managed floating exchange rate system in China, this imbalance of international trade cannot be sustainable in the long run. Therefore, reducing the dependence of China's economic growth on international trade, especially exports, and seeking economic growth models that are more sound and sustainable are the main challenges to Chinese policy makers.

Finally, the identification of cointegrating relationships and VEC Models suggest the long-run relationships between the indicators of China's monetary policy, bank balance sheet variables (total deposits, total loans, and bank securities), and the real economic variables (output, CPI inflation, export, import, foreign exchange reserve), which confirms again that bank loans play a significant role in the transmission effects of monetary policy on the real economy in China.

Appendix 4.1 Data: Sources and Construction

Data are monthly from January 1996 to December 2006.

1 ***Macroeconomic data:***

Inter-bank weighted average rate: it is a weighted average of inter-banks interest rate including inter-bank overnight rate, inter-bank weekly rate, inter-bank 14 days rate, inter-bank monthly data, inter-bank two months data, three months data and inter-bank 4 months data. The inter-bank overnight rate dominates the weights in average. The data are collected from the Data Base of China's Economic Networks.

Growth rate of M2: it is monthly growth rate of broad money from the central bank and the Data Base of China's Economic Networks.

Industrial Production: it is monthly industry adding value from the National Statistics Bureau of China.

Stock Market Index: it is the end-month composite index (A Shares) of Shanghai Stock Market from the Data Base of China's Economic Networks and Shanghai Securities Trade Agency.

CPI: it is monthly net consumer's price index from the National Statistics Bureau of China and IFS.

Export: it is monthly volume of goods exports from the Data Base of China's Economic Networks and IFS.

Import: it is monthly volume of goods imports from the Data Base of China's Economic Networks and IFS.

Foreign Exchange Reserves: it is end-month accumulated foreign exchange reserves from the Data Base of China's Economic Networks and IFS.

2 ***Banks' Balance Sheets Data***

Bank's balance sheet data are from the People's Bank of China in Chinese currency, RMB, excluding the foreign currencies given the foreign currencies are rare used in the operations of domestic firms because of the regulation on foreign currency in China. Data from 1996 to 1999 are collected from the Data Base of China's Economic Networks.

Total Deposits: including demand deposits, savings deposits and time deposits in RMB.

Total Loans: consists of all loans to firms, household and institutions in RMB.

Securities: the investment of banks on bonds and other equities in RMB.

The use of loans:

State Banks Loans: banks loans from state owned big banks, mainly consisting of Commercial and Industry Bank of China, Bank of China, Agricultural Bank of China and

Construction Bank of China.

Non-state Banks Loans: loans from private banks, holding banks and foreign banks in RMB, most of them are small-medium banks.

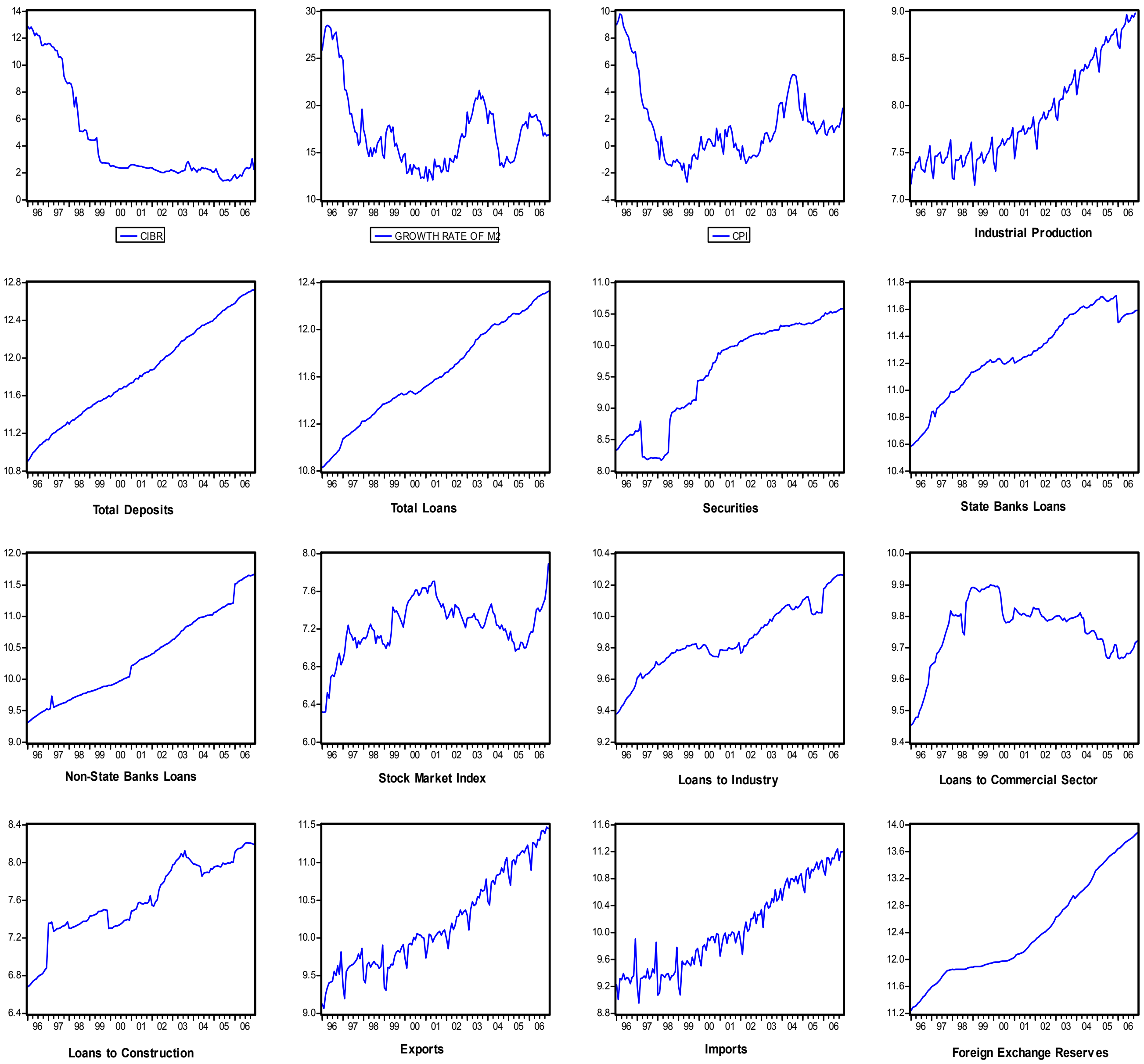
Loans to industry: loans extended for manufacture firms in RMB.

Loans to commercial sector: loans extended for service sector in RMB.

Loans to Construction: loans extended for construction sector.

All variables are graphically shown in Figure 4.10

Figure 4.10 All Variables Employed by the VEC Model (Non seasonally Adjusted; Log level excluding CIBR, Growth rate of M2 and CPI Inflation)



Appendix 4.2 The Results of Unit Roots Tests

Table 4.20 Augmented Dickey Fuller Tests on Unit Roots for all variables

(All variables in log level excluding the CIBR, Growth rate of M2, and CPI Inflation; Industrial Production, Exports, and Imports are seasonal adjusted by X12 approach)

No	Variables	Level	First Difference	Integration Order I( )
1	CIBR (Inter-Bank weight average rate)	-1.090448	-11.44710*	1
2	Growth rate of M2	-1.928968	-12.58975*	1
3	Industrial Production	-1.411231	-12.64923*	1
4	CPI Inflation	-2.309244	-12.37492*	1
5	Total loans	-2.043317	-9.075165*	1
6	Total deposits	-2.601544	-2.481981	>1
7	Securities	-1.369118	-11.67492*	1
8	State banks loans	-1.461132	-11.40432*	1
9	Non-state banks loans	-1.486994	-14.27718*	1
10	Loans to industry	3.711444	-9.514662*	1
11	Loans to commercial sector	0.978767	-8.573893*	1
12	Loans to construction	-2.726180	-11.33162*	1
13	Exports	-0.905718	-13.04839*	1
14	Imports	-2.412666	-13.45037*	1
15	Foreign exchange reserves	-0.573275	-7.07166*	1
16	Stock Market Index	-2.407367	-7.999141*	1
	1% Critical Value*	-4.029595	-4.010357	
	5% Critical Value**	-3.44487	-3.444756	
	10% Critical Value***	-3.147063	--3.147221	

Table 4.21 Philips-Perron Tests on Unit Roots for all variables

(All variables in log level excluding the CIBR, Growth rate of M2, and CPI Inflation; Industrial Production, Exports, and Imports are seasonal adjusted by X12 approach)

No	Variables	Level	First Difference	Order I( )
1	CIBR (Inter-Bank weight average rate)	-1.079867	-11.44591*	1
2	Growth rate of M2	-1.925148	-27.79934*	1
3	Industrial Production	-1.079845	-12.64923*	1
4	CPI Inflation	-2.291693	-12.37706*	1
5	Total loans	-2.219350	-9.204935*	1
6	Total deposits	-2.877610	-14.23495*	1
7	Securities	-1.493564	-11.67493*	1
8	State banks loans	-1.371133	-11.47795*	1
9	Non-state banks loans	-1.733440	-14.47162*	1
10	Loans to industry	-2.560330	-10.34191*	1
11	Loans to commercial sector	-2.952558	-9.079619*	1
12	Loans to construction	-2.746373	-11.33529*	1
13	Exports	-2.559082	-21.83549*	1
14	Imports	0.235484	-29.55445*	1
15	Foreign exchange reserves	-0.421330	-7.557914*	1
16	Stock Market Index	-2.448651	-9.771553*	1
	1% Critical Value*	-4.029595	-4.010357	
	5% Critical Value**	-3.44487	-3.444756	
	10% Critical Value***	-3.147063	--3.147221	

Appendix 4.3 Results of Cointegration Tests and the VECM Equations

Table 4.22 The Cointegration Test for Total Loans Group (CIBR as indicator)

Trend assumption: Linear deterministic trend

Series: CIBR, TOTAL DEPOSIT, TOTAL LOAN, SECURITIES, STOCK INDEX, INDUSTRIAL PRODUCTION CPI INFLATION

Lags interval (in first differences): 1 to 5

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.463809	206.57	125.6154	0
At most 1 *	0.287662	128.662	95.75366	0.0001
At most 2 *	0.247109	86.26174	69.81889	0.0014
At most 3 *	0.183845	50.78231	47.85613	0.0259
At most 4	0.112075	25.3884	29.79707	0.148
At most 5	0.071986	10.52987	15.49471	0.2421
At most 6	0.009485	1.191321	3.841466	0.2751

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4.23 The Cointegration Test for Total Loans Group (Growth rate of M2 as indicator)

Trend assumption: Linear deterministic trend

Series: GROWTH_RATE_OF_M2, TOTAL DEPOSIT, TOTAL LOAN, SECURITIES, STOCK INDEX, INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 7

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.446662	238.4845	125.6154	0
At most 1 *	0.36202	165.6948	95.75366	0
At most 2 *	0.325999	110.4125	69.81889	0
At most 3 *	0.257259	61.88606	47.85613	0.0014
At most 4	0.100045	25.30487	29.79707	0.1508
At most 5	0.072022	12.33939	15.49471	0.1414
At most 6	0.025249	3.145458	3.841466	0.0761

Table 4.24 The Cointegration Test for Bank Type Loans Group (CIBR as indicator)

Trend assumption: Linear deterministic trend

Series: CIBR, TOTAL DEPOSIT, STATE BANK LOAN, NON STATE BANK LOAN, SECURITIES, STOCK INDEX, INDUSTRIAL PRODUCTION CPI INFLATION

Lags interval (in first differences): 1 to 5

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.473993	289.3823	159.5297	0
At most 1 *	0.43667	209.0772	125.6154	0
At most 2 *	0.297178	137.3409	95.75366	0
At most 3 *	0.248821	93.2595	69.81889	0.0002
At most 4 *	0.238913	57.49552	47.85613	0.0048
At most 5	0.090575	23.36954	29.79707	0.2284
At most 6	0.076236	11.50173	15.49471	0.1824

Table 4.25 The Cointegration Test for Bank Type Loans Group (Growth rate of M2 as indicator)

Trend assumption: Linear deterministic trend

Series: GROWTH_RATE_OF_M2, TOTAL DEPOSIT, STATE BANK LOAN, NON STATE BANK LOAN, SECURITIES, STOCK INDEX, INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 5

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.473704	271.8957	159.5297	0
At most 1 *	0.370992	191.6591	125.6154	0
At most 2 *	0.335495	133.7077	95.75366	0
At most 3 *	0.251344	82.61849	69.81889	0.0034
At most 4	0.158905	46.434	47.85613	0.0676
At most 5	0.122744	24.8027	29.79707	0.1686
At most 6	0.062333	8.433137	15.49471	0.4203
At most 7	0.0031	0.38813	3.841466	0.5333

Table 4.26 The Cointegration Test for Loans To different sectors Group (CIBR as indicator)

Trend assumption: Linear deterministic trend

Series: CIBR, TOTAL DEPOSIT, INDUSTRY LOAN, COMMERCIAL LOAN, CONSTRUCTION LOAN, SECURITIES, STOCK INDEX INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 3

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.451343	290.5157	197.3709	0
At most 1 *	0.346835	214.2799	159.5297	0
At most 2 *	0.319088	160.1873	125.6154	0.0001
At most 3 *	0.253243	111.3783	95.75366	0.0027
At most 4 *	0.193526	74.29226	69.81889	0.021
At most 5	0.156274	46.97668	47.85613	0.0603
At most 6	0.118761	25.39582	29.79707	0.1478
At most 7	0.051477	9.339626	15.49471	0.3349

Table 4.27 The Cointegration Test for Loans To different sectors Group (Growth rate of M2 as indicator)

Trend assumption: Linear deterministic trend

Series: GROWTH_RATE_OF_M2, TOTAL DEPOSIT, INDUSTRY LOAN, COMMERCIAL LOAN, CONSTRUCTION LOAN, SECURITIES, STOCK INDEX, INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 3

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.440539	293.7564	197.3709	0
At most 1 *	0.380484	219.9973	159.5297	0
At most 2 *	0.291453	159.1875	125.6154	0.0001
At most 3 *	0.269975	115.431	95.75366	0.0011
At most 4 *	0.216717	75.46719	69.81889	0.0165
At most 5	0.159206	44.44597	47.85613	0.1009
At most 6	0.103874	22.42302	29.79707	0.2756
At most 7	0.059723	8.494433	15.49471	0.4141

Table 4.28 The Cointegration Test for International Trade Group (CIBR as indicator)

Trend assumption: Linear deterministic trend

Series: CIBR, TOTAL DEPOSIT, TOTAL LOAN, SECURITIES, STOCK INDEX, EXPORT, IMPORT FOREIGN EXCHANGE, INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 3

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.471165	366.5807	239.2354	0
At most 1 *	0.42739	285.6716	197.3709	0
At most 2 *	0.356686	214.8626	159.5297	0
At most 3 *	0.337787	158.8401	125.6154	0.0001
At most 4 *	0.246921	106.4948	95.75366	0.0074
At most 5 *	0.178387	70.47942	69.81889	0.0442
At most 6	0.145403	45.52576	47.85613	0.0814
At most 7	0.105273	25.57092	29.79707	0.142
At most 8	0.066177	11.44387	15.49471	0.1856
At most 9	0.021409	2.748448	3.841466	0.0973

Table 4.29 The Cointegration Test for International Trade Group (Growth rate of M2 as indicator)

Trend assumption: Linear deterministic trend

Series: GROWTH_RATE_OF_M2, TOTAL DEPOSIT, TOTAL LOAN, SECURITIES, STOCK INDEX, EXPORT IMPORT FOREIGN EXCHANGE, INDUSTRIAL PRODUCTION, CPI INFLATION

Lags interval (in first differences): 1 to 3

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 critical value	Prob.**
None *	0.487287	380.907	239.2354	0
At most 1 *	0.431275	296.0659	197.3709	0
At most 2 *	0.368238	224.3925	159.5297	0
At most 3 *	0.297598	166.0686	125.6154	0
At most 4 *	0.269114	121.206	95.75366	0.0003
At most 5 *	0.226461	81.39178	69.81889	0.0045
At most 6 *	0.178298	48.78082	47.85613	0.0408
At most 7	0.127925	23.8409	29.79707	0.2073
At most 8	0.036529	6.457189	15.49471	0.6415
At most 9	0.013539	1.731146	3.841466	0.1883

Appendix 4.4 The Structural Innovations in CBIR and Growth Rate of M2

We report the regression results for the structural innovations with the unanticipated residuals of base money and required rate of reserve. The following abbreviations have been made as following:

·cibrrtloan: for *cibr* residuals for total loans group

·cibrrbloan: for *cibr* residuals for bank type group

·cibrrbortype: for *cibr* residuals for borrow type group

·cibrrtrade: for *cibr* residuals for international trade group

·m2rtloan: for growth rate of M2 residuals for total loans group

·m2rbbloan: for growth rate of M2 residuals for bank type group

·m2rbortype: for growth rate of M2 residuals for borrow type group

·m2rtrade: for growth rate of M2 residuals for international trade group

And

·residualmb: predicted errors for base money equation (unanticipated changes in base money)

·residualrrr: predicted errors for required rate of reserve equation (unanticipated changes in required rate of reserve)

The results for estimation for total loans group and other groups are presented below:

·For Total Loans Group

Dependent Variable: CIBRRTLOAN				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 10 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.056192	0.031961	1.758154	0.082
RESIDUALMB(-1)	-0.059912	0.033711	-1.777234	0.0788
RESIDUALMB(-2)	0.051655	0.033058	1.562547	0.1216
RESIDUALMB(-3)	-0.016228	0.030799	-0.526904	0.5995
RESIDUALMB(-6)	0.019703	0.024475	0.805002	0.4229
RESIDUALMB(-12)	-0.005982	0.02692	-0.222199	0.8247
RESIDUALRRR	0.011366	0.011116	1.022461	0.3092
RESIDUALRRR(-1)	-0.037946	0.012557	-3.021873	0.0033
RESIDUALRRR(-2)	0.038809	0.012547	3.093204	0.0026
RESIDUALRRR(-3)	-0.016521	0.011557	-1.429478	0.1563
RESIDUALRRR(-6)	-0.005918	0.010186	-0.580963	0.5627
RESIDUALRRR(-12)	-0.013531	0.009934	-1.36216	0.1765
AR(1)	0.20595	0.102692	2.005513	0.0478
AR(5)	-0.172812	0.104458	-1.654371	0.1015
R-squared	0.209917	Mean dependent var		-0.002266
Adjusted R-squared	0.098275	S.D. dependent var		0.20341
S.E. of regression	0.193157	Akaike info criterion		-0.328131
Sum squared resid	3.432469	Schwarz criterion		0.023644
Log likelihood	31.39096	Durbin-Watson stat		2.053687
Inverted AR Roots	.61+.41i	.61-.41i	-.18+.67i	-.18-.67i
	-0.67			

Dependent Variable: M2RTLOAN				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 8 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.094553	0.099245	0.952723	0.3432
RESIDUALMB(-1)	0.213258	0.113177	1.884283	0.0627
RESIDUALMB(-2)	-0.141193	0.112133	-1.259158	0.2112
RESIDUALMB(-3)	0.126412	0.093354	1.354113	0.179
RESIDUALMB(-6)	0.061022	0.066698	0.914899	0.3626
RESIDUALMB(-12)	-0.228036	0.07604	-2.99892	0.0035
RESIDUALRRR	0.011077	0.035267	0.314076	0.7542
RESIDUALRRR(-1)	0.022042	0.043566	0.505942	0.6141
RESIDUALRRR(-2)	-0.01037	0.043439	-0.238723	0.8119
RESIDUALRRR(-3)	-0.014477	0.035711	-0.405393	0.6861
RESIDUALRRR(-6)	-0.04503	0.027836	-1.617694	0.1092
RESIDUALRRR(-12)	-0.009304	0.02765	-0.336488	0.7373
AR(1)	-0.064489	0.108665	-0.593469	0.5543
AR(5)	-0.103008	0.098025	-1.050825	0.2961
R-squared	0.153806	Mean dependent var		-0.016411
Adjusted R-squared	0.034235	S.D. dependent var		0.604699
S.E. of regression	0.594258	Akaike info criterion		1.919496
Sum squared resid	32.48916	Schwarz criterion		2.27127
Log likelihood	-87.73326	Durbin-Watson stat		1.976305
Inverted AR Roots	.50+.37i	.50-.37i	-.21-.60i	-.21+.60i
	-0.65			

·For Bank Type Group

Dependent Variable: CIBRRBLOAN				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 11 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.041426	0.031944	1.296816	0.1979
RESIDUALMB(-1)	-0.040878	0.03416	-1.196649	0.2345
RESIDUALMB(-2)	0.037138	0.033389	1.112274	0.2689
RESIDUALMB(-3)	-0.015065	0.0309	-0.487525	0.627
RESIDUALMB(-6)	0.022878	0.024712	0.925773	0.357
RESIDUALMB(-12)	-0.016029	0.026722	-0.599833	0.5501
RESIDUALRRR	0.012777	0.011079	1.153237	0.2518
RESIDUALRRR(-1)	-0.042274	0.012629	-3.347303	0.0012
RESIDUALRRR(-2)	0.043108	0.012608	3.419093	0.0009
RESIDUALRRR(-3)	-0.016815	0.011522	-1.459418	0.1479
RESIDUALRRR(-6)	-0.007786	0.010086	-0.771918	0.4421
RESIDUALRRR(-12)	-0.008903	0.009852	-0.90365	0.3685
AR(1)	0.181065	0.104073	1.73979	0.0852
AR(5)	-0.181223	0.106088	-1.708232	0.091
R-squared	0.208418	Mean dependent var		-0.001526
Adjusted R-squared	0.096564	S.D. dependent var		0.202681
S.E. of regression	0.192647	Akaike info criterion		-0.333412
Sum squared resid	3.414391	Schwarz criterion		0.018363
Log likelihood	31.67083	Durbin-Watson stat		2.055169
Inverted AR Roots	.61+.42i	.61-.42i	-.18+.67i	-.18-.67i
	-0.68			

Dependent Variable: M2RBLOAN				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 10 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.118452	0.115419	1.026281	0.3075
RESIDUALMB(-1)	0.055033	0.126615	0.434648	0.6648
RESIDUALMB(-2)	-0.043384	0.125314	-0.346205	0.73
RESIDUALMB(-3)	0.061162	0.109735	0.557363	0.5786
RESIDUALMB(-6)	0.05434	0.081021	0.670688	0.5041
RESIDUALMB(-12)	-0.144525	0.092099	-1.569233	0.12
RESIDUALRRR	-0.026753	0.041025	-0.65213	0.5159
RESIDUALRRR(-1)	0.043874	0.04854	0.903867	0.3684
RESIDUALRRR(-2)	-0.050344	0.048309	-1.042124	0.3001
RESIDUALRRR(-3)	0.015294	0.041577	0.367853	0.7138
RESIDUALRRR(-6)	-0.042493	0.034281	-1.239525	0.2183
RESIDUALRRR(-12)	0.007093	0.033994	0.208669	0.8352
AR(1)	0.040125	0.107939	0.371737	0.7109
AR(5)	-0.1339	0.098405	-1.3607	0.1769
R-squared	0.069725	Mean dependent var		-0.008406
Adjusted R-squared	-0.061727	S.D. dependent var		0.671313
S.E. of regression	0.691721	Akaike info criterion		2.223233
Sum squared resid	44.02001	Schwarz criterion		2.575008
Log likelihood	-103.8314	Durbin-Watson stat		1.976081
Inverted AR Roots	.55-.39i	.55+.39i	-.20+.64i	-.20-.64i
	-0.66			

·For Borrow Type Group

Dependent Variable: CIBRRBORTYPE				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 10 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.034514	0.034654	0.995944	0.3219
RESIDUALMB(-1)	-0.025407	0.036922	-0.688115	0.4931
RESIDUALMB(-2)	0.014179	0.036378	0.389759	0.6976
RESIDUALMB(-3)	-0.02535	0.03272	-0.774752	0.4405
RESIDUALMB(-6)	0.014401	0.025919	0.555596	0.5798
RESIDUALMB(-12)	-0.015511	0.028808	-0.538423	0.5916
RESIDUALRRR	0.018774	0.012103	1.551115	0.1243
RESIDUALRRR(-1)	-0.053842	0.013736	-3.919727	0.0002
RESIDUALRRR(-2)	0.068846	0.013963	4.930778	0
RESIDUALRRR(-3)	-0.028279	0.012652	-2.235179	0.0278
RESIDUALRRR(-6)	-0.003529	0.010761	-0.327974	0.7437
RESIDUALRRR(-12)	-0.026022	0.010648	-2.443785	0.0164
AR(1)	0.165952	0.104549	1.587313	0.1159
AR(5)	-0.105857	0.108118	-0.979081	0.3301
R-squared	0.309254	Mean dependent var		0.000198
Adjusted R-squared	0.211649	S.D. dependent var		0.233706
S.E. of regression	0.207506	Akaike info criterion		-0.184816
Sum squared resid	3.961389	Schwarz criterion		0.166959
Log likelihood	23.79526	Durbin-Watson stat		2.006158
Inverted AR Roots	.55+.37i	.55-.37i	-.17+.60i	-.17-.60i
	-0.61			

Dependent Variable: M2RBORTYPE				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 9 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.04692	0.121803	0.385211	0.701
RESIDUALMB(-1)	0.028722	0.134124	0.214144	0.8309
RESIDUALMB(-2)	-0.089021	0.133004	-0.669309	0.505
RESIDUALMB(-3)	0.018082	0.115968	0.155919	0.8764
RESIDUALMB(-6)	0.043574	0.083959	0.518986	0.605
RESIDUALMB(-12)	-0.137453	0.095136	-1.444801	0.1519
RESIDUALRRR	-0.034044	0.042715	-0.796994	0.4275
RESIDUALRRR(-1)	0.058818	0.051996	1.131211	0.2609
RESIDUALRRR(-2)	-0.054028	0.051831	-1.042379	0.3
RESIDUALRRR(-3)	0.00889	0.043583	0.203989	0.8388
RESIDUALRRR(-6)	-0.023415	0.035214	-0.664914	0.5078
RESIDUALRRR(-12)	-0.00629	0.034738	-0.181086	0.8567
AR(1)	-0.001595	0.107997	-0.01477	0.9882
AR(5)	-0.155281	0.098977	-1.568853	0.1201
R-squared	0.077187	Mean dependent var		-0.009142
Adjusted R-squared	-0.05321	S.D. dependent var		0.70884
S.E. of regression	0.727455	Akaike info criterion		2.32397
Sum squared resid	48.68548	Schwarz criterion		2.675745
Log likelihood	-109.1704	Durbin-Watson stat		1.987114

·For International Trade Group

Dependent Variable: CIBRRTRADE				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 12 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	0.051559	0.033505	1.538843	0.1273
RESIDUALMB(-1)	-0.018275	0.036322	-0.503132	0.6161
RESIDUALMB(-2)	0.009297	0.036064	0.257794	0.7971
RESIDUALMB(-3)	-0.014859	0.031016	-0.479083	0.633
RESIDUALMB(-6)	0.013023	0.024397	0.533823	0.5948
RESIDUALMB(-12)	-0.005836	0.027933	-0.208918	0.835
RESIDUALRRR	0.009365	0.011823	0.792093	0.4303
RESIDUALRRR(-1)	-0.049669	0.013562	-3.662257	0.0004
RESIDUALRRR(-2)	0.067106	0.013851	4.844728	0
RESIDUALRRR(-3)	-0.022599	0.012269	-1.842031	0.0687
RESIDUALRRR(-6)	-0.005691	0.010215	-0.557103	0.5788
RESIDUALRRR(-12)	-0.026124	0.010214	-2.557759	0.0122
AR(1)	0.119809	0.109854	1.090627	0.2783
AR(5)	-0.012401	0.113406	-0.109349	0.9132
R-squared	0.336598	Mean dependent var		0.001079
Adjusted R-squared	0.242857	S.D. dependent var		0.231027
S.E. of regression	0.201026	Akaike info criterion		-0.248263
Sum squared resid	3.717859	Schwarz criterion		0.103512
Log likelihood	27.15794	Durbin-Watson stat		1.95279
Inverted AR Roots	.36+.24i	.36-.24i	-.11+.39i	-.11-.39i
	-0.39			

Dependent Variable: M2RTRADE				
Method: Least Squares				
Sample (adjusted): 1998M02 2006M11				
Included observations: 106 after adjustments				
Convergence achieved after 9 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUALMB	-0.001364	0.11821	-0.011536	0.9908
RESIDUALMB(-1)	0.128539	0.130463	0.985252	0.3271
RESIDUALMB(-2)	-0.199709	0.129114	-1.546766	0.1254
RESIDUALMB(-3)	0.127472	0.111215	1.146172	0.2547
RESIDUALMB(-6)	0.062246	0.081029	0.768191	0.4443
RESIDUALMB(-12)	-0.078585	0.092676	-0.847956	0.3987
RESIDUALRRR	-0.034257	0.041697	-0.821562	0.4135
RESIDUALRRR(-1)	0.057073	0.051055	1.117882	0.2665
RESIDUALRRR(-2)	-0.037097	0.050454	-0.735259	0.4641
RESIDUALRRR(-3)	0.013539	0.042291	0.32015	0.7496
RESIDUALRRR(-6)	-0.016655	0.034142	-0.48781	0.6268
RESIDUALRRR(-12)	-0.009256	0.033881	-0.273198	0.7853
AR(1)	0.001729	0.109862	0.015735	0.9875
AR(5)	-0.12082	0.101241	-1.193383	0.2358
R-squared	0.074003	Mean dependent var		-0.013567
Adjusted R-squared	-0.056844	S.D. dependent var		0.684307
S.E. of regression	0.703488	Akaike info criterion		2.256968
Sum squared resid	45.53037	Schwarz criterion		2.608743
Log likelihood	-105.6193	Durbin-Watson stat		1.993532

Appendix 4.5 Variance Decompositions of Forecasted Variables (1-60 STEPS)

Table 4.30 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Total Bank Loans Group (CIBR as Indicator)

Cholesky Ordering: CIBR DEPOSITS LOANS SECURITIES STOCK MARKET INDEX INDUS. PRODUC. CPI

Variance Decomposition of CIBR:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	100	0	0	0	0	0	0
3	87.31	0.22	2.64	6.37	0.87	0.68	1.90
7	56.40	10.71	4.25	22.62	1.37	2.24	2.41
10	39.90	12.97	3.02	34.07	1.49	2.88	5.66
20	27.54	10.13	3.27	34.23	1.50	7.84	15.49
40	20.16	7.91	3.17	26.07	1.18	7.60	33.90
60	18.13	7.11	3.95	23.77	2.95	9.83	34.25
Variance Decomposition of DEPOSITS:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	1.67	98.33	0.00	0.00	0.00	0.00	0.00
3	1.17	88.03	3.89	1.84	1.46	0.28	3.34
7	2.67	66.76	12.49	9.01	2.85	2.25	3.98
10	2.76	59.23	13.99	8.39	9.14	2.79	3.70
20	4.01	41.95	16.13	6.09	25.82	2.96	3.04
40	5.54	33.87	14.70	11.94	24.19	3.26	6.50
60	5.36	31.76	14.71	11.65	23.26	3.56	9.69
Variance Decomposition of LOANS:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	1.81	21.80	76.39	0.00	0.00	0.00	0.00
3	2.55	20.46	70.14	4.04	0.53	0.01	2.26
7	2.54	25.19	44.80	10.19	3.67	11.02	2.58
10	2.04	27.47	35.90	7.44	8.16	16.59	2.41
20	2.72	18.97	30.34	5.20	25.35	13.07	4.35
40	4.85	15.95	27.26	8.32	26.50	11.86	5.26
60	4.84	14.82	26.72	8.38	26.44	12.21	6.58
Variance Decomposition of SECURITIES:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	0.05	0.68	0.21	99.06	0.00	0.00	0.00
3	4.24	0.65	2.87	78.90	4.04	0.08	9.21
7	6.28	0.73	4.78	54.59	4.33	3.05	26.23
10	5.71	5.28	6.99	47.34	3.80	3.37	27.51
20	5.17	18.47	6.17	40.25	3.26	5.00	21.69
40	4.90	16.88	5.49	37.20	4.02	7.22	24.29
60	4.58	15.04	4.98	34.62	3.89	6.68	30.21
Variance Decomposition of STOCK MARKET INDEX:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	1.46	0.11	1.60	0.09	96.75	0.00	0.00
3	8.18	0.90	5.79	7.63	77.27	0.14	0.09
7	23.13	1.63	5.35	11.20	57.30	0.58	0.82
10	20.72	3.24	6.66	10.16	56.75	0.63	1.84
20	16.28	4.69	8.35	10.60	46.61	7.73	5.74
40	15.17	4.75	7.77	16.50	39.01	8.50	8.30
60	14.77	5.34	8.09	16.26	38.75	8.36	8.43
Variance Decomposition of INDUSTRIAL PRODUCTION:							
Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	0.01	12.42	0.19	0.53	0.26	86.58	0.00
3	0.46	11.31	0.38	4.23	2.18	79.80	1.64
7	1.39	12.83	1.21	5.09	2.76	69.35	7.36
10	1.86	15.05	1.16	6.87	2.56	61.49	11.02
20	1.42	15.21	3.07	10.42	5.36	42.94	21.58
40	1.20	10.55	3.90	12.68	8.46	30.47	32.76
60	1.31	9.83	3.58	13.47	7.63	28.06	36.11
Variance Decomposition of CPI:							

Period	CIBR	DEPOSITS	LOANS	SECURITIES	STOCK INDEX	INDUS. PRODUCTION	CPI
1	2.30	1.50	0.21	0.83	0.22	6.64	88.30
3	2.77	0.70	0.35	6.38	0.16	3.01	86.62
7	2.29	1.30	0.26	14.71	2.94	2.08	76.42
10	3.06	1.06	0.30	17.62	2.57	2.05	73.34
20	2.72	1.16	0.58	16.67	3.21	4.10	71.55
40	2.91	1.76	1.30	14.90	5.68	7.84	65.61
60	2.94	1.93	1.55	14.95	5.84	8.07	64.71

Table 4.31 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Total Bank Loans Group (Growth of M2)

Cholesky Ordering: GROWTH_RATE_OF_M2 DEPOSITS LOANS SECURITIES STOCK MARKET INDEX INDUSTRI. PRODUCTION CPI

Variance Decomposition of GROWTH_RATE_OF_M2:							
Period	GROWTH_RATE of M2	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00
3	86.77	4.67	2.05	1.59	2.84	0.17	1.92
7	58.31	11.77	6.39	5.01	13.04	0.55	4.94
10	42.41	12.46	11.80	6.22	21.97	0.78	4.36
20	26.02	7.24	19.69	12.66	24.45	7.46	2.48
40	26.88	7.52	20.32	10.52	22.64	7.67	4.46
60	31.14	6.68	18.44	9.21	20.62	7.04	6.87
Variance Decomposition of DEPOSITS:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	17.96	82.04	0.00	0.00	0.00	0.00	0.00
3	14.53	66.12	10.09	1.41	2.27	0.35	5.23
7	16.60	44.59	23.51	2.60	3.37	1.54	7.80
10	12.91	38.85	25.99	4.58	8.51	2.72	6.45
20	5.58	26.49	34.51	11.25	13.24	4.25	4.69
40	7.62	19.92	34.04	12.86	10.96	5.93	8.67
60	9.74	19.39	32.72	12.51	10.78	5.94	8.93
Variance Decomposition of LOANS:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	16.11	13.48	70.41	0.00	0.00	0.00	0.00
3	10.26	14.63	69.34	0.55	1.92	0.90	2.41
7	7.79	22.32	54.88	2.68	4.00	5.63	2.70
10	6.36	22.59	47.59	8.39	4.65	7.13	3.30
20	4.49	20.57	44.88	11.69	9.81	5.66	2.89
40	5.22	17.11	41.95	13.18	10.22	7.11	5.22
60	7.76	16.50	40.45	12.43	9.97	6.78	6.12
Variance Decomposition of SECURITIES:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	0.47	0.44	2.38	96.71	0.00	0.00	0.00
3	2.52	0.60	2.12	83.60	7.63	0.49	3.04
7	2.43	3.49	15.22	62.43	8.77	4.14	3.52
10	2.40	16.70	21.65	45.43	7.18	3.09	3.54
20	2.54	27.12	23.17	30.31	6.90	2.11	7.85
40	6.26	20.93	24.39	26.49	7.79	2.83	11.31
60	6.40	19.36	24.76	26.20	8.24	3.98	11.06
Variance Decomposition of STOCK SINDEX:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	0.74	0.21	4.61	2.28	92.17	0.00	0.00
3	1.46	1.25	10.92	3.40	78.72	4.02	0.24
7	2.36	14.59	22.06	3.97	49.95	6.52	0.55
10	2.59	12.57	28.22	5.62	40.36	7.63	3.02
20	3.36	9.41	32.46	12.08	26.65	9.67	6.37
40	10.46	8.04	29.26	11.95	22.87	8.58	8.84
60	11.05	8.94	28.73	11.75	22.92	8.37	8.24
Variance Decomposition of INSTRIAL PRODUCTION:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	8.46	9.15	0.27	0.12	0.02	81.98	0.00
3	8.25	9.39	1.09	1.95	2.23	75.99	1.11
7	7.19	10.76	2.78	4.90	2.53	63.40	8.44
10	9.06	10.57	2.75	4.68	2.92	60.05	9.97
20	12.58	12.31	12.33	6.21	10.72	31.86	13.99
40	9.21	8.34	24.93	13.87	12.23	18.06	13.35
60	9.77	8.09	24.84	14.53	11.60	17.69	13.48
Variance Decomposition of CPI:							
Period	GROWTH_RATE_OF	DEPOSIT	LOANS	SECURITIES	STOCK INDEX	INDUSTR. PRODUC.	CPI
1	0.27	1.93	1.04	0.10	0.36	6.19	90.11
3	2.83	1.49	1.91	1.68	1.71	5.02	85.37
7	26.21	4.53	4.32	2.35	3.26	5.03	54.31
10	29.22	6.18	5.43	2.12	4.27	4.96	47.82

20	38.74	6.64	5.75	3.06	5.78	3.84	36.20
40	28.42	5.80	14.46	7.29	13.23	7.99	22.82
60	26.51	6.36	17.38	7.30	14.84	7.73	19.87

Table 4.32 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Bank Type Group(CIBR)

Variance Decomposition of CIBR:								
Period	CIBR	Deposits	State Bank Loans	NonState Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	87.29	1.72	2.10	2.37	2.57	0.76	0.95	2.24
10	58.71	13.43	2.16	4.01	15.06	1.01	2.19	3.44
20	42.27	11.89	3.69	2.71	27.98	0.72	2.67	8.07
40	28.85	8.07	4.14	3.64	31.29	0.55	5.62	17.84
60	22.03	7.19	4.08	5.86	25.89	0.55	8.97	25.43
Variance Decomposition of DEPOSIT:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.38	99.62	0.00	0.00	0.00	0.00	0.00	0.00
7	0.98	84.25	1.21	4.95	3.47	1.92	0.27	2.95
10	1.35	63.88	1.65	12.91	11.71	2.07	2.70	3.74
20	1.41	57.92	4.12	13.06	10.57	6.80	2.80	3.32
40	2.25	43.17	6.74	15.07	8.29	18.79	2.43	3.26
60	3.73	29.59	6.88	13.58	13.24	14.12	5.38	13.49
Variance Decomposition of State Bank Loan:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	1.11	0.92	97.97	0.00	0.00	0.00	0.00	0.00
7	3.85	7.86	83.48	1.01	0.66	0.81	1.28	1.05
10	6.40	10.76	64.10	4.69	1.87	2.92	5.69	3.58
20	4.95	9.00	50.09	11.58	1.94	3.00	11.02	8.41
40	2.90	6.15	27.28	21.30	4.44	4.43	23.58	9.93
60	2.47	7.73	25.09	20.65	4.67	5.07	25.83	8.48
Variance Decomposition of Non State Bank Loan:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.03	4.00	66.16	29.81	0.00	0.00	0.00	0.00
7	1.24	2.65	59.90	32.38	0.85	0.31	2.38	0.28
10	3.36	2.80	50.18	31.39	3.21	0.63	4.60	3.82
20	4.35	4.90	47.79	30.35	3.17	0.86	4.32	4.24
40	3.79	4.33	36.02	25.68	2.61	1.86	15.42	10.27
60	3.73	4.72	30.81	24.70	3.36	3.00	18.49	11.19
Variance Decomposition of Securities:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.10	3.53	5.68	9.79	80.90	0.00	0.00	0.00
7	6.72	2.18	3.03	5.43	65.33	5.45	0.06	11.82
10	9.15	2.99	5.60	3.52	42.32	5.00	3.26	28.18
20	7.92	10.72	6.11	3.72	34.90	4.42	3.97	28.25
40	7.32	19.29	4.84	4.60	32.22	4.04	5.17	22.52
60	6.83	17.70	4.24	4.19	31.91	4.77	6.73	23.63
Variance Decomposition of Stock Index:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	2.31	0.17	2.22	1.10	2.47	91.73	0.00	0.00
7	7.61	1.37	2.36	3.69	4.49	80.08	0.14	0.27
10	23.34	1.31	3.50	4.80	5.14	60.06	0.80	1.05
20	20.75	3.77	5.41	7.32	4.44	55.93	1.10	1.29
40	14.85	3.91	6.39	10.73	6.69	38.70	8.76	9.97
60	11.52	4.12	6.98	9.85	12.66	25.74	10.99	18.13
Variance Decomposition of Industrial Production								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.05	8.91	1.18	1.58	3.84	0.39	84.05	0.00
7	0.85	8.63	1.09	3.34	5.70	1.54	75.59	3.27
10	2.65	10.97	2.10	2.81	8.49	2.03	62.76	8.19
20	3.90	13.20	2.22	2.59	11.31	1.81	54.10	10.87
40	2.94	13.21	3.29	2.54	18.91	3.31	37.56	18.24
60	1.93	8.13	2.62	4.14	20.95	3.72	24.63	33.86
Variance Decomposition of CPI:								
Period	CIBR	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	2.05	4.05	0.52	0.00	0.47	0.06	6.28	86.56
7	3.07	2.89	0.75	1.40	13.22	0.50	2.60	75.56
10	2.26	2.04	0.77	1.04	18.28	3.87	1.60	70.14
20	2.63	1.52	0.63	1.07	19.45	3.30	1.84	69.55
40	2.34	1.39	0.63	1.09	19.52	3.03	2.83	69.16
60	2.58	2.00	0.95	2.56	17.15	3.68	7.06	64.04

Table 4.33 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Bank Type Group (Growth Rate of M2)

Variance Decomposition of GROWTH_RATE_OF_M2:								
Period	Growth rate of M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	88.18	1.04	0.90	0.78	3.60	3.42	0.77	1.30
10	69.35	3.03	3.66	2.33	2.82	16.74	0.88	1.19
20	55.48	2.28	6.24	3.82	2.13	26.70	0.71	2.64
40	35.72	4.51	6.84	9.28	1.63	37.40	2.00	2.63
60	29.79	6.12	6.77	11.91	2.63	34.90	3.15	4.74
Variance Decomposition of Deposit:								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	15.04	84.96	0.00	0.00	0.00	0.00	0.00	0.00
7	13.66	72.34	0.81	7.19	1.71	1.62	0.37	2.29
10	15.27	45.93	3.72	21.88	2.96	2.96	3.63	3.65
20	16.38	33.48	7.88	23.13	4.00	8.01	3.04	4.08
40	14.81	18.85	8.78	31.97	4.20	17.06	1.96	2.38
60	21.87	13.41	7.18	32.08	4.66	14.16	3.52	3.11
Variance Decomposition of State Bank Loan:								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.34	2.09	97.56	0.00	0.00	0.00	0.00	0.00
7	5.76	6.82	78.61	2.97	0.37	2.35	1.41	1.70
10	12.72	7.22	55.40	12.53	0.64	4.09	4.58	2.81
20	14.95	5.10	39.56	23.37	1.08	4.68	7.09	4.18
40	26.93	2.30	19.04	31.41	3.08	4.52	10.20	2.53
60	26.93	2.79	14.90	30.72	3.24	6.29	13.21	1.92
Variance Decomposition of Nonstate Bank Loans								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	4.06	1.19	61.75	32.99	0.00	0.00	0.00	0.00
7	3.81	1.76	53.84	37.60	0.45	0.39	1.76	0.39
10	6.75	1.54	42.94	39.30	2.91	1.77	2.09	2.71
20	8.62	2.08	39.10	36.15	5.57	1.72	1.96	4.81
40	11.85	2.11	30.92	29.80	6.68	4.83	6.81	7.00
60	15.90	2.61	26.09	27.34	5.95	6.79	8.41	6.92
Variance Decomposition of Securities:								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.05	0.64	3.27	4.66	91.38	0.00	0.00	0.00
7	0.52	1.03	1.98	2.43	85.71	3.83	0.07	4.43
10	0.44	2.41	1.91	16.03	63.23	4.40	3.21	8.38
20	0.57	6.53	1.76	26.31	49.60	5.05	2.64	7.55
40	4.01	9.21	2.94	29.75	39.88	5.14	2.98	6.09
60	12.99	7.25	6.78	27.24	28.98	9.19	2.57	5.01
Variance Decomposition of Stock Index								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.20	0.65	2.89	0.41	8.95	86.89	0.00	0.00
7	1.41	0.94	3.94	3.01	3.22	86.44	0.88	0.16
10	2.37	2.61	8.86	9.48	2.25	71.34	2.52	0.58
20	2.23	4.03	8.95	18.59	2.21	61.22	2.10	0.66
40	9.65	3.33	6.31	26.98	6.51	38.69	4.88	3.64
60	20.17	3.08	5.99	22.29	5.78	34.33	4.78	3.57
Variance Decomposition of Industrial Production								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	0.87	7.52	2.54	0.72	1.65	0.05	86.66	0.00
7	0.97	8.77	2.14	4.82	1.37	1.28	76.60	4.06
10	2.22	10.74	4.58	5.81	2.94	2.35	67.08	4.27
20	4.22	11.21	6.53	5.33	2.83	2.36	63.57	3.95
41	13.82	9.34	14.85	5.93	1.97	7.52	43.37	3.20
60	25.55	5.16	14.08	13.60	1.60	12.55	23.30	4.16
Variance Decomposition of CPI:								
Period	GROWTH_RATE_OF_M2	Deposits	State Bank Loans	Non State Bank Loan	Securities	Stock Index	Industrial Production	CPI
1	1.78	3.91	1.16	0.13	0.00	0.09	3.90	89.02
7	1.15	4.56	1.68	8.99	7.73	0.14	2.32	73.43
10	11.58	4.33	1.81	11.17	10.36	7.79	2.93	50.04
20	15.58	3.67	3.58	12.06	8.63	7.70	2.84	45.94
40	27.78	2.60	8.27	9.80	6.63	10.96	2.04	31.92
60	21.34	5.77	8.43	11.01	5.65	17.02	6.74	24.04

Table 4.34 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Borrow Type Group (Cibr)

Variance Decomposition of CIBR:									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	63.01	5.10	7.74	12.64	0.31	4.51	1.46	4.12	1.13
20	46.60	4.23	6.51	23.27	0.97	4.46	2.10	5.32	6.53
60	31.41	4.03	4.48	19.22	2.97	3.24	5.02	4.62	25.00
Variance Decomposition of Deposit:									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	1.83	98.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1.65	59.56	14.05	1.75	10.06	1.20	9.15	1.63	0.94
20	1.03	46.21	8.53	1.25	16.85	1.03	23.56	0.96	0.59
60	1.30	40.88	8.44	2.14	16.76	1.02	26.26	0.89	2.31
Variance Decomposition of Loans to Industrial Sector									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.39	2.29	97.33	0.00	0.00	0.00	0.00	0.00	0.00
10	6.08	5.14	74.72	0.70	5.93	1.89	3.07	0.82	1.66
20	4.55	12.42	51.51	1.70	11.18	1.90	12.03	0.63	4.07
60	5.11	12.36	45.56	2.87	11.57	1.90	14.50	0.73	5.40
Variance Decomposition of Loans to Commercial Sector									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.20	0.03	0.27	99.50	0.00	0.00	0.00	0.00	0.00
10	5.37	3.22	6.00	59.46	7.46	4.75	1.54	6.33	5.86
20	3.49	3.96	4.97	40.70	8.04	3.50	5.05	5.87	24.42
60	6.57	5.72	5.38	28.19	8.56	2.62	10.26	4.77	27.93
Variance Decomposition of Loans to Property Sector									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.76	1.72	25.04	0.06	72.42	0.00	0.00	0.00	0.00
10	8.40	15.85	13.66	0.39	40.35	1.22	6.76	5.27	8.11
20	7.89	13.81	15.31	0.48	33.43	1.20	9.54	4.60	13.74
60	6.59	16.71	13.24	0.96	30.35	1.00	16.40	3.88	10.86
Variance Decomposition of Securities:									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.94	0.32	0.32	0.02	3.53	94.86	0.00	0.00	0.00
10	17.23	4.09	4.04	23.22	7.65	24.11	3.86	6.70	9.11
20	24.60	9.68	10.37	16.90	6.16	15.83	2.76	5.34	8.37
60	22.28	8.64	8.08	17.84	5.16	12.38	2.95	5.96	16.72
Variance Decomposition of Stock Index									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.52	0.68	1.03	0.29	0.05	0.72	96.71	0.00	0.00
10	10.35	4.41	4.47	1.74	6.58	4.91	62.95	0.50	4.09
20	9.37	6.68	4.57	1.64	8.64	3.81	58.90	0.71	5.68
60	9.25	7.84	5.79	1.67	9.23	3.45	55.73	1.30	5.73
Variance Decomposition of Industrial Production									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	1.21	8.59	0.07	0.06	2.75	0.00	0.24	87.08	0.00
10	8.43	11.64	10.25	5.08	3.08	0.25	1.68	52.86	6.73
20	6.48	15.52	9.39	7.85	3.67	0.48	3.63	37.55	15.43
60	6.94	14.41	6.71	8.65	4.92	0.77	9.87	22.04	25.70
Variance Decomposition of CPI:									
Period	CIBR	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.69	0.24	1.67	0.80	2.67	1.40	0.21	2.87	89.44
10	1.09	0.94	4.53	13.61	4.28	7.32	2.48	1.71	64.04
20	4.42	2.79	3.68	15.38	3.80	5.97	3.38	1.23	59.36
60	9.31	3.42	5.63	12.07	4.96	4.50	8.06	2.82	49.23

Table 4.35 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for Borrow Type Group(Growth rate of M2)

Variance Decomposition of Growth rate of M2									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	53.34	1.85	0.76	4.36	5.94	1.12	28.55	3.11	0.97
20	28.34	6.16	1.53	3.85	9.03	0.84	39.13	3.30	7.82
60	22.71	9.70	1.97	3.16	12.67	2.42	33.84	2.60	10.92
Variance Decomposition of Deposit:									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	15.50	84.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11.30	46.38	15.76	1.84	13.86	1.44	6.75	1.31	1.36
20	5.33	33.91	8.34	2.26	29.46	0.82	15.42	0.59	3.88
60	4.67	31.82	6.90	2.43	28.56	1.44	15.22	0.62	8.35
Variance Decomposition of Loans to Industry Sector									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	6.03	0.08	93.90	0.00	0.00	0.00	0.00	0.00	0.00
10	6.40	2.31	77.40	0.96	5.52	0.70	2.48	0.45	3.77
20	3.97	10.25	37.78	1.66	27.65	1.74	13.59	0.32	3.04
60	4.66	15.39	26.19	1.76	26.71	2.01	15.16	0.42	7.69
Variance Decomposition of Loans to Commercial Sector									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.21	0.14	0.63	99.02	0.00	0.00	0.00	0.00	0.00
10	6.47	6.74	13.58	38.34	9.44	13.51	1.79	8.19	1.95
20	6.68	8.62	9.78	24.72	27.15	9.57	2.01	6.06	5.41
60	9.86	9.93	8.20	20.41	26.62	8.17	5.84	5.15	5.82
Variance Decomposition of Loans to Property Sector									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	4.03	0.10	23.31	0.21	72.34	0.00	0.00	0.00	0.00
10	2.21	6.08	15.86	2.80	67.25	1.33	2.34	1.53	0.59
20	2.66	9.19	11.94	2.95	58.92	1.16	9.49	1.88	1.80
60	3.73	10.80	10.24	2.74	52.06	1.91	12.14	1.68	4.70
Variance Decomposition of Securities									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.46	0.02	0.01	0.08	6.56	92.86	0.00	0.00	0.00
10	5.95	5.37	7.36	4.50	39.57	25.35	2.38	8.45	1.07
20	4.62	14.08	8.81	4.06	40.21	16.52	3.48	6.29	1.94
60	4.41	15.95	7.10	3.95	35.95	12.53	8.54	4.72	6.85
Variance Decomposition of Stock Index									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.01	0.65	1.10	0.01	0.18	4.35	93.69	0.00	0.00
10	1.10	12.34	0.52	1.42	5.44	0.75	62.89	2.69	12.84
20	1.49	16.51	0.49	1.56	8.29	1.61	49.97	2.03	18.05
60	3.57	16.15	1.08	1.53	8.55	2.03	47.44	2.21	17.42
Variance Decomposition of Industrial Production									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	0.75	5.96	0.24	0.02	3.73	0.01	0.22	89.07	0.00
10	3.40	7.81	8.96	1.80	7.81	2.34	2.02	61.24	4.62
20	9.19	9.14	7.09	2.17	8.75	1.64	8.56	44.22	9.24
60	8.29	11.08	5.38	3.07	11.38	2.06	18.01	24.82	15.92
Variance Decomposition of CPI:									
Period	Growth rate of M2	Deposit	Loans to Industrial Sector	Loans to Commercial Sector	Loans to Property Sector	Securities	Stock Index	Industrial Production	CPI
1	1.02	0.02	1.36	0.14	2.18	1.53	1.85	3.10	88.80
10	16.96	2.14	3.53	0.28	21.65	10.24	2.06	1.74	41.41
20	26.47	4.83	3.54	0.45	19.40	8.51	3.38	1.88	31.54
60	21.15	6.42	4.16	1.04	18.87	7.05	12.28	2.49	26.55

Table 4.36 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for International Trade Group (CIBR as indicator)

Cholesky Ordering: CIBR Deposits Loans Stock Index Exports Imports Foreign Exchange Reserves Industrial Production CPI

Variance Decomposition of CIBR:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign Reserves	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	50.80	10.48	3.56	18.77	0.35	6.44	2.71	0.65	1.45
20	35.33	7.90	2.07	19.32	0.33	17.88	2.77	0.92	3.93
40	34.31	7.63	2.00	19.14	0.33	18.91	2.71	0.93	4.12
60	24.31	6.43	3.45	16.10	1.57	26.71	2.03	1.31	4.45
Variance Decomposition of Deposits									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	2.36	97.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4.17	55.49	17.25	2.72	11.89	1.25	1.54	2.97	1.45
20	2.57	39.10	16.93	6.49	22.84	5.31	1.39	3.27	0.86
40	3.00	36.44	17.02	5.92	24.63	5.87	1.41	3.10	1.00
60	3.00	35.48	16.60	6.15	24.01	6.77	1.42	3.40	1.12
Variance Decomposition of Loans:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	1.06	15.24	83.71	0.00	0.00	0.00	0.00	0.00	0.00
10	0.63	24.54	51.17	2.63	8.03	3.08	1.75	1.45	4.88
20	0.40	22.40	34.61	4.64	18.20	11.21	1.20	1.47	3.41
40	1.18	20.70	31.12	5.18	18.90	14.04	1.45	1.61	3.27
60	1.19	19.99	29.63	5.66	18.96	15.52	1.37	1.67	3.21
Variance Decomposition of Securities									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.04	2.44	0.01	97.51	0.00	0.00	0.00	0.00	0.00
10	11.86	4.75	6.10	43.10	3.66	1.28	2.91	6.62	2.02
20	14.65	12.74	6.96	34.45	3.50	1.66	4.42	6.12	1.74
40	14.66	11.23	5.85	27.30	4.16	9.24	4.41	4.55	3.81
60	12.57	11.36	7.57	23.77	6.23	11.59	3.79	4.22	3.60
Variance Decomposition of Stock Index									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	2.47	0.15	0.06	0.90	96.43	0.00	0.00	0.00	0.00
10	4.87	1.39	6.41	20.67	45.77	12.24	2.14	3.35	2.29
20	3.79	4.88	12.06	17.65	42.52	12.05	1.73	2.69	1.79
40	3.49	6.52	12.73	16.21	41.77	12.34	1.59	2.85	1.68
60	3.43	7.36	13.26	15.66	41.44	11.95	1.57	2.88	1.63
Variance Decomposition of Exports:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.03	0.02	0.36	1.66	0.39	97.53	0.00	0.00	0.00
10	5.66	2.30	3.24	4.89	3.23	70.00	2.48	5.30	0.43
20	4.76	7.94	8.03	4.51	6.97	55.84	1.94	3.86	0.84
40	3.50	12.63	13.57	3.24	15.99	40.23	1.40	2.94	0.77
60	3.47	12.72	13.71	3.16	16.93	38.95	1.41	3.26	0.75
Variance Decomposition of Imports:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.59	8.03	4.27	1.98	1.10	51.64	32.39	0.00	0.00
10	2.34	8.90	6.05	3.55	4.73	46.20	22.10	0.80	0.66
20	2.12	10.43	9.25	3.19	9.99	39.86	18.60	0.70	0.62
40	2.07	11.37	11.49	3.44	14.40	35.34	15.86	0.78	0.62
60	2.12	11.60	11.74	3.45	14.48	35.02	15.35	0.87	0.65
Variance Decomposition of Foreign Exchange Reserves:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	5.26	0.06	3.01	0.85	0.04	6.31	1.14	83.34	0.00
10	3.71	8.97	12.02	8.40	16.01	2.54	8.67	35.88	1.25
20	6.89	20.67	19.66	3.87	20.38	1.41	5.38	16.87	1.43
40	6.84	21.20	18.29	3.61	22.28	4.35	3.46	9.43	2.49
60	6.36	20.06	17.90	3.59	22.26	5.44	3.26	9.41	2.50
Variance Decomposition of Industrial Production:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	1.13	10.54	3.28	1.80	0.09	9.92	4.02	0.51	68.70
10	5.59	7.98	5.62	8.68	3.18	17.46	6.48	4.67	29.89
20	5.70	12.30	11.05	6.19	8.49	18.28	4.21	2.82	19.01
40	3.89	16.83	16.73	3.96	17.98	12.97	2.52	2.03	11.70
60	3.81	16.72	16.92	3.78	19.49	12.33	2.47	2.51	10.98
Variance Decomposition of CPI:									
Period	CIBR	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	1.05	0.43	1.52	1.00	0.74	0.56	0.44	0.01	5.53
10	1.20	10.49	7.51	9.76	1.16	22.22	1.36	5.77	3.37
20	1.03	12.13	11.19	8.51	7.56	21.40	1.20	4.79	2.37
40	1.94	11.78	12.66	8.35	12.85	19.97	1.34	4.28	2.20
60	2.16	12.01	12.86	8.13	12.80	20.78	1.31	4.04	2.25

Table 4.37 (Cholesky) Variance Decomposition of Forecasted Variables (1-60 STEPS) for International Trade Group (Growth rate of M2 as Indicator)

Variance Decomposition of GROWTH_RATE_OF_M2:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	47.16	8.63	2.86	4.86	27.31	2.61	3.27	0.59	0.11
20	28.23	8.82	10.30	8.94	31.28	6.83	2.26	0.48	0.30
40	27.71	8.28	11.42	8.55	29.25	6.83	2.52	0.96	0.52
60	27.70	8.22	11.15	8.47	29.10	7.32	2.51	0.98	0.55
Variance Decomposition of Deposits:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	16.02	83.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	17.41	38.13	18.98	4.53	6.06	1.44	1.61	7.81	2.46
20	8.70	25.72	22.34	13.94	12.47	5.71	1.32	7.49	1.21
40	7.56	22.59	26.43	13.97	13.88	5.67	1.05	6.37	0.94
60	7.45	21.93	26.50	13.80	14.92	6.00	1.01	5.97	0.94
Variance Decomposition of Loans:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	13.18	8.81	78.02	0.00	0.00	0.00	0.00	0.00	0.00
10	10.11	10.42	45.47	9.95	1.86	6.83	1.86	7.44	5.06
20	6.55	14.06	33.15	15.37	8.78	11.37	0.99	5.86	3.01
40	5.65	13.96	33.85	15.32	9.62	11.95	0.85	5.10	2.39
60	5.95	13.91	33.43	15.20	9.99	11.99	0.83	4.99	2.39
Variance Decomposition of Securities									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.04	2.44	0.01	97.51	0.00	0.00	0.00	0.00	0.00
10	11.86	4.75	6.10	43.10	3.66	1.28	2.91	6.62	2.02
20	14.65	12.74	6.96	34.45	3.50	1.66	4.42	6.12	1.74
40	14.66	11.23	5.85	27.30	4.16	9.24	4.41	4.55	3.81
60	12.57	11.36	7.57	23.77	6.23	11.59	3.79	4.22	3.60
Variance Decomposition of Stock Index									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.56	0.33	0.05	99.06	0.00	0.00	0.00	0.00	0.00
10	1.10	1.30	4.37	59.54	4.27	1.04	1.91	17.87	0.56
20	2.22	4.97	8.76	49.54	4.34	1.35	2.52	19.29	0.52
40	3.77	7.00	14.60	37.45	13.74	1.19	2.42	14.71	0.50
60	4.11	7.62	17.30	33.67	16.23	1.59	2.10	12.68	0.48
Variance Decomposition of Exports:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.29	0.44	0.07	3.93	95.28	0.00	0.00	0.00	0.00
10	1.28	10.53	24.35	8.95	41.73	8.25	1.05	1.21	0.74
20	1.77	9.91	30.52	9.59	34.37	7.70	0.93	1.52	0.59
40	4.26	10.23	29.10	9.74	33.16	7.86	0.83	1.31	0.75
60	4.35	10.15	29.02	9.68	32.71	8.12	0.98	1.40	0.79
Variance Decomposition of Imports:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.14	0.00	0.03	0.43	0.67	98.72	0.00	0.00	0.00
10	1.50	2.35	4.87	1.12	3.32	72.81	2.19	10.55	0.50
20	7.17	3.43	6.92	2.36	10.23	56.46	2.71	9.54	0.54
40	5.94	6.72	16.12	6.50	20.07	35.16	1.94	6.24	0.35
60	5.96	7.04	17.28	6.66	20.16	33.52	1.91	5.98	0.49
Variance Decomposition of Foreign Reserves									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	6.65	5.12	2.18	0.41	1.66	52.53	31.45	0.00	0.00
10	8.37	4.46	4.38	1.39	5.92	47.83	23.84	1.54	0.37
20	9.81	5.31	6.91	2.73	12.21	39.93	19.79	1.34	0.36
40	8.21	6.69	11.88	4.43	14.95	34.44	16.23	1.17	0.40
60	8.20	6.65	11.88	4.40	14.86	34.33	16.18	1.34	0.55
Variance Decomposition of Industrial Production:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	0.03	0.03	1.92	2.80	0.27	5.70	0.40	88.86	0.00
10	0.39	8.63	20.67	17.66	5.56	3.21	4.64	37.15	0.60
20	2.20	9.85	25.88	16.75	9.71	2.01	3.78	27.57	0.79
40	5.87	10.34	26.54	14.43	22.22	1.58	2.47	14.82	0.50
60	5.45	10.58	27.99	13.77	23.36	2.49	2.12	12.35	0.52
Variance Decomposition of CPI:									
Period	Growth rate of M2	Deposits	Loans	Stock Index	Exports	Imports	Foreign	Industrial Production	CPI
1	1.36	0.34	0.56	0.22	2.44	0.20	1.67	0.04	6.49
10	20.43	0.52	0.84	5.05	3.39	21.20	1.81	4.35	4.89
20	27.29	2.57	2.34	5.19	17.23	15.77	1.41	2.84	3.02
40	18.72	5.43	10.28	6.77	22.56	15.07	1.49	2.32	2.14
60	18.19	5.35	10.59	6.80	22.84	14.56	1.73	2.74	2.39

Chapter 5 China's Monetary Policy Transmission and Business Cycle

--Bayesian Dynamic Stochastic General Equilibrium (DSGE) Model Simulation

5.1 Introduction

Since Kydland and Prescott (1982) introduced a new approach to the business cycle analysis, the so-called real business cycle (RBC) model has made lasting and widespread methodological contributions to macroeconomic modeling in various aspects. The dynamic stochastic general equilibrium (DSGE) models are developed from RBC models by injecting some so-called New Keynesian Macroeconomic (NKM) approaches such as nominal stickiness and market imperfections into it. Like the VAR approach, DSGE models simulate the impulse responses of economic variables to many shocks, especially the technical shocks and policy shocks based on an estimated theoretical structure, in which the utility-maximizing rational agents (households), profit maximisized firms and government (monetary and fiscal authorities) operate subject to the budget constraints and technological constraints(stochastic production function), interact and interdependence of the markets with the ultimate markets equilibriums assumptions in a dynamic stochastic (Frisch-Slutsky paradigm[48]) model economy.

By incorporating many concepts, ideas and theories of microeconomics into macroeconomic dynamics, the DSGE models make the macroeconomic modeling more consistent and effective because its rigorous microfoundations link the development in macroeconomics to the advances in microeconomics, contributing its great success and attractiveness.

The inclusion of nominal rigidities such as sticky prices and wages by Taylor (1980) and Calvo (1983) in DSGE models has proved to be extremely useful for explaining the empirical evidence of macroeconomics. Moreover, by introducing monetary variables in agent's utility function (MIU model) and the monetary policy and fiscal rules, DSGE models provide powerful aspects on the monetary policy analysis and fiscal policy analysis as well as on many other theoretical issues.[49]

As vast literatures have been dedicated to the shaping and developing of DSGE Models, progress has been made and the DSGE models have dominated many branches of macroeconomics, such as international macroeconomics, monetary economics, labour economics and public economics. As a consequent, many techniques have taken it to the data. Today, the DSGE models are not only attractive from a theoretical perspective, but also are

[48] Frisch-Slutsky paradigm is an impulse-propagation-fluctuations procedure. See Blanchard and Fischer (1989).

[49] See Rotemberg and Woodford (1997) on monetary policy, Obstfeld and Rogoff (1995) on new-open economy macroeconomics, and Chari, Christiano and Kehoe (1994) on fiscal policy.

emerging as useful tools for forecasting and quantitative policy analysis in macroeconomics.

Most DSGE models are developed for advanced economies, but this does not imply that DSGE models cannot capture the features of China's economy. This is because the Chinese economy has become so marketised since 1978 that some of the macroeconomic models rooted in the developed economy can be applied to it, according to the arguments from Scheibe and Vines (2005) and Chow (2002).

In this chapter, we employ the Smets-Wouters model to simulate China's monetary policy transmission and the roles of monetary variables in business cycle following Smets and Wouters (2002) and Christiano et al (2001, 2005). Two scenarios are discussed and examined. First, in the benchmark Smets-Wouters model, money is endogenous in the system and the monetary authority follows a Taylor's rule (Interest rate rule). Second, referring to the reality of China's monetary operation, following Zhang (2009), we establish an improved Smets-Wouters model, in which money is injected and the central bank of China follows a money growth rule. We will discuss these two scenarios and compare the results from them. The model economy consist of a utility-maximizing rational agent (households), profit-maximizing two-sector firms-private final good firms in competitive market and state owned monopolistic intermediate firms, and a monetary authority. By computing the first-order solutions to the behavioural equations and state equations, we obtain a group of nonlinear equations for the model economy. On the basis of regarding perturbation algorithms developed in the Matlab and Dynare software[50], the nonlinear equations can be solved and transformed to policy and transmission equations to simulate the monetary policy transmission and business cycle in China with real time series data.

The remainder of the chapter is arranged as follows, section 5.2 specifies the benchmark Smets-Wouters model with Taylor's rule and the improved Smets-Wouters model with a money growth rule for China's economy and its first-order solutions; section 5.3 estimates the parameters by a Bayesian approach; section 5.4 presents the simulation results from the Taylor's rule model for monetary policy transmission and business cycle in China. Section 5.5 reports the simulations results from the money growth model for monetary policy transmission and the business cycle in China. Section 5.6 conducts discussions and summarizes. The results

[50] We use Dynare V4.02 on Matlab 2007a. Dynare software was originally developed by Professor Michel Juillard in France, who is the adviser of the Bank of France and editor of the Journal of Economic Dynamics and Control. Professor Frank Schorfheide from the University of Pennsylvania also contributes much to this software. At present there is a team which is responsible for the development and maintenance of Dynare software, see Dynare home webside. Dynare is a processor to collect the DSGE equations into the Matlab computation environments. "It is a powerful and highly customizable engine, with intuitive front-end interface, to solve, simulate, and estimate DSGE models" according to the User's Guide of Dynare. I have written a dynare program (code) for Smets-Wouters model in Appendix 4.1. Perturbation algorithms are numerical analisis methods used to solve the non-linear systems, such as **Metropolis–Hastings (M–H) algorithm.**

of simulation are reported in Appendix 5.1 for Taylor's rule model and in Appendix 5.2 for the money growth rule model. Appendix 5.3 demonstrates the solutions process for Smets-Wouters model.

5.2 The Smets-Wouters Models Specification for China's Economy

Frank Smets and Raf Wouters (2002) developed an elegant stochastic dynamic general equilibrium model for ECB's monetary policy analysis, which has become a benchmark model in this field around Europe and US. With reform and openness since 1978, China has transformed its economic system from a planned central-control regime to more market-oriented free economy, which is the first reason why I can choose this model designed for a developed economy to simulate China's macro economy. Second, the Smets-Wouters model assumes two production sectors, the final firm in perfect competition market and the intermediate firms in monopolistic market, which is in line with the realities of China's economy: state owned companies have a monopolistic position by controlling the raw materials and energy sectors as intermediate firms, the private and small firms produce final consumption goods in competitive markets. Third, the Smets-Wouters model provides ten exogenous stochastic shocks, which compose of not only two monetary shocks (an interest rate shock and a money supply shock; with the money supply shock this model is closer to the practical operations of China's monetary policy), but also two fiscal policy shocks(investment shock and government expenditure shock). This coincides with the macro policy environment of China, in which not only monetary policy, but also fiscal policy play very important roles in stabilizing and promoting the growth of China's economy. Finally, the elegance and complexity of the Smets-Wouters model can provide more aspects in simulating China's macro economy.

In this model economy, a continuum of households supply labour services to the intermediate firms in monopolistic competition market, they set wage with Calvo-stickiness, invest with adjustment cost and variable capital utilization, and consume final goods provided by the final firms with habit formation. The continuum of intermediate firms operates in a monopolistic competition market, provide intermediate goods to the final firm and set prices with Calvo's stickiness. The final goods are produced in a perfect competitive market. There exists a monetary authority following a Taylor's rule in the implementation of monetary policy. Incorporating many other sources of exogenous shocks with monetary policy shocks, the model do simulate the business cycle of real economy and provide lots of implications for analyzing policies.

5.2.1 Households

The household agent j from a continuum of households maximizes the present value of his stream of utilities in an infinite horizon

$$U = E_t \sum_{i=0}^{\infty} \beta^{t+i} U_{t+i}^j \tag{5.1}$$

The preference of household j is

$$U_t^j = e_t^c \left[\frac{(C_t^j - H_t^j)^{1-\sigma}}{1-\sigma} + \frac{1}{1-\sigma_M} (\frac{M_t^j}{P_t})^{1-\sigma_M} - e_t^l \frac{(l_t^j)^{1+\upsilon}}{1+\upsilon} \right] \tag{5.2}$$

Where $0 < \beta < 1, \sigma > 0, \upsilon > 0$ β is the discount factor or time preference, σ is the inverse of the elasticity of inter-temporal substitution; e_t^c is a stochastic shock of preference, $H_t^j = hC_{t-1}^j$, h represents the consumption habit stock,[51] $\frac{M_t^j}{P_t}$ denotes the real cash balance (demand for money), σ_M is the inverse of the elasticity of money holding with respect to the interest rate; e_t^l denotes labour supply shocks, υ is the inverse of the elasticity of work efforts to the real wage. C_t^j represents the consumption of the final good by agent j at time t, l_t represents the work hours provided by household agent, which contributes the disutility of works to the preference.

Household agent faces the following inter-temporal budget constraints

$$\frac{M_t^j}{P_t} + \frac{B_t^j}{R_t P_t} = \frac{M_{t-1}^j}{P_t} + \frac{B_{t-1}^j}{P_t} + Y_t^j - C_t^j - I_t^j \tag{5.3}$$

Where B_t^j are nominal bonds purchased by the household agent with market price $\frac{1}{R_t}$, R_t denotes gross nominal rate of return. I_t^j represents the investment of household agent. The real income Y_t^j consists of following components

$$Y_t^j = (w_t^j l_t^j + A_t^j) + (r_t^k z_t^j K_{t-1}^j - \psi(z_t^j) K_{t-1}^j) + D_t^j - T_t^j \tag{5.4}$$

Where w_t^j is the real wage, A_t^j represents the payoff from the state-contingent Securities. The second term in (5.4) are the return on the real capital stock ($r_t^k z_t^j K_{t-1}^j$) minus the costs on the basis of the variation of capital utilization z_t^j, assuming that the cost function of the capital

[51] This concept has a long history in macroeconomics, which argues that household's utility is not only from the consumption of a bundle of goods, but also depends on his past consumption. The consumption-habit variable has been widely used in the New Business Cycle models, further discussion, see, for example, Dennis (2008).

utilization is zero ($\psi(z_t^j)$=0) when the utilization rate $z_t^j = 1$. D_t^j denotes the dividends received from the state owned intermediate companies and T_t^j is the lump sum tax paid to the government.

The capital stock is owned by the households and rented out to the state's own intermediate goods producers at rental rate of r_t^k. The investment I_t^j is conducted either by installing new capital or changing the utilization rate of installed capital stock z_t^j.

Following Christiano et al. (2001), the capital accumulation equation is given by

$$K_t^j = K_{t-1}^j(1-\tau) + [1 - S(e_t^I I_t^j / I_{t-1}^j)]I_{t-1}^j \quad (5.5)$$

Where K_t^j is the capital stock and τ is the depreciation rate of capital. $S(.)$ represents a positive function associated with the change of investment, in steady state, $S = S'$ =0 and the adjustment costs only depend on the second derivative of S . e_t^I is a shock to the investment cost following AR (1) process.[52]

Assuming that the wage is set with Calvo-stickiness (as explained in Chapter 2), the probability that the households can change its wage equals to $1-\omega_w$ and the new nominal wage is set at

$$W_t^j = \tilde{W}_t^j . \quad (5.6)$$

The wages which can not be re-optimized are indexed with the past inflation as

$$W_t^j = (\frac{P_{t-1}}{P_{t-2}})^{\gamma_w} W_{t-1}^j \quad (5.7)$$

Where γ_w is the degree of partial wage indexation between zero and one.

The aggregate labour supply and aggregate wages are calculated by the following Dixit-Stiglitz technology[53]

$$L_t = (\int_0^1 (l_t^j)^{1/(1+\lambda_{w,t})} dj)^{1+\lambda_{w,t}} \quad (5.8)$$

$$W_t = (\int_0^1 (W_t^j)^{-1/\lambda_{w,t}} dj)^{-\lambda_{w,t}} \quad (5.9)$$

Where $\lambda_{w,t}$ is the mark up of the real wage over the current ratio of the marginal disutility

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52 In RBC and later DSGE model literatures, most stochastic shocks follow AR(1) process, which can capture the persistent and stochastic effects of the exogenous shocks.

53 This "packaging technology" is also named as the Dixit-Stiglizt Aggregator, governing the features of substitutability and monopoly in a monopolistic competition. See Dixit, Avinash K. and Joseph E. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*, Vol. 67, p297-308.

of labour and the marginal utility of consumption.

$$\lambda_{w,t} = \lambda_w + \varepsilon_t^W . \quad (5.10)$$

Where ε_t^W is a wage mark up shock that is I.I.D...

Household agent's maximizing behaviour implies the following labour supply function

$$l_t^j = (\frac{W_t^j}{W_t})^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t \quad (5.11)$$

On the basis of (5.9), following Calvo (1983), the law of motion of the aggregate wage is[54]

$$(W_t)^{-1/\lambda_{w,t}} = \omega_w ((\frac{P_{t-1}}{P_{t-2}})^{\gamma_w} W_{t-1})^{-1/\lambda_{w,t}} + (1-\omega_w)(\tilde{W}_t)^{-1/\lambda_{w,t}} \quad (5.12)$$

Also the mark-up equation for the re-optimise wage is given by the maximizing theory

$$\frac{\tilde{W}_t}{P_t} E_t \sum_{i=0}^{\infty} \beta^{t+i} \omega_w^{t+i} (\frac{P_t / P_{t-1}}{P_{t+i} / P_{t+i-1}})^{\gamma_w} \frac{e_t^c (C_{t+i}^j - hC_{t+i-1}^j)^{-\sigma} l_{t+i}^j}{1+\lambda_{w,t+i}} = -E_t \sum_{i=0}^{\infty} \beta^{t+i} \omega_w^{t+i} e_{t+i}^c e_{t+i}^l (l_{t+i}^j)^{\upsilon+1} \quad (5.13)$$

Following Christiano et al. (2001, see Appendix 1) and Uhlig (2007), we have:

$$\int_0^1 K_t^j = K_t, \int_0^1 C_t^j = C_t, \int_0^1 B_t^j = B_t, \int_0^1 D_t^j = D_t, \int_0^1 M_t^j = M_t$$

We drop the superscripts in the above variables in the following.

The first-order conditions[55] for the household can be obtained as follows

Euler equation: $E_t(\beta \frac{\lambda_{t+1} P_t R_t}{\lambda_t P_{t+1}}) = 1$ (5.14)

Where $\lambda_t = -e_t^c (C_t^j - hC_{t-1}^j)^{-\sigma}$, λ_t is the Lagrange multiplier which represents the marginal utility of income.

The demand for cash (serves the medium of transactions) is given by

$$(\frac{M_t}{P_t})^{-\sigma_M} = \frac{R_{t-1} - 1}{R_t} (C_t - H_t)^{-\sigma} \quad (5.15)$$

First, following Smets and Wouters (2002), this equation is ignored in the further procedure, which implies a money neutral assumption in the long run and endogenous money in the system. Referring to the discussions on the Smets-Wouters Model provided by Professor Uhlig (his website: wiwi.hu-belin.de), this suggests a utility function without money (because the first-order conditions (equations) when this money demand function is ignored are same as that in a utility function without money. Money is dropped out from the system and implicitly incoporated into the system). In the later works of Smets and Wouter (2005, 2007), they accept

[54] See, for example, Appendix in Calvo (1983), Yun (1996), Erceg et al (2000) and Appendix A in Christiano et al (2001).

[55] The solutions process for first-order conditions refer to Appendix 5.3.

the suggestion of Professor Uhlig, taking a utility function without money. Some Chinese researchers also suggest a utility function without money (see Chen Kunting and Gong Liutang, 2006). They argue that a utility function without money implies an assumption of endogenous money. Also money as the cash in circulation is only the medium of exchange, cannot provide utilities to the consumers. By making these assumptions, the final ten linear equations in the Smets-Wouters model are kept unchanged when applied to simulate China's economy in the first scenario.

Second, we introduce this money demand equation into the system; this implies that money is injected explicitly into the system. By assuming that the PBC follows a money growth policy rule, an improved Smets-Wouters model will be set up to simulate the monetary policy transmission and business cycle in China.

The Lucas asset pricing equation for the real value of capital:

$$Q_t = E_t[\beta \frac{\lambda_{t+1}}{\lambda_t}(Q_{t+1}(1-\tau)+z_{t+1}r_{t=1}^k-\psi(z_{t+1}))] \qquad (5.16)$$

The investment equation is

$$Q_t(1-S(\frac{e_t^I I_t}{I_{t-1}}))=Q_t S'(\frac{e_t^I I_t}{I_{t-1}})\frac{e_t^I I_t}{I_{t-1}}+1-E_t[\beta\frac{\lambda_{t+1}}{\lambda_t}Q_{t+1}S'(\frac{e_{t+1}^I I_{t+1}}{I_t})\frac{e_{t+1}^I I_{t+1}}{I_t}\frac{I_{t+1}}{I_t} \qquad (5.17)$$

The equation for the rate of capital utilization[56]: $r_t^k = \psi'(z_t)$ (5.18)

5.2.2 Technologies and Firms

The economy produces a single final good by the final firm (private firms in China) and a continuum of intermediate goods (state owned firms) indexed by j ($j \in (0,1)$).

The final firm provide a single good by combining the intermediate goods in a perfect competitive market with Dixit-Stigliz approach:

$$Y_t = \{\int_0^1 [Y_t^j]^{1/(1+\lambda_{p,t})} dj\}^{1+\lambda_{p,t}} \qquad (5.19)$$

Where Y_t^j denotes the inputs of intermediate good of type j at time t; $\lambda_{p,t}$ is a stochastic parameter governing the time-variance mark-up in the goods market, the shock to which reflects a cost-push shock to the inflation equation.

The cost minimization or profits maximization implies the following standard relationships, which can be explained as intermediate-good demand curve,

$$\frac{Y_t^j}{Y_t} = [\frac{P_t^j}{P_t}]^{-\frac{1-\lambda_{p,t}}{\lambda_{p,t}}} \qquad (5.20)$$

[56] Following 3.3.4 in Christiano et al (2001)

and

$$P_t = \{\int_0^1 [P_t^j]^{-1/\lambda_{p,t}} dj\}^{-\lambda_{p,t}} \quad (5.21)$$

Where P_t denotes the price of the final good; P_t^j is the price of the intermediate good of type j.

The representative intermediate firm j produces goods in terms of the following technology in a monopolistic competition market.

$$Y_t^j = e_t^a (z_t K_t^j)^\alpha (L_t^j)^{1-\alpha} - \Theta \quad (5.22)$$

Where K_t^j is the capital stock, and L_t^j are the aggregate labours employed by firm j, α is output elasticity of the capital in the production function, e_t^a is the productivity shock, Θ is the fixed cost.

The total cost of the intermediate firm is

$$TC_t^j = r_t^k z_t K_t^j + W_t L_t^j \quad (5.23)$$

Minimizing (5.23) subject to (5.22) produces

$$\frac{r_t^k z_t K_t^j}{W_t L_t^j} = \frac{\alpha}{1-\alpha} \quad (5.24)$$

Substituting the optimal ratio of capital to labour (5.24) into (5.22) and (5.23), then we can obtain the marginal cost of the intermediate firm as

$$MC_t = \partial TC_t^j / \partial Y_t^j = \frac{1}{e_t^a}(\frac{1}{1-\alpha})^{1-\alpha}(\frac{1}{\alpha})^\alpha [r_t^k]^\alpha [W_t]^{1-\alpha} \quad (5.25)$$

The nominal profit of intermediate firm j is

$$\Pi_t^j = P_t^j Y_t^j - P_t MC_t Y_t^j - MC_t \Theta = [P_t^j - P_t mc_t][\frac{P_t^j}{P_t}]^{-\frac{1-\lambda_{p,t}}{\lambda_{p,t}}} Y_t - P_t mc_t \Theta \quad (5.26)$$

Following Calvo (1983) (see Calvo's model in Section 2.3 of Chapter 2), and Christiano et al. (2001), the probability of the firms that can re-optimise the price is $1-\omega_p$, and the prices of the firms that can not follow the price signal are indexed on the past inflation similar as in the wage setting.

Using $\tilde{p}_t^j$ to represent the re-optimised price, we have the following optimality relationship for setting $\tilde{p}_t^j$

$$E_t[\sum_{i=0}^{\infty} \beta^i (\omega_p)^i \lambda_{t+i} Y_{t+i}^j (\frac{\tilde{p}_t^j}{P_t}(\frac{(P_{t-1+i}/P_{t-1})^{\gamma_p}}{P_{t+i}/P_t}))] = E_t[\sum_{i=0}^{\infty} \beta^i (\omega_p)^i \lambda_{t+i} Y_{t+i}^j (1+\lambda_{p,t+i}) mc_{t+i}] \quad (5.27)$$

Alos following Calvo (1983) and Christiano et al. (2001, Appendix 1), (5.21) implies the law of motion for the price:

$$(P_t)^{-1/\lambda_{p,t}} = \omega_p((\frac{P_{t-1}}{P_{t-2}})^{\gamma_p} P_{t-1})^{-1/\lambda_{p,t}} + (1-\omega_p)(\tilde{p}_t)^{-1/\lambda_{p,t}} \quad (5.28)$$

5.2.3 Monetary Policy and the Government

The government expenditure is met by levying lump sum taxation on the households, bond issuing and seigniorage as

$$\frac{M_t - M_{t-1}}{P_t} + T_t + \frac{B_t - R_t B_{t-1}}{P_t} = G_t \quad (5.29)$$

The PBC has never released its monetary policy model. There are different arguments on the China's monetary policy rules. Some researchers have suggested that China's monetary policy rule is close to a Taylor's rule. For example, Yuan (2008) pointed out that China's monetary policy rule based on some type rule such as Taylor's rule on the basis of an empirical study by employing SVAR model. Zhang (2009) suggested that an interest rate rule is more effective than a quantity (money supply) rule in China. Burdekin and Silklos (2005) claimed that the PBC seems to follow a money growth rule like the McCallum rule.

As mentioned above, two scenarios for the monetary policy rules which maybe taken by the PBC are considered.

In the first scenario, the monetary authority conducts its monetary policy by setting interest rates following an improved Taylor's rule (Smets and Wouters, 2002) as follows:

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1-\rho)[e_t^{\bar{\pi}} + r_\pi(\hat{\pi}_{t-1} - \hat{\pi}_t) + r_y \hat{Y}_t] + r_{d\pi}(\hat{\pi}_t - \hat{\pi}_{t-1}) + r_{dy}(\hat{Y}_t - \hat{Y}_{t-1}) + \varepsilon_t^R \quad (5.30)$$

Where R_t is nominal interest rate, Y_t is the output level at time t, π_t denotes the inflation rate at time t; so $\hat{Y}_t$ represents the output gap at time t; captures the persistence of interest rate, $e_t^{\bar{\pi}}$ is a persistent shock to the inflation objective following an AR (1) process which implies a monetary supply shock in the benchmark Smets-Wouters model. ε_t^R is a monetary interest rate shock. r_π is inflation coefficient, r_y is the output gap coefficient, $r_{d\pi}, r_{dy}$ are coefficients of inflation growth and output gap growth respectively.

According to Smets and Wouters, this is an empirical monetary policy reaction function modified from Taylor's rule. The monetary authority gradually respond to deviations of lagged inflation $((\hat{\pi}_t - \hat{\pi}_{t-1})$ and lagged output $(\hat{Y}_t - \hat{Y}_{t-1})$; Furthermore, the feedback effect from the current change in inflation, the current growth rate is also included in this model. Here for a vector of variables Z_t, let $\bar{Z}$ denote their steady state, then $\hat{z}_t = \log Z_t - \log \bar{Z}$ represents the vector of log-deviations from the steady state.

In the second scenario, referring to the framework of China's monetary policy in Chapter 1, following Zhang (2009), the PBC is assumed to inject money as

$$M_t^s = \kappa_t M_{t-1}^s \tag{5.31}$$

Where M_t^s is the money supply at time t; κ_t is the growth rate of money.

Defining $m_t = \dfrac{M_t}{P_t}$, we obtain form 5.31

$$m_t^s = \frac{\kappa_t}{\pi_t} m_{t-1}^s \tag{5.32}$$

Because the PBC targets inflation and output, we can assume a monetary growth rule as following:

$$\hat{\kappa}_t = \rho_M \hat{\kappa}_{t-1} - \zeta_1 E_t \hat{\pi}_{t+1} - \zeta_2 \hat{Y}_t + \varepsilon_t^m \tag{5.33}$$

Where ρ_M is used to capture the persistence of the money growth, e_t^M is a money supply shock following an AR (1) process same as $e_t^{\bar{\pi}}$. ζ_1 and ζ_2 are coefficients of inflation and output respectively.

5.2.4 Market Equilibriums

The equilibrium conditions for the model economy require clearing the labour market, goods market, capital rental market. The equilibriums include

Labour Market: the demand for the labour equals to labour supply,

$$\int_0^1 L_t^j dj = L_t = (\int_0^1 (l_t^j)^{1/(1+\lambda_{w,t})} dj)^{1+\lambda_{w,t}} \tag{5.34}$$

Goods Market:

$$Y_t = C_t + G_t + I_t + \psi(z_t) K_{t-1} \tag{5.35}$$

Capital rent Market: capital demand equals capital supply

$$\int_0^1 K_t^j dj = K_t \tag{5.36}$$

In our second scenario, money is injected by the PBC, the money market equilibrium is

$$M_t = M_t^s \tag{5.37}$$

5.2.5 The Linearised Models and the Exogenous Shocks

From the Euler equation (5.14), the long-term steady state interest rate is $\bar{R} = \dfrac{1}{\beta}$ and the steady state rental rate of capital equals $\overline{r}^k = \frac{1}{\beta} - 1 + \tau$,[57] the steady state inflation is set at the inflation objective $\overline{\pi}$. The steady values of capital, investment, consumption, government expenditure to GDP are defined by the empirical time series data. We log linearise above equations so the steady state values of other variables are zeros.

The principle of log-linearization is to use a Taylor approximation around the steady state to approximate all the equations with linear functions, for example, for a vector of variables Z_t , let $\overline{Z}$ denote their steady state, and then $\hat{z}_t = \log Z_t - \log \overline{Z}$ represents the vector of log-deviations from the steady state.

A simple method[58] has been provided by Harald Uhlig (1995) to log-linearize the rational expectation equation system.

First, we use the benchmark Smets-Wouters, which consists of ten linear equations[59] (log-linearized) as follows

The benchmark Smets-Wouters model with Taylor's Rule:

The *consumption equation* is:

$$\hat{C}_t = \frac{h}{1+h}\hat{C}_{t-1} + \frac{1}{1+h}E_t\hat{C}_{t+1} - \frac{1-h}{(1+h)\sigma}(\hat{R}_t - E_t\hat{\pi}_{t+1}) + \frac{1-h}{(1+h)\sigma}\hat{e}_t^c \tag{5.38}$$

The *investment equation* is given by:

$$\hat{I}_t = \frac{1}{1+\beta}\hat{I}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{I}_{t+1} + \frac{\varphi}{1+\beta}\hat{Q}_t + \hat{e}_t^I \tag{5.39}$$

Where $\varphi = 1/\overline{S}''$, capturing the capital adjustment costs as a function of the change in investment.[60]

The *Q equation (Tobin's Q)* is:

$$\hat{Q}_t = -(\hat{R}_t - E_t\hat{\pi}_{t+1}) + \frac{1-\tau}{1-\tau+\overline{r}^k}E_t\hat{Q}_{t+1} + \frac{\overline{r}^k}{1-\tau+\overline{r}^k}E_t\hat{r}_{t+1}^k + \varepsilon_t^Q \tag{5.40}$$

Where ε_t^Q is a shock to the required rate of return on equity investment.

The standard *capital accumulation equation*:

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[57] When we use lagrange method to get the first condition against the capital K, we can obtain

$$(C_t)^{-\sigma} = \beta E_t (C_{t+1})^{-\sigma}(1 + r_{t+1}^k - \tau)$$

In steady state, $C_t = C_{t+1}$, then we get $\overline{r}^k = \frac{1}{\beta} - 1 + \tau$.

[58] See Uhlig (1999), more log-linearization methods see, for example, King, Plosser and Rebelo (1987), Campbell (1994).

[59] Detailed model analysis and linearizing procedure see Appendix 5.4.

[60] The meanings of φ and S refer to Christiano, Eichenbaum and Evans (2001)

$$\hat{K}_t = (1-\tau)\hat{K}_{t-1} + \tau\hat{I}_{t-1} \quad [61] \tag{5.41}$$

The *labour demand equation*:

$$\hat{L}_t = -\hat{W}_t + (1+\psi)\hat{r}_t^k + \hat{K}_{t-1} \tag{5.42}$$

Where $\psi = \frac{\psi'(1)}{\psi''(1)}$ is the inverse of elasticity of the capital utilization cost function.

The *production function* is standard[62]:

$$\hat{Y}_t = \phi e_t^a + \phi\alpha\hat{K}_{t-1} + \phi\alpha\psi\hat{r}_t^k + \phi(1-\alpha)\hat{L}_t \tag{5.43}$$

Where ϕ is inverse of one plus the share of the fixed cost in production.

The *goods market equilibrium condition*:

$$\hat{Y}_t = (1-\tau k_y - g_y)\hat{C}_t + \tau k_y\hat{I}_t + e_t^G \tag{5.44}$$

Where k_y is the steady state ratio of capital to output, g_y is the steady state government expenditure-output ratio, e_t^G is government expenditure shock following AR(1) process.

The *inflation equation* or the *New Keynesian Philips Curve* is given by

$$\hat{\pi}_t = \frac{\beta}{1+\beta\gamma_p}E_t\hat{\pi}_{t+1} + \frac{\gamma_p}{1+\beta\gamma_p}\hat{\pi}_{t-1} + \frac{1}{1+\beta\gamma_p}\frac{(1-\beta\omega_p)(1+\beta\omega_p)}{\omega_p}[\alpha\hat{r}_t^k + (1-\alpha)\hat{W}_t - \hat{e}_t^a] + \varepsilon_t^p \tag{5.45}$$

Where ε_t^p is a price mark-up shock.

The *wage equation* is:

$$\begin{aligned}\hat{W}_t = {} & \frac{\beta}{1+\beta}E_t\hat{W}_{t+1} + \frac{1}{1+\beta}\hat{W}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{\pi}_{t+1} - \frac{1+\beta\gamma_w}{1+\beta}\hat{\pi}_t + \frac{\gamma_w}{1+\beta}\hat{\pi}_{t-1} \\ & - \frac{1}{1+\beta}\frac{(1-\beta\omega_w)(1-\omega_w)}{(1+\frac{(1+\lambda_w)\upsilon}{\lambda_w})\omega_w}[\hat{W}_t - \upsilon\hat{L}_t - \frac{\upsilon}{1-h}(\hat{C}_t - h\hat{C}_{t-1}) + \hat{e}_t^L) + \varepsilon_t^W\end{aligned} \tag{5.46}$$

Where ε_t^W is the wage mark-up shock.

The *monetary policy reaction function* is

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[61] A standard capital accumulation equation is $K_t = (1-\tau)K_{t-1} + I_{t-1}$, in steady state, $K_t = K_{t-1} = \bar{K}$, so the steady state investment $\bar{I} = \tau\bar{K}$, because $\hat{K}_t = \frac{dK_t}{\bar{K}}$, differentiating the standard capital accumulation, we get $dK_t = d(1-\tau)K_{t-1} + dI_{t-1}$, this equation is divided by $\bar{K}$, then we have

$$\frac{dK_t}{\bar{K}} = (1-\tau)\frac{dK_{t-1}}{\bar{K}} + \frac{dI_{t-1}}{\bar{K}}$$

Substituting $\bar{I} = \tau\bar{K}$ into the above equation, we can obtain equation 5.41.

[62] From the production function 5.22, $Y_t^j = e_t^a(z_tK_t^j)^\alpha(L_t^j)^{1-\alpha} - \Theta$

Assuming $\Theta = \vartheta Y_t$, then 5.22 becomes $Y_t^j = \frac{1}{1+\vartheta}e_t^a(z_tK_t^j)^\alpha(L_t^j)^{1-\alpha}$, let $\phi = \frac{1}{1+\vartheta}$, log-linearized 5..22, equation 5.43 can be obtained.

$$\hat{R}_t = \rho\hat{R}_{t-1} + (1-\rho)[e_t^{\bar{\pi}} + r_\pi(\hat{\pi}_{t-1} - \hat{\pi}_t) + r_y\hat{Y}_t] + r_{d\pi}(\hat{\pi}_t - \hat{\pi}_{t-1}) + r_{dy}(\hat{Y}_t - \hat{Y}_{t-1}) + \varepsilon_t^R \quad (5.47)$$

The improved Smets-Wouters model with a money growth rule:

In the second scenario, the money is injected into the system by the PBC, the Taylor's rule is replaced by a money growth rule, the equation 5.47 is replaced by the following equations:

$$\hat{m}_t = \frac{\sigma}{(1-h)\sigma_M}\hat{C}_t - \frac{\sigma h}{(1-h)\sigma_M}\hat{C}_{t-1} - \frac{1}{\sigma_M}\hat{R}_t \quad (5.48)$$

$$\hat{m}_t = \hat{m}_{t-1} - \hat{\pi}_t + \hat{\kappa}_t \quad \text{(From 5.32)} \quad (5.49)$$

$$\hat{\kappa}_t = \rho_M\hat{\kappa}_{t-1} - \zeta_1 E_t\hat{\pi}_{t+1} - \zeta_2\hat{Y}_t + \varepsilon_t^m \quad (5.50)$$

Where 5.48 comes from money demand function (5.15).

There are ten exogenous shocks in this regime, the preference shock e_t^c follows,

$$e_t^c = \rho_c e_{t-1}^c + \varepsilon_t^c, \text{ where } \rho_c < 1, \varepsilon_t^c \in IID, (0, \sigma_C)$$

The productivity shock, e_t^a is

$$e_t^a = \rho_a e_{t-1}^a + \varepsilon_t^a, \text{ where } \rho_a < 1, \varepsilon_t^a \in IID, (0, \sigma_a)$$

The labour supply shock e_t^L follows,

$$e_t^L = \rho_L e_{t-1}^L + \varepsilon_t^L, \text{ where } \rho_L < 1, \varepsilon_t^L \in IID, (0, \sigma_L)$$

The investment shock, e_t^I

$$e_t^I = \rho_I e_{t-1}^I + \varepsilon_t^I, \text{ where } \rho_I < 1, \varepsilon_t^I \in IID, (0, \sigma_I)$$

The government expenditure shock, e_t^G

$$e_t^G = \rho_G e_{t-1}^G + \varepsilon_t^G, \text{ where } \rho_G < 1, \varepsilon_t^G \in IID, (0, \sigma_G)$$

The three "cost-push" shocks, the wage mark-up shock, ε_t^W, the price mark-up shock, ε_t^p and the return on equity market shock, ε_t^Q are I.I.D...

One of monetary policy shock, the interest rate shock, ε_t^R is I.I.D.., another shock to the inflation target can be explained as a monetary supply shock, $\varepsilon_t^{\bar{\pi}}$ (or e_t^M) also follows AR (1) process:

$$e_t^{\bar{\pi}} = \rho_\pi e_{t-1}^{\bar{\pi}} + \varepsilon_t^{\bar{\pi}}, \text{ where } \rho_{\bar{\pi}} < 1, \varepsilon_t^{\bar{\pi}} \in IID, (0, \sigma_{\bar{\pi}}) \text{ in Taylor's rule model,}$$

Or $e_t^M = \rho_{em} e_{t-1}^M + \varepsilon_t^M$ in the money growth model, two equations are completely same.

On the basis of ten exogenous shocks, the singular problem can be avoided for solving the system consisting of ten endogenous variables $(Y_t, C_t, W_t, L_t, K_t, I_t, Q_t, \pi_t, R_t, r_t^k)$ for the benchmark Smets-Wouters Model with Taylor's rule.

For the improved Smets-Wouters model, we have nine exogenous shocks (without interest rate shock) for solving twelve endogenous variables. $(Y_t, C_t, W_t, L_t, K_t, I_t, Q_t, \pi_t, R_t, r_t^k, m_t, \kappa_t)$

To solve a linear rational expectation system like this model, an approximate solution algorithm has first developed by Blanchard and Kahn (1980) for a state space form like

$$E_t X_{t+1} = AX_t + Bz_{t+1}$$

Where A, B are coefficients matrix respectively, X_t is the vector of variables, E_t is the expected operator, z_t is a vector of exogenous variables following stochastic process, such as AR(1).

The vector of variables X_t composed of two parts, a vector of backward-looking variables X_t^1, which is defined as predetermined variables, and a vector of forward-looking variables X_t^2, defined as control variables. Then the above state space form changes to

$$\begin{bmatrix} X_{t+1}^1 \\ E_t X_{t+1}^2 \end{bmatrix} = A \begin{bmatrix} X_t^1 \\ X_t^2 \end{bmatrix} + Bz_{t+1}$$

The solution to this system is to find the function in which all the variables can be expressed by current backward-looking variables and exogenous variables, which needs to meet the so-called Blanchard-Kahn conditions.

Using Jordan decomposition on A,

$$A = V \Lambda V^{-1}$$

Where V is the eigenvectors, Λ represents the diagonal matrix of eigenvalues. The Blanchard-Kahn condition says that if the number of unstable eigen values is exactly equal to the number of control variables (forward-looking variables), then the solution of the rational expectation model is unique, which implies that the equilibrium path is unique with saddle path stability. Otherwise, if the number of unstable eigen values in Λ (greater than 1) is more than the number of control variables, the system will have sunspot solutions, if the number of unstable eigen values in Λ (greater than 1) is less than the number of forward-looking variables, no solutions can be found, meaning explosive paths.

Since Blanchard and Kahn (1980), many algorithms have been developed, including Anderson and Moore (1983), Binder and Pesaran (1994), Sims (1996), King and Watson

(1998), Klein (1999) and Uhlig (1999).[63]

We employ Dynare v4 and Matlab R2007a to solve our model.

5.3 Bayesian Estimation of the Parameters

To solve the above system, we need to estimate the parameters of the model. Many econometric methods can be employed to estimate them, such as the minimum distance approach in Christiano et al (2001), GMM approach, classical maximum likelihood methods in Ireland (1999), Bayesian approach in An and Schorfheide (2007). We use Bayesian technique with maximum likelihood method to estimate the parameters for the benchmark Smets-Wouters model. This is because that, according to User's Guide of Dynare and other macroeconomists[64], Bayesian estimation has following advantages: first, Bayesian estimation provides better fits for the complete, solved DSGE model than GMM estimation which based on particular equilibrium relationships such as Euler equation in consumption; second, the priors in Bayesian estimation can supply weights in the estimation process so that the posterior distribution avoids peaking at strange points where the likelihood peaks; third, the inclusion of priors also helps identifying parameters; fourth, by including shocks, which can be interpreted as observation errors in the structural equations, Bayesian estimation addressed model misspecification. Because the values of these parameters are estimated in terms of real macroeconomic quarterly time series from 1996 to 2006, they are independent of the monetary policy rules and the behavioral equations, therefore, we can use these estimated parameters as the calibration in the second scenario to simulate the improved Smets-Wouters model with the money growth rule.

Referring to Hamilton (1994) and other literatures, we summarize the Bayesian technique as following. First, we need to know the *prior* density function of the parameters before the observing data, say

$$p(\Psi_M / M)$$

Where M is the model, Ψ_M denotes the parameters of the model. $p(.)$ stands for a probability density function, which includes normal, gamma, beta, inverse gamma, generalized beta, and uniform function, and so on.

Second, given the model and its parameters, the density of the observed data can be expressed by a likelihood function as

63 Gary S. Anderson (2006) provided detailed discussions on this issue.

64 See, for example, Schorfheide (2000), Lubik and Schorfheide (2000), Smets and Wouters (2002), Ireland (2004a).

$$\Gamma(\Psi_M / X_T, M) \equiv p(X_T / \Psi_M, M)$$

Where X_T represents the set of observed data with T periods, recursing the likelihood function, we obtain

$$p(X_T / \Psi_M, M) = p(x_0 / \Psi_M, M) \prod_{t=1}^{T} p(x_t / X_{T-1}, \Psi_M, M)$$

Applying the Bayesian theorem,

$$p(\Psi_M / X_T) = \frac{p(\Psi_M ; X_T)}{p(X_T)}$$

And also

$$p(X_T / \Psi_M) = \frac{p(\Psi_M ; X_T)}{p(\Psi_M)} \Leftrightarrow p(\Psi_M ; X_T) = p(X_T / \Psi_M) p(\Psi_M)$$

Then, the *posterior density* can be attained by combing the *prior density* and the *likelihood function* as

$$p(\Psi_M / X_T, M) = \frac{p(X_T / \Psi_M ; M) P(\Psi_M / M)}{p(X_T / M)}$$

Where $p(X_T / M)$ is defined as marginal density of the data under the model as

$$p(X_T / M) = \int_{\Psi_M} p(\Psi_M ; X_T / M) d\Psi_M$$

Finally, the posterior kernel is

$$p(\Psi_M / X_T, M) \propto p(X_T / \Psi_M ; M) P(\Psi_M / M) \equiv \kappa(\Psi_M / X_T, M)$$

And the Posterior predictive density is

$$p(\widetilde{X} \mid X_T) = \int_{\Psi_M} p(\widetilde{X}, \Psi_M \mid X_T, M) d\Psi_M = \int_{\Psi_M} p(\widetilde{X} \mid \Psi_M, X_T, M) p(\Psi_M \mid X_T, M) d\Psi_M$$

Dynare v4 uses the Kalman Filter to estimate the likelihood function and employ the MCMC[65] (Monte Carlo Markov Chain[66]) approach with Metropolis-Hastings algorithm[67] to

[65] MCMC as a modern method in Bayesian analysis, according to Cameron and Trevidi (2005), involves simulation (Monte Carlo) and the sequence is that of a Markov chain. After convergence of the chain, S sequential draws can be used to compute summary measures for the posterior. It is desirable to obtain a large sample from the posterior distribution. Then the summary statistics of this sample from the posterior will provide desired information about the moment characteristics of the sample of estimates and about other interesting associated measures such as marginal distributions of parameters or functions of parameters.

[66] A **Markov chain** is defined as a sequence of random variables y_n (n = 0, 1, 2 . . .), where y_n takes values in a finite space B, together with a transition kernel K(.) that defines the probability that y_n equals a particular value given previous values y_{n-j}. For example, for a general Markov Chain with: $\Pr(y_{n+1} = y / y_n, y_{n-1}, \ldots, y_0) = \Pr(y_{n+1} = y / y_n)$, so that the distribution of y_{n+1} given the past is completely determined only by the preceding value y_n. See Cameron and

calculate the posterior kernel.

Following Smets-Wouters (2002), Christiano et al (2001) and Rotemberg and Woodford (1998), the parameters in this model are broken down into two groups.

First group of parameters consist of $(\beta, \tau, c_y, inv_y, k_y, g_y, \overline{r}^k)$, which can be fixed by setting according to the regressed results by many other researchers and observations from the empirical data. Following Smets and Wouters (2002), Christiano et al (2001), Chen Kunting and Gong Liutang (2006), Zhang (2009) and other Chinese economists, β is set to be 0.99, regarding to a steady state real annual interest rate as 0.04; the depreciation rate of capital stock, τ, is set equal to 0.025 per quarter, implying that the annual depreciation rate is 0.10; given β, τ, the steady state value of capital rental rate is 0.0351 by calculating ($\overline{r}^k = \frac{1}{\beta} - 1 + \tau$); referring to the second part of Chapter 3 (Figure 3.5), the share of consumption in GDP, c_y is set to 0.38 according to the actual time series data of China's economy; the ratio of private investment to GDP is assumed to equal 0.22 following Uhlig (2006/2007) and Smets and Wouters (2002)(the ratio of investment to GDP is between 0.18-0.50 in China, see Figure 3.7), so the capital-output ratio k_y is 8.8 ($k_y = inv_y / \tau$) and the government expenditure-output ratio g_y=0.40, in line with the great weights of government investment in China's output (see Figure 3.8). Table 5.1 shows the set valuse for the first group parameters.

Table 5.1 The Values of Parameters by setting (Taylor's rule)

Parameters	β	τ	c_y	inv_y	k_y	g_y	$\overline{r}^k$
Value	0.99	0.025	0.38	0.22	8.8	0 . 40	0.0351

The second group is composed of 32 other model parameters. We use China's quarterly time series data from 1996q1 to 2006q4 to estimate the second group of parameters by Bayesian approach, the data treatment method and data description are discussed in Appendix 5.1.

In our case, the **priors** of second group parameters are determined and presented in Table

Trevidi (2005).

[67] The **Metropolis** algorithm constructs a sequence $\{\boldsymbol{\theta}(n), n = 1, 2, \ldots\}$ whose distributions converge to the target posterior, assumed to be computable up to a normalizing constant which generates a Markov chain that has properties of reversibility, irreducibility, and Harris recurrence that ensure convergence to a stationary distribution. The **Metropolis–Hastings (M–H) algorithm** has improved the Metropolis algorithm. See, for example, Cameron and Trevidi (2005).

5.2.

The inter-temporal elasticity of substitution σ locates between 0.5-1.50 generally according to the results of other research, which is assumed to be distributed as a normal distribution; its precise mean was based on previous outcomes and trials. The inverse elasticity of labour supply, υ, following Smets and Wouters (2002), is set to 2.0 as normal distribution. The output elasticity of capital in production function, α, is set to 0.30 as beta distribution (Beta distribution ranges from 0 to 1) following most researchers. The inverse elasticity of capital utility cost, ψ is normal distribution, prior mean is assumed to 5.917 following Uhlig (2006/2007); the share of fixed cost in production, ϕ is set to 0.408 as normal distribution; the inverse of investment adjustment cost, φ, following a normal distribution with prior mean 0.15; All the coefficients for inflation, inflation growth, output gap and output gap growth [$r_{\pi}, r_{y}, r_{d\pi}, r_{dy}$] are assumed to be normal distribution and the priors for them are set following Uhlig (2006/2007); the habit coefficient of historical consumption has a prior mean 0.5 with standard error 0.10 in beta distribution; the degree of price indexation, the Calvo stickiness of price and wage, and the wage mark up are set to be equal or greater than 0.5 with a beta distribution based on Euro data following Smets and Wouters (2002); All AR coefficients of lagged variables for interest rate and stochastic shocks are assumed to follow a beta distribution (stationary) following Smets and Wouters (2002), their standard errors are set to make the domain covers a reasonable band. Following Smets and Wouters (2002), the variance of ten shocks are assumed to be inverse Gamma distribution, which guarantees the positive variance.

Using Bayesian technology, the **posterior** modes of the parameters are estimated with China's time series quarterly data from 1996q1 to 2006 q4. We estimated these parameters using MCMC approach with Metropolis-Hastings algorithm (100000 draws) in dynare v4.02. We also exploit the maximum likelihood methods to estimate the parameters; the results are also shown in Table 5.3, which is consistent with the results of Bayesian estimation.

From table 5.3, overall, most posterior modes of parameters estimated are significantly different from zero, except the coefficients for the output gap and output gap growth, implying that the deviation of the interest rate rule in china's implementation of monetary policy from the Taylor's rule. Generally, China's monetary authority exploits quantity tools to promote economy growth other than the interest rate, which is often used to be against the inflation. The standard errors of all the shocks are also significant, especially the large value of government expenditure shock, which is in line with the real economic situation in china, where government consumption and investment play great roles in economic growth; the big value of wage mark up shock reflects a flat or elastic upward labour supply curve in China, demonstrating that the abundant of labour in China; the great shock of productivity demonstrates that huge technology progress took place in China in the last decade.

On table 5.3, we can see that the 32 parameters are not only estimated by a Bayesian approach, but also by a Maximum Likelihood method for a check. Comparing the results, we can find that the results are very close based on the two methods. For example, the coefficient of relative risk aversion, σ, is 1.3589 (mean) from the Bayesian approach; checked by Maximum Likelihood method, its value is 1.3592(mode). The Calvo price stickiness, ω_p, is 0.9529 from the Bayesian estimation; using the Maximum Likelihood estimation, it is 0.9516. Similar results to all parameters, therefore, we can conclude that the estimation of the parameters by the Bayesian approach is robust.

Focusing on the parameters governing the characteristics of price and wage stickiness in China's economy, we find that the 4 parameters ($\gamma_p\ \omega_p\ \gamma_w\ \omega_w$) are estimated to be greater than that in prior distribution, especially the considerable degree of Calvo price and wage stickiness (ϖ_p=0.9529, ω_w=0.7947), implying a long period of wage and price contracts more than two years.

Comparing the values of our estimated parameters from China's economic data with that from Euro area and US data based on the same model and same estimating approach, we can draw some interesting conclusions from Table 5.4. The external habit formation of past consumption in China is the greatest, saying that Chinese have the biggest habit consumption, which implies that an expected one percent increase in the short-term interest rate for four quarters has more impact on consumption in the Euro area and the US than in China according to the consumption equation(5.33). China has the biggest output elasticity of capital in GDP. This is in line with the large share of investment in GDP formation in China, but the adjustment cost parameter in China is also the biggest, showing the lowest efficiency of capital utilization. China's elasticity of labour supply is relatively smaller than that in Europe and US. Among three economies, US hold the biggest elasticity of capital utility cost, China's elasticity of capital utility cost is close to Europe's. China's interest rate is more persistent than that in Europe and US. This implies that China has a higher inertia in the implementation of monetary policy when the interest rate is taken as main policy tool. Our estimation delivers very lower values for the coefficients in the reaction function of China's monetary authority than that in US and Europe, implying that China's central bank does not completely follow Taylor's rule, although the response of interest rate to inflation was greater than and close to the values in Europe and US which is consistent with the Taylor's principle, the response of interest rate to output gap is very weaker in China than that in US and Europe. This result consists with the reality that the main policy tool is a quantity tool rather than a price tool in China. China has the biggest degree of price indexation (γ_P), two times as in Europe and US, implying that inflation depends more on past inflation than expected future inflation in China according to the inflation equation (5.40), namely, backward-looking plays more roles than forward looking in inflation formation process in China. Moreover, China has the most considerable degree of Calvo price stickiness among three economies, reflecting that underdevelopment of market mechanism and high degree of regulation on the prices by the government. Finally, China's government expenditure shock, productivity shock, preference shock, investment shock and mark up in price and wage shocks are very significant compared with that in Europe and US, which are shaping the special characteristics of China's economy.

Table 5.2 The priors[68] of the parameters

parameters	pdf type	Prior distribution Mean(1st)	Prior distribution St. error	Prior distribution Mean(2nd)	Remarks
σ	Normal	1.2000	0.25	1.20	coefficient of relative risk aversion
υ	Normal	2.0	0.75	2.0	Inverse elasticity of labour supply
α	Beta	0.3	0.1	0.3	output elasticity of capital
ψ	Normal	5.917	0.05	6.0	inverse elasticity of capital utility cost
ϕ	Normal	1.408	0.25	**3.0**	1+share of fixed cost in production
φ	Normal	0.15	0.05	0.15	Inverse of invest. adjustment cost
ρ	Beta	0.93	0.03	0.95	AR for lagged interest rate
r_π	Normal	1.68	0.05	1.68	Inflation coefficient
r_y	Normal	0.10	0.05	**0.01(0.005)**	output gap coefficient
$r_{d\pi}$	Normal	0.15	0.10	**0.10(0.005)**	inflation growth coefficient
r_{dy}	Normal	0.40	0.10	**0.01(0.005)**	output gap growth coefficient
h	Beta	0.50	0.10	0.70	habit coefficient of past consumption
γ_p	Beta	0.50	0.15	0.80	degree of partial indexation of price
ω_p	Beta	0.9	0.05	0.9	Calvo price stickiness
γ_w	Beta	0.75	0.15	0.75	degree of partial indexation of wage
ω_w	Beta	0.70	0.15	0.70	Calvo wage stickiness
λ_w	Beta	0.5	0.15	0.5	markup in wage setting
ρ_c	Beta	0.85	0.10	0.85	AR for preference shock
ρ_a	Beta	0.80	0.10	0.80	AR for productivity shock
ρ_I	Beta	0.85	0.10	0.85	AR for investment shock
ρ_L	Beta	0.85	0.10	0.85	AR for labour supply shock
ρ_G	Beta	0.85	0.10	0.85	AR for government expenditure shock
ρ_π	Beta	0.85	0.10	0.85	AR for money supply shock
ε_t^c	Inv gamma	0.336	Inf.	1.2	Preference shock
ε_t^a	Inv gamma	0.598	Inf.	**3.0**	Productivity shock
ε_t^L	Inv gamma	3.52	Inf.	3.52	Labour supply shock
ε_t^G	Inv gamma	0.325	inf.	**8.0**	Government expenditure shock
ε_t^I	Inv gamma	0.085	Inf.	**1.2**	Investment shock
ε_t^π	Inv gamma	0.017	Inf.	0.017	Money supply shock
ε_t^R	Inv gamma	0.081	Inf.	**0.15**	Interest rate shock
ε_t^W	Inv gamma	0.289	Inf.	**5.0**	Wage mark up shock
ε_t^Q	Inv gamma	0.604	Inf.	0.70	Return on equity shock
ε_t^P	Inv gamma	0.16	Inf.	**0.50**	Price mark up shock

[68] We set first prior distribution mean referring to the results of Smets and Wouters (2002) and Chen and Gong (2006), and then set the second priors in accordance with our estimation.

Table 5.3 Estimated parameters by Bayesian Approach and Maximum Likelihood

Parameters	Prior distribution			Posterior distribution MH			Maximum likelihood	
	pdf type	Mean	St. error	Mean	Std. error	Conf. interval	Mode	Std. error
σ coeff. of relative risk aversion	normal	1.20	0.25	1.3582	0.25	0.9649-1.7226	1.3592	0.2271
υ inverse elasticity of labour supply	normal	2.0	0.75	2.2095	0.5	1.4533-2.9545	2.1687	0.4684
α output elasticity of capital	beta	0.3	0.1	0.4209	0.1	0.3416-0.4969	0.4222	0.0470
ψ inverse elasticity of capital utility cost	normal	6.0	1.0	6.1839	1.0	4.5236-7.6779	6.2775	0.9483
ϕ 1+share of fixed cost in production	normal	3.0	0.25	3.4945	0.25	3.1323-3.8353	3.5319	0.2174
φ inverse of invest. Adjustment cost	normal	0.15	0.05	0.0633	0.05	0.0026-0.1196	0.0613	0.0458
ρ AR for lagged interest rate	beta	0.95	0.03	0.9835	0.03	0.9780-0.9890	0.9854	0.0033
r_π inflation coefficient	normal	1.68	0.05	1.6731	0.05	1.5911-1.7524	1.6757	0.05
r_y output gap coefficient	normal	0.01	0.005	0.0090	0.005	0.0013-0.0169	0.0087	0.0048
$r_{d\pi}$ inflation growth coefficient	Normal	0.10	0.05	0.0906	0.05	0.0536-0.1270	0.0831	0.021
r_{dy} output gap growth coefficient	Normal	0.01	0.005	0.0037	0.005	0.0001-0.0074	0.0033	0.0021
h habit coefficient of past consumption	Beta	0.70	0.10	0.8142	0.1	0.7371-0.8940	0.8099	0.0525
γ_p degree of partial indexation of price	Beta	0.80	0.15	0.9657	0.15	0.9288-1.00	0.9902	0.0192
ω_p calvo price stickiness	Beta	0.9	0.05	0.9529	0.05	0.9364-0.9696	0.9516	0.0096
γ_w degree of partial indexation of wage	Beta	0.75	0.15	0.6093	0.15	0.3203-0.9112	0.6159	0.2384
ω_w calvo wage stickiness	Beta	0.70	0.15	0.7947	0.05	0.7322-0.8590	0.7931	0.0441
λ_w markup in wage setting	Beta	0.5	0.15	0.2667	0.15	0.0380-0.4894	0.1521	0.1202
ρ_c AR for preference shock	Beta	0.85	0.10	0.9332	0.10	0.8887-0.9788	0.9631	0.0183
ρ_a AR for productivity shock	Beta	0.80	0.10	0.9228	0.10	0.8658-0.9788	0.9413	0.0355
ρ_I AR for investment shock	Beta	0.85	0.10	0.7810	0.10	0.6208-0.9457	0.8493	0.1064
ρ_L AR for labour supply shock	Beta	0.85	0.10	0.8533	0.10	0.7063-0.9952	0.9222	0.0858
ρ_G AR for government expenditure shock	Beta	0.85	0.10	0.9019	0.10	0.8384-0.9670	0.9163	0.0415
ρ_π AR for money supply shock	Beta	0.85	0.10	0.8429	0.10	0.6846-0.9945	0.9218	0.086
ε_t^c Preference shock	Inv gamma	1.2	Inf.	1.2392	Inf.	0.4158-2.1375	0.6724	0.2972
ε_t^a Productivity shock	Inv gamma	3.0	Inf.	2.7720	Inf.	2.2490-3.2871	2.6396	0.2983
ε_t^L Labour supply shock	Inv gamma	3.52	Inf.	3.6627	Inf.	0.7654-8.5130	1.6239	0.6649
ε_t^G Government expenditure shock	Inv gamma	8.0	inf.	8.7388	Inf.	7.2692-10.1926	8.4378	0.8705
ε_t^I Investment shock	Inv gamma	1.2	Inf.	1.2805	Inf.	0.6902-1.8504	0.9929	0.3620
ε_t^π Money supply shock	Inv gamma	0.017	Inf.	0.0149	Inf.	0.0041-0.0264	0.0078	0.0032
ε_t^R Interest rate shock	Inv gamma	0.15	Inf.	0.1457	Inf.	0.1175-0.1720	0.1366	0.0155
ε_t^W Wage mark up shock	Inv gamma	5.0	Inf.	5.0508	Inf.	3.9890-6.1190	4.7423	0.6190
ε_t^Q Return on equity shock	Inv gamma	0.70	Inf.	0.6511	Inf.	0.1542-1.4246	0.3225	0.1317
ε_t^P Price mark up shock	Inv gamma	0.50	Inf.	0.4482	Inf.	0.3596-0.5343	0.4195	0.0474

Table 5.4 Comparison of Estimated parameters between China, Euro Area and US[69]

Parameters	Euro Area		China		US	
	mean	**Conf. interval**	**Mean**	**Conf. interval**	**Mean**	**Conf. interval**
σ coefficient of relative risk aversion	1.613	1.126-2.106	1.3582	0.9649-1.7226	1.38	1.16-1.59
υ inverse elasticity of labour supply	1.265	0.439-2.365	2.2095	1.4533-2.9545	1.83	0.91-2.78
α output elasticity of capital	0.3	By setting	0.4209	0.3416-0.4969	0.19	0.16-0.21
ψ inverse elasticity of capital utility cost	5.714	3.46-16.129	6.1839	4.5236-7.6779	1.85	1.39-2.78
ϕ 1+share of fixed cost in production	1.499	1.199-1.835	3.4945	3.1323-3.8353	1.60	1.48-1.73
φ inverse of invest. adjustment cost	0.165	0.1254-0.2314	0.0633	0.0026-0.1196	0.174	0.135-0.252
ρ AR for lagged interest rate	0.928	0.901-0.946	0.9835	0.9780-0.9890	0.81	0.77-0.85
r_{π} inflation coefficient	1.668	1.537-1.821	1.6731	1.5911-1.7524	2.04	1.74-2.33
r_y output gap coefficient	0.144	0.079-0.215	0.0090	0.0013-0.0169	0.08	0.05-0.12
$r_{d\pi}$ inflation growth coefficient	0.222	0.134-0.313	0.0906	0.0536-0.1270	N/A	N/A
r_{dy} output gap growth coefficient	0.174	0.131-0.219	0.0037	0.0001-0.0074	0.22	0.18-0.27
h habit coefficient of past consumption	0.551	0.416-0.681	0.8142	0.7371-0.8940	0.71	0.64-0.78
γ_p degree of partial indexation of price	0.429	0.268-0.597	0.9657	0.9288-1.00	0.24	0.10-0.38
ω_p calvo price stickiness	0.909	0.890-0.927	0.9529	0.9364-0.9696	0.66	0.56-0.74
γ_w degree of partial indexation of wage	0.655	0.383-0.900	0.6093	0.3203-0.9112	0.58	0.38-0.78
ω_w calvo wage stickiness	0.756	0.690-0.817	0.7947	0.7322-0.8590	0.70	0.60-0.81
λ_w markup in wage setting	0.593	0.503-0.671	0.2667	0.0380-0.4894	1.5	By setting
ρ_c AR for preference shock	0.882	0.817-0.931	0.9332	0.8887-0.9788	0.22	0.07-0.36
ρ_a AR for productivity shock	0.822	0.712-0.912	0.9228	0.8658-0.9788	0.95	0.94-0.97
ρ_I AR for investment shock	0.914	0.856-0.961	0.7810	0.6208-0.9457	0.71	0.61-0.80
ρ_L AR for labour supply shock	0.952	0.916-0.98	0.8533	0.7063-0.9952	N/A	N/A
ρ_G AR for government expenditure shock	0.952	0.912-0.982	0.9019	0.8384-0.9670	0.97	0.96-0.99
ρ_{π} AR for money supply shock	0.847	0.658-0.970	0.8429	0.6846-0.9945	N/A	N/A
ε_t^c Preference shock	0.324	Inf.	1.2392	0.4158-2.1375	0.23	0.19-0.27
ε_t^a Productivity shock	0.628	Inf.	2.7720	2.2490-3.2871	0.45	0.41-0.50
ε_t^L Labour supply shock	1.709	Inf.	3.6627	0.7654-8.5130	N/A	N/A
ε_t^G Government expenditure shock	0.331	inf.	8.7388	7.2692-10.1926	0.53	0.48-0.58
ε_t^I Investment shock	0.140	Inf.	1.2805	0.6902-1.8504	0.45	0.37-0.53
ε_t^{π} Money supply shock	0.028	Inf.	0.0149	0.0041-0.0264	N/A	N/A
ε_t^R Interest rate shock	0.140	Inf.	0.1457	0.1175-0.1720	0.24	0.22-0.27
ε_t^W Wage mark up shock	0.286	Inf.	5.0508	3.9890-6.1190	0.24	0.20-0.28
ε_t^Q Return on equity shock	0.614	Inf.	0.6511	0.1542-1.4246	N/A	N/A
ε_t^P Price mark up shock	0.163	Inf.	0.4482	0.3596-0.5343	0.14	0.11-0.16

[69] The estimated results for Euro area are from Smets and Wouters (2002) and for US are from Smets and Wouters (2007)

5.4 The Simulation Results from the Benchmark Smets-Wouters Model (Taylor's Rule)

5.4.1 Impulse Response Analysis

In this section, we use the estimated DSGE model to conduct analysis on the impulse responses of the endogenous economic variables to the various structural shocks, especially the monetary policy shocks and productivity shocks to uncover the transmission mechanism of monetary policy in China and the characteristics of China's business cycles.

The impulse responses of endogenous variables on the exogenous shocks-two monetary policy shocks, three cost-push shocks, technology shocks, preference shocks, government expenditure shock, investment shock will be presented and discussed as follows. Before discussion, we provide a notation table for the variables in the model system. For other notations see the Dynare code in Appendix 5.1.

Table 5.5 Notation Table

Variables	Notation	Variables	Notation	Variables	Notation
Real consumption	c	Labour hours	l	Interest rate	R
Real investment	I	Real Wage	w	Rent rate of capital	rk
Real output	Y	Inflation rate	pi	Asset price(Tobin's Q)	Q
Growth of money	Kai			Money supply	M

The Effects of Monetary Policy Shocks and the Transmission Channels of China's Monetary Policy

Figure 5.1 shows the effects of the money supply shock. The real wage, labour hours, capital stock, consumption, investment, and output rise, which is in line with the canonical conclusions. The real interest rate falls immediately, demonstrating a liquidity effect following an inflation effect: two years later the real interest rate begins to rise against the increase of inflation. These results are different from that in Euro Area from Smets and Wouters (2002), where no liquidity effect is found without persistent monetary policy shock.

The increase of money supply causes the fall of interest rate and thereby the rises of consumption, investment and then the output, these results provide the evidence of *interest rate channel* of MTM in China. Also, the immediate rise of the asset price (q, Tobin's q) caused by a money supply shock following the gradual rise of consumption (*Wealth Effect)* and investment (*Tobin's Q*) supports the existence of an *asset price channel* in MTM in China. Moreover, the inflation equation (5.41) incorporates the effects of expectations in the monetary policy transmission (*Expectation channel*).

Figure 5.1 The effects of money supply shocks (Taylor's Rule)

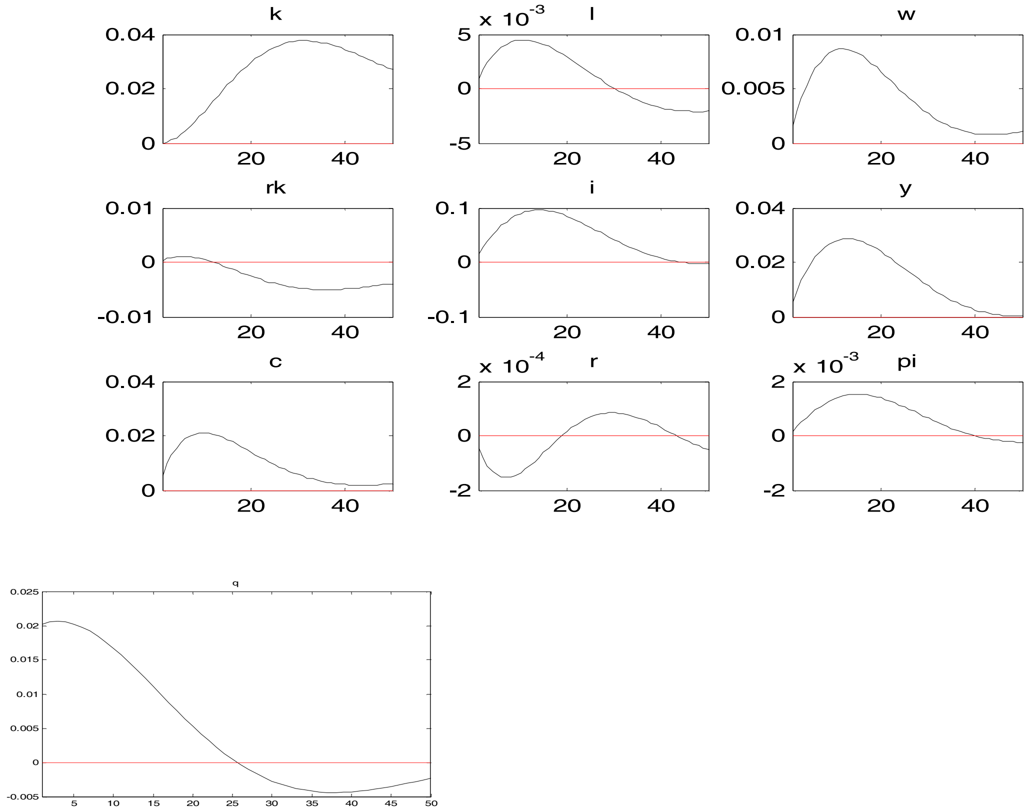
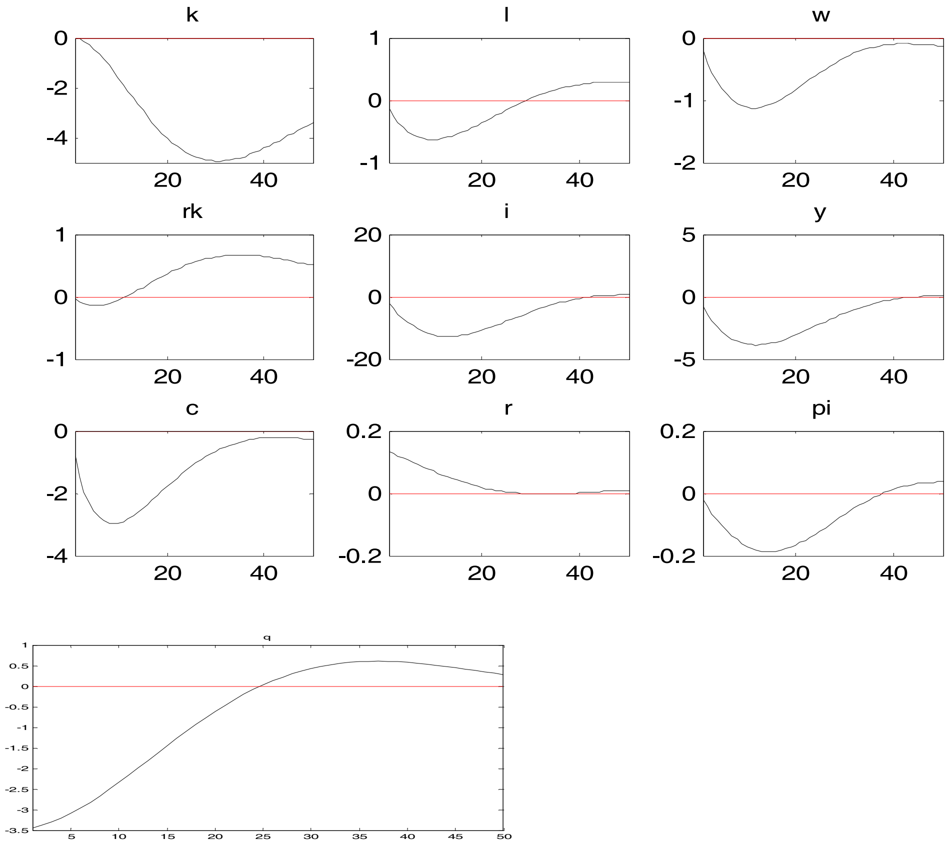


Figure 5.2 Responses to interest rate shocks (Taylor's Rule)

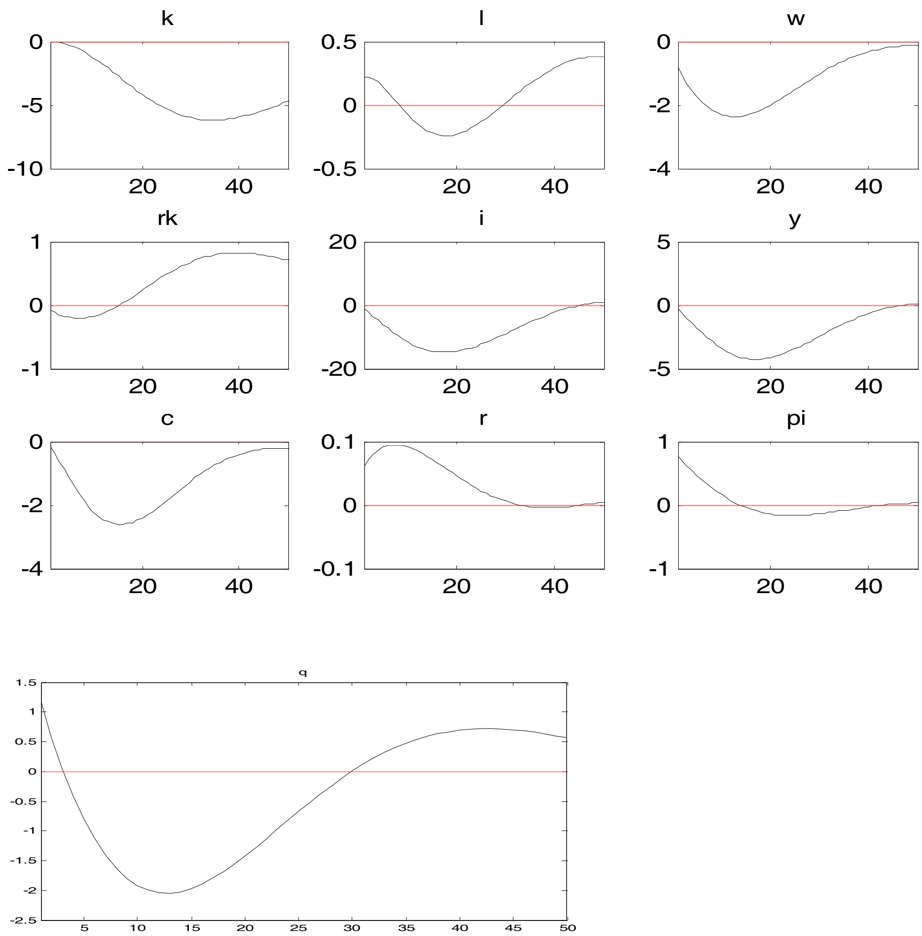


The effects of an interest rate shock are presented in Figure 5.2. A positive interest rate shock makes the real interest rate rise, and thereby reduces the consumption, investment, output, capital stock, labour supply, real wage level and the rate of inflation, but the rental rate of capital soon rebounds after a temporary decrease. This clearly prooves the existence of *interest rate channel* of monetary policy in China. The immediate fall of the asset price following the fall in consumption and investment also implies the existence of an *asset price channel* through *Tobin's effect* and *Wealth effect*. Moreover, the above effects uncover the role of monetary policy in China's business cycles.

The Effects of Cost-Pushed Shocks

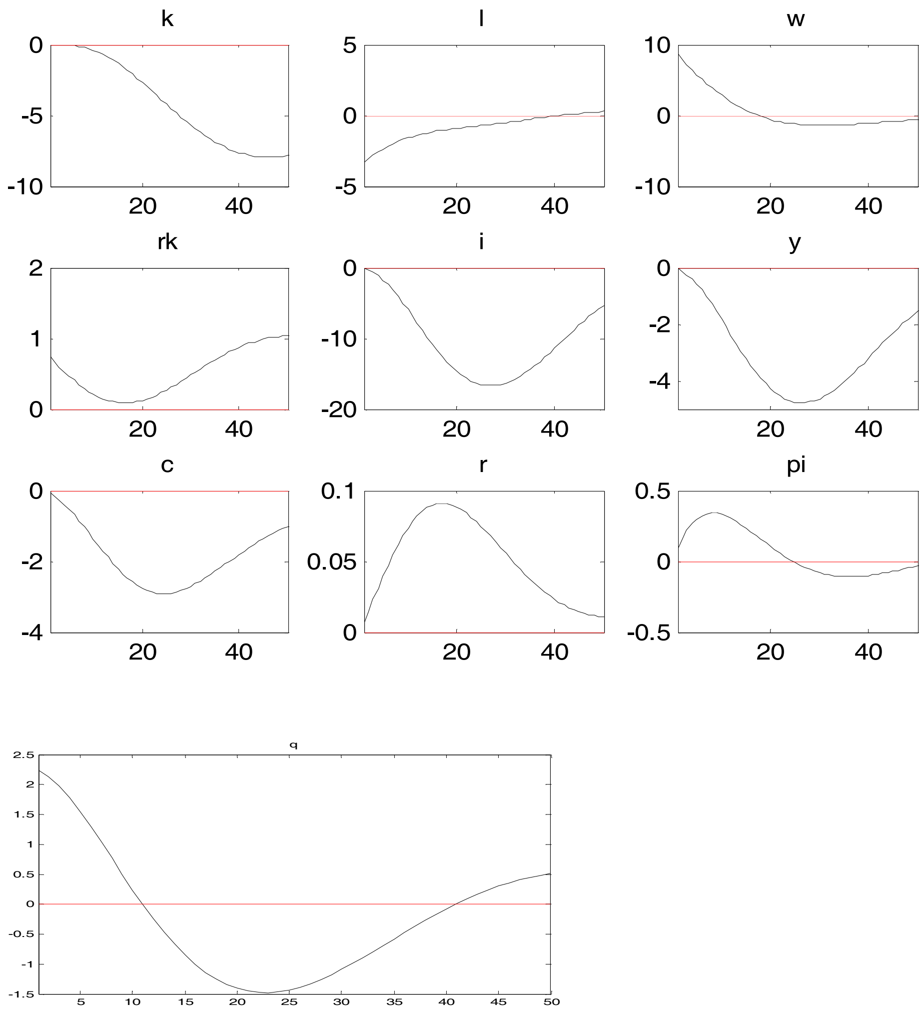
A price mark up shock increases the rate of inflation immediately, and then the interest rate to be against the inflation, the immediate fall in output comes from two sides: the left shift of the aggregate demand curve because of the decline of consumption and investment (*Interest rate channel*); the left shift of the aggregate supply curve because of the fall of labour hours and wages. At the outset, the labour supply and equity premium rise and then begin to fall after 3 years (Figure 5.3).

Figure 5.3 Responses to Price Mark up Shocks (Taylor's Rule)



A wage mark up shock also increases the rate of inflation and interest rate with the rise of real wage, the consumption, investment, output and equity premium have similar responses as that to the price mark up shock excluding opposite responses of the labour supply and capital rental rate and the similar mechanism (Figure 5.4).

Figure 5.4 Responses to Wage Mark up Shocks (Taylor's Rule)



A positive equity premium shock (asset price rise) increases the investment and consumption (gradually) and thereby the output, which supports the evidence of the *asset price channel*. The capital stock, labour supply, real wage, and interest rate also increase, which reduces inflation rate and capital rental rate (Figure 5.5).

The Effects of Other Shocks

Figure 5.6 shows, following a positive *productivity shock*, the consumption, investment, output, capital stock and real wage rise, while labour supply (employment) falls. The rental rate of capital, return on equity market, interest rate and inflation rate also fall. These effects tell the

Figure 5.5 Responses to Return on Equity Market Shocks (Taylor's Rule)

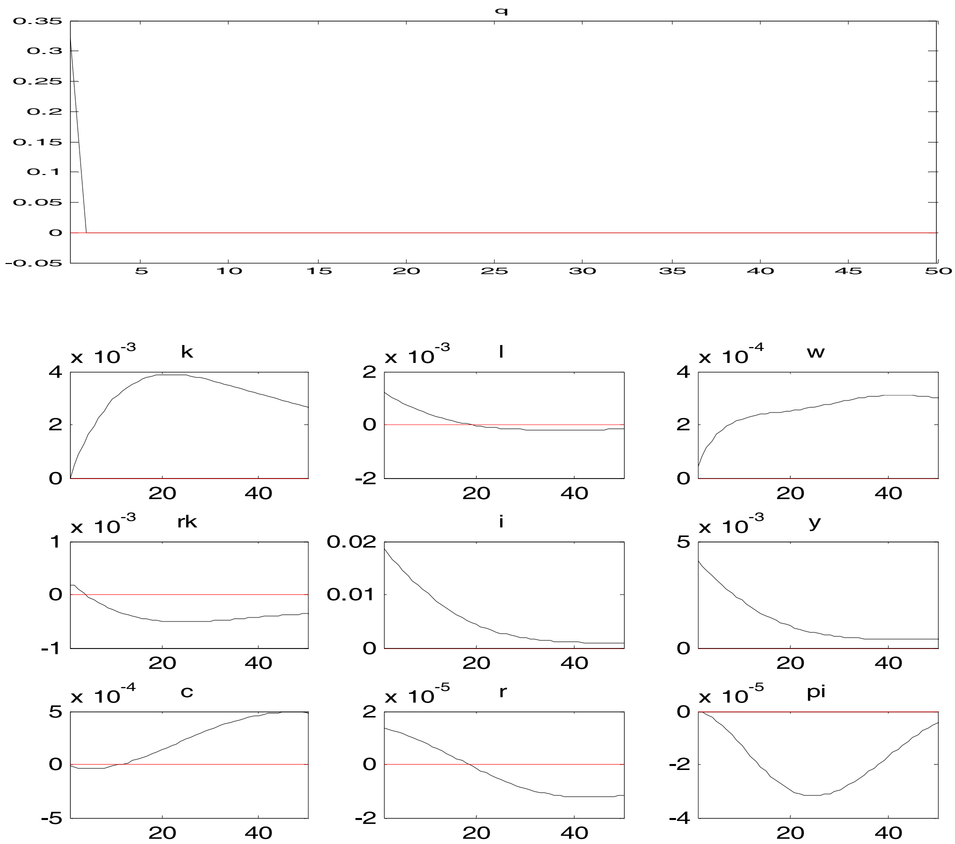
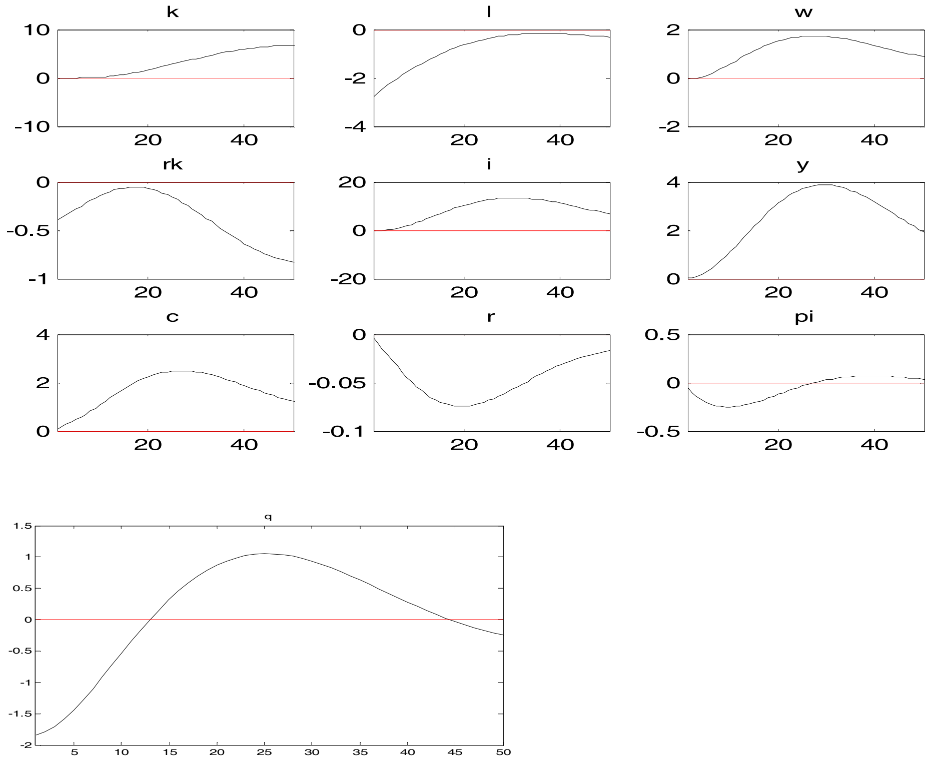


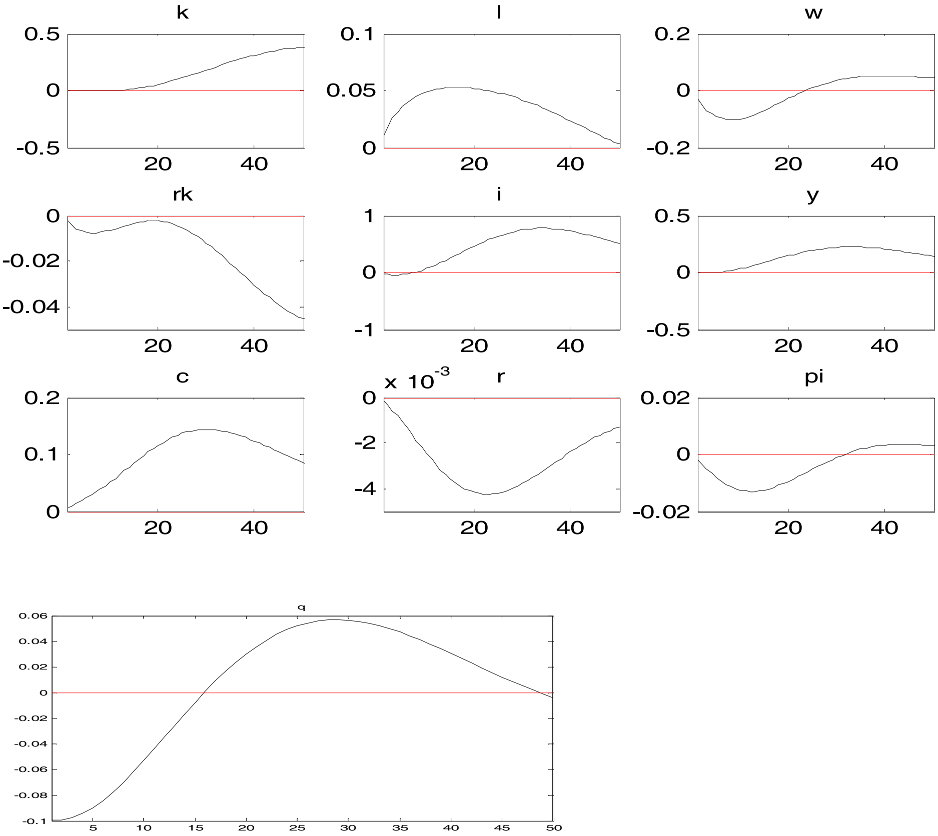
Figure 5.6 Responses to Productivity Shock (Taylor's Rule)



same story identified as in US and Euro Area. As Smets and Wouters (2002) pointed out, the rise in productivity causes the fall in marginal cost, because the monetary policy does not reacts timely and strongly (interest rate falls slowly) to offset this fall in marginal cost, which decreases inflation gradually;

Figure 5.7 demonstrated the effects of a positive *labour supply shock.* The qualitative effects of this shock on consumption, investment, output, capital stock, inflation and interest rate are similar to those of a productivity shock. But the employment and real wage have opposite responses as those of a productivity shock.

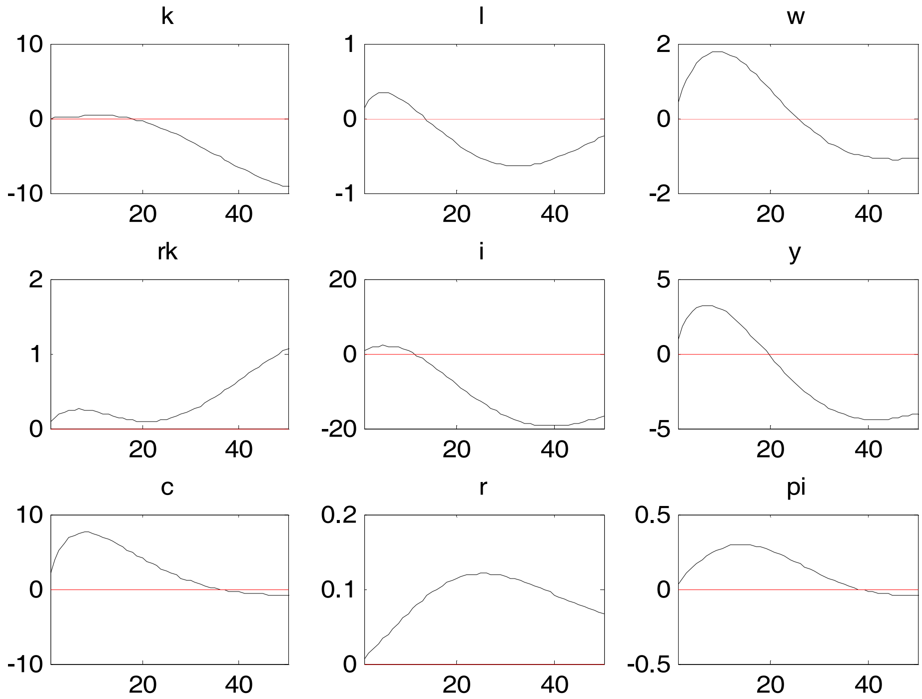
Figure 5.7 The Impulse Responses to Labour Supply Shocks (Taylor's Rule)



Following a *preference shock* as shown in Figure 5.8, the consumption and output increase significantly, while the investment increases initially and then begin to fall, demonstrating a delay significant crowding out effect; the labour supply and real wage also increase, which causes the rise in marginal cost and thereby increase the inflation rate, the interest rate rise following the rise in inflation.

The *government expenditure shock* has significant effects in China, increasing the labour supply, real wage and output immediately and thereby causing demand-pull inflation gradually. It decreases the private consumption and investment, implying a significant crowding out effect on private consumption and private investments. The fall in consumption leads to the rise of marginal utility of working, which increases the labour supply. The return on equity market rises while the capital stock falls. The interest rate and rental rate of capital also increase (Figure 5.9).

Figure 5.8 Responses to Preference Shocks (Taylor's Rule)



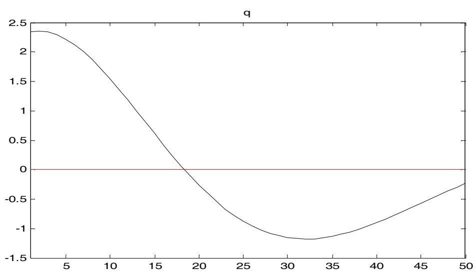


Figure 5.10 shows the effects of a positive investment shock. Investment, the capital stock and output increase significantly with a weak crowding out effect on consumption, which has a similar result to that of a government expenditure shock: labour supply and real wage also rise. The investment shock causes a weak rise in inflation, while the equity premium and capital rental rate falls.

Figure 5.9 Responses to Government Expenditure Shocks (Taylor's Rule)

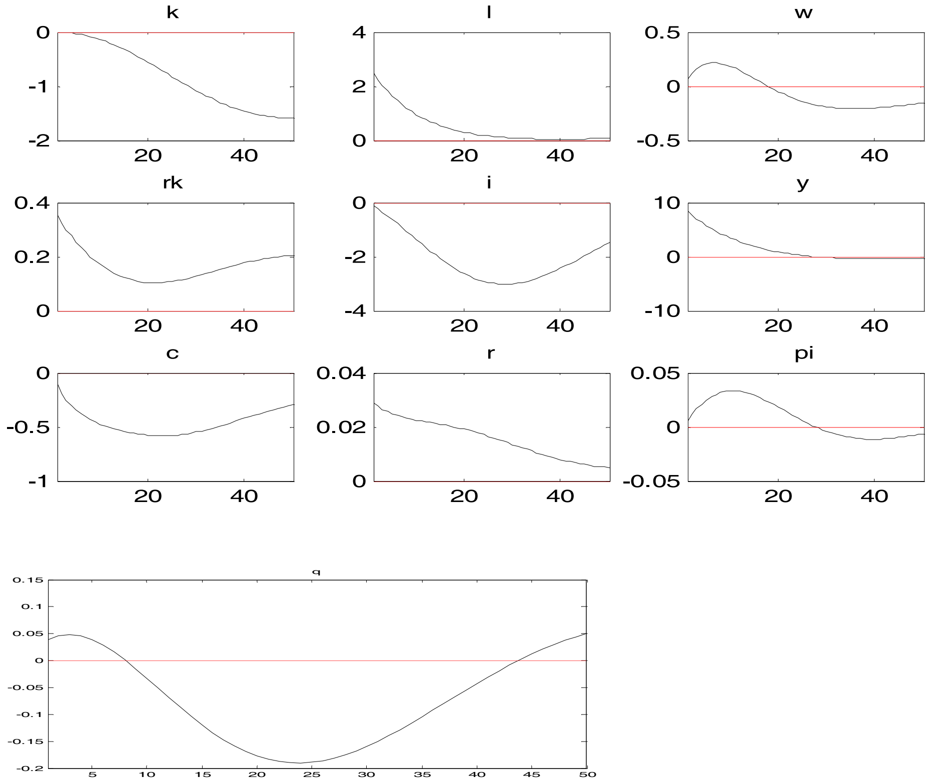
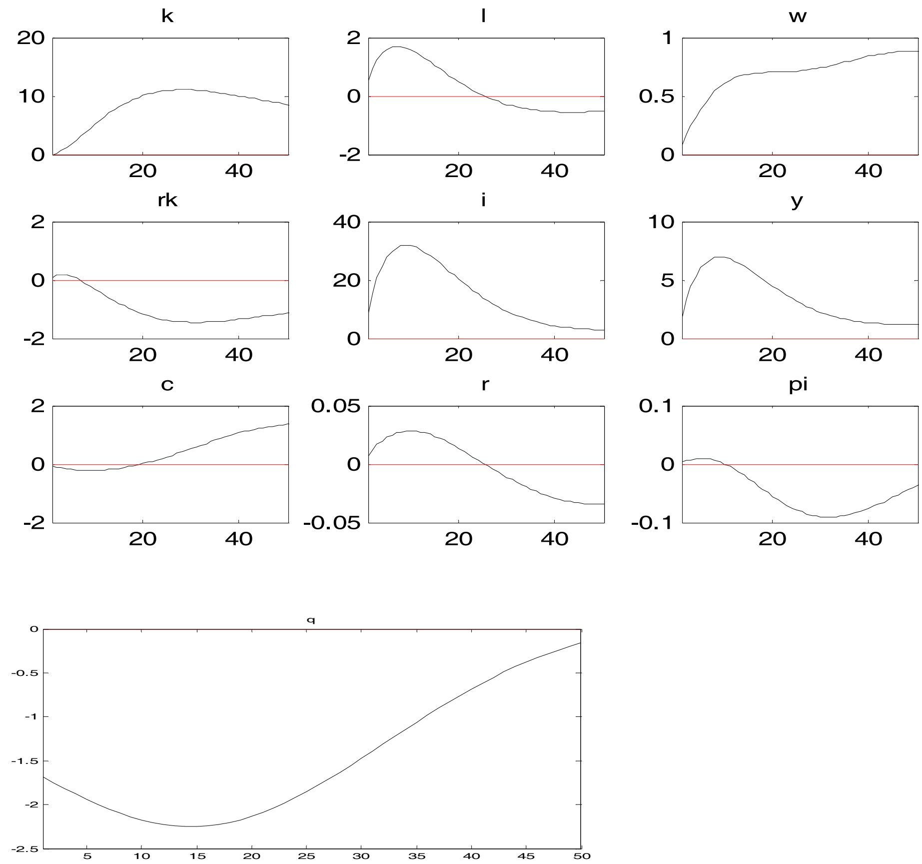


Figure 5.10 Responses to Investment Shocks (Taylor's Rule)



5.4.2 Variance Decomposition from Taylor's Rule Model

Table 5.6 shows the variance decomposition in infinite horizon from Taylor's rule model.

Table 5.6 Variance Decomposition (in percent) (Taylor's Rule)

	ε_t^L	ε_t^a	ε_t^c	ε_t^G	ε_t^π	ε_t^R	ε_t^I	ε_t^P	ε_t^W	ε_t^Q
k	**0.04**	**10.83**	**35.14**	**0.64**	**0.00**	**4.54**	**28.01**	**6.88**	**13.93**	0.00
l	**0.03**	**24.91**	**7.83**	**12.26**	**0.00**	**3.06**	**17.22**	**1.99**	**32.69**	0.00
w	**0.03**	**11.77**	**14.48**	**0.26**	**0.00**	**2.97**	**6.01**	**14.05**	**50.44**	0.00
rk	**0.04**	**10.60**	**34.75**	**0.90**	**0.00**	**4.60**	**28.36**	**6.75**	**14.01**	0.00
i	**0.03**	**9.81**	**26.67**	**0.55**	**0.00**	**6.12**	**33.79**	**9.05**	**13.97**	0.00
y	**0.04**	**11.53**	**22.23**	**10.40**	**0.00**	**7.39**	**22.96**	**9.79**	**15.66**	0.00
c	**0.04**	**11.72**	**52.60**	**0.76**	**0.00**	**8.21**	**5.14**	**7.70**	**13.84**	0.00
r	**0.04**	**11.83**	**45.41**	**1.26**	**0.00**	**10.63**	**4.84**	**11.05**	**14.94**	0.00
pi π	**0.04**	**12.06**	**20.42**	**0.22**	**0.00**	**8.45**	**2.47**	**36.20**	**20.15**	0.00
q	0.03	7.78	15.34	0.15	0.00	24.05	27.31	13.09	12.24	0.02

Focusing on the contribution of each of the structural shocks to output, we can find that in the long run, the investment and preference shocks drives the forecasted GDP variances, which can explain about 20% of output forecast error respectively; technology shock, monetary policy shock (interest rate shock), government expenditure shock and cost-pushed shocks (price mark up, wage mark up) also play distinguished roles, each contributes about 10% respectively. Money supply shocks have no impact on output variance in the long run. This is in line with the assumption that the money is neutral in our utility function. These conclusions are very different from that in Euro Area from Smets and Wouters (2002).

Turning to the determinants of inflation, it shows that the cost-push shock dominates the forecast errors, which contributes about 50% of inflation variance, uncovering the special characteristics of inflation formulation in China. Preference shocks also account for 20%, technology shocks account for 12%, whereas monetary policy shocks also contribute about 10%.

The interest rate is mainly driven by the preference shock (45%), cost-push shocks and technology shocks also account for above 10%.

Obviously, the consumption variance is dominated by preference shock (50%); whereas technology shock, cost-push shock and monetary policy shocks also have impacts.

In summary, the preference shock and investment shock play significant roles in China's business cycle, cost-push shocks, technology shock, government expenditure shock and monetary policy (interest rate) shock also explain distinguished fraction of output, inflation, interest rate and consumption.

It is worth noting that the wage mark-up shock and technology shock determine 50% of labour supply variance in the long run. Investment and government expenditure shocks also play important roles in labour supply in China.

5.5 The Simulation Results for the Improved Smets-Wouters Model (Money Growth Rule)

Replacing the Taylor's rule with money growth rule, in this section, we simulate the monetary policy transmission mechanism and business cycle in terms of the calibration parameters in section 5.3.

Besides the estimated parameters in section 5.3, following Zhang (2009), the money growth parameters are set as in Table 5.7.

Table 5.7 Money growth process parameters

Parameters	ρ_M	ζ_1	ζ_2	σ_M
Value	0.8	1.0	0.5	3.13

Another Dynare programme (See appendix 5.1) is written to simulate the monetary policy transmission mechanism and the business cycle in China again. The results are presented in Appendix 5.5.

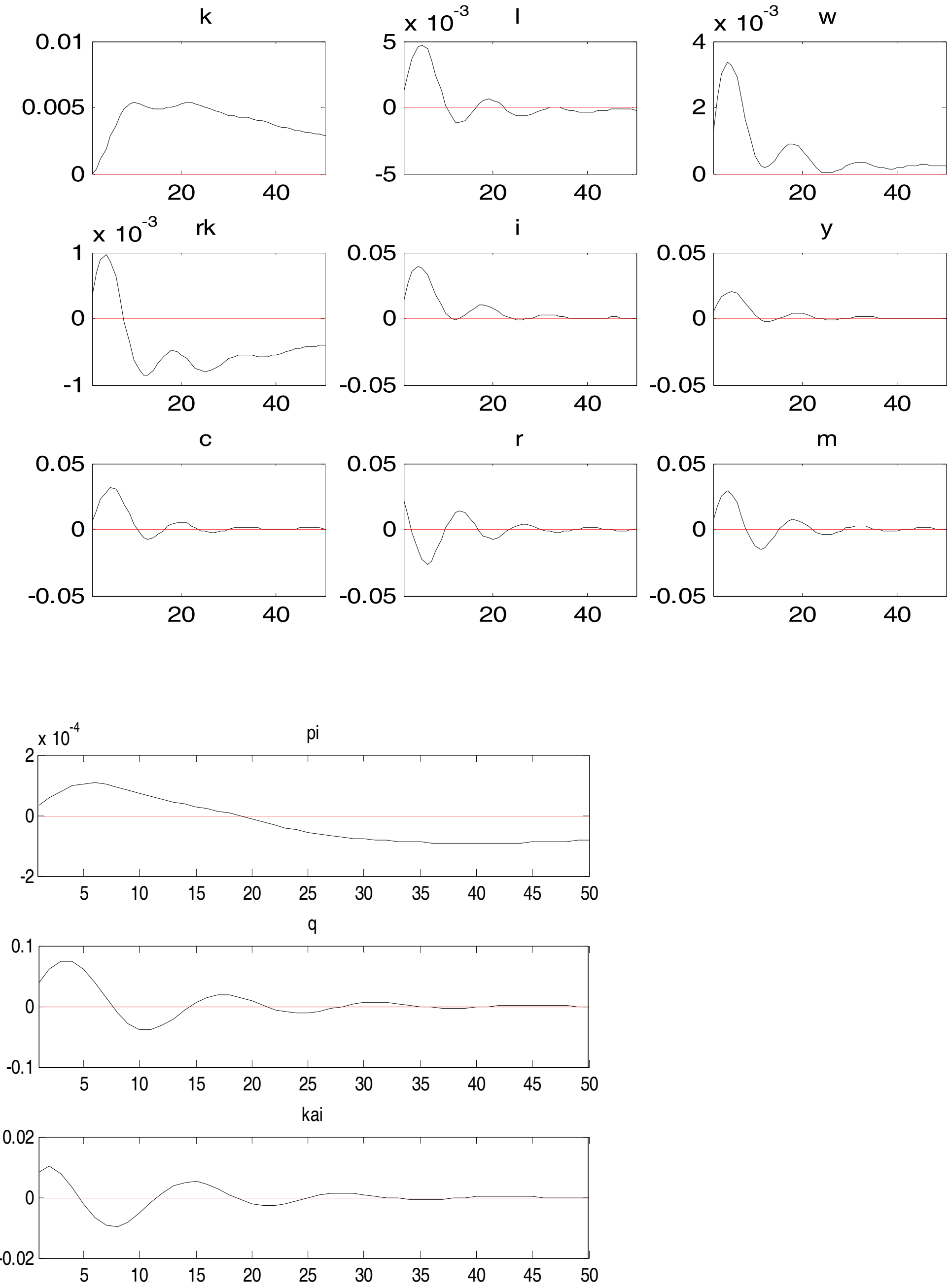
5.5.1 Impulse Response Analysis (Money Growth Rule)

The Transmission Channels of China's Monetary Policy

A money supply shock increases money growth rate and the money supply, and makes inflation rate rise. Consumption, investment and capital all rise and thereby raising the output. The interest rate rises initially and then falls quickly. These effects confirm the existence of the *monetary channel* (interest rate channel) and the *liquidity effec*t in China. The rise in the asset price (q) shows the evidence of the *asset price channel*. The labour supply and the wage rate also rise after a money supply shock. (See Figure 5.11)

Comparing the effects of money supply shock in Taylor's rule and the money growth rule, we can find the responses of all variables are similar. The difference is that the effects of a money supply are stronger in a money growth model than in Taylor's model.

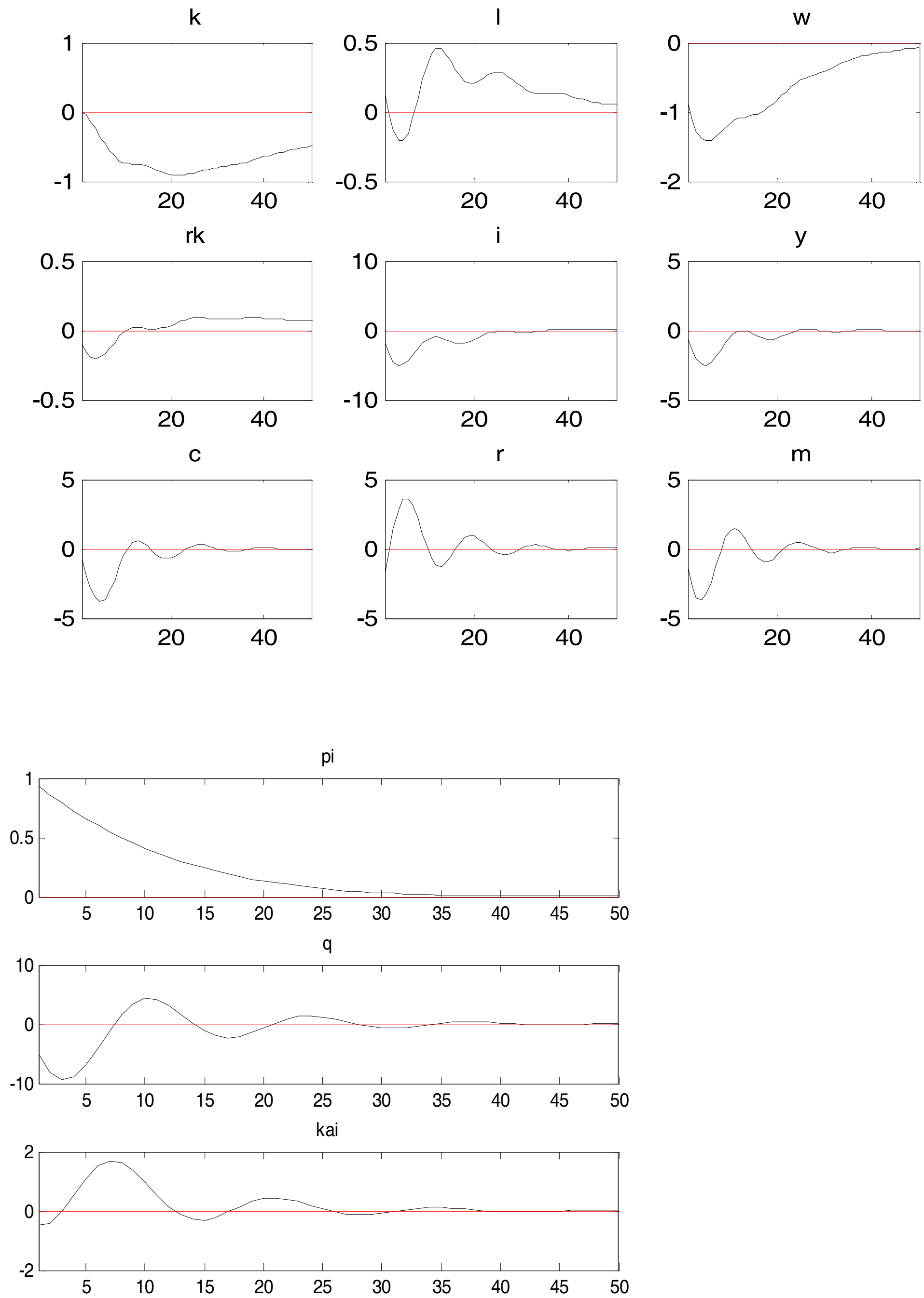
Figure 5.11 The Responses to the Money Supply Shock (Money Growth Rule)



The Effects of Cost-Push Shocks

Figure 5.12 shows that a price mark up shock increases the inflation immediately like in the Taylor's rule. The interest rate soon is raised by the PBC and the money supply decreases to depress the inflation, all other macroeconomic variables excluding the asset price fall following the contractionary policy operation (The interest rate channel). The wage rate falls and increases the labour supply later.

Figure 5.12 The Responses to the Price Mark up Shock (Money Growth Rule)



A wage mark up shock raises the wage rate and inflation, depresses the labour supply, the rise in the interest rate soon depressed the consumption, investment, money supply, capital and thereby the output. A similar effect is demonstrated as the price mark up shock (See Figure 5.13). These effects are similar as in Taylor's rule excluding the asset price response is opposite.

Figure 5.13 The Responses to the Wage Mark up Shock (Money Growth Rule)

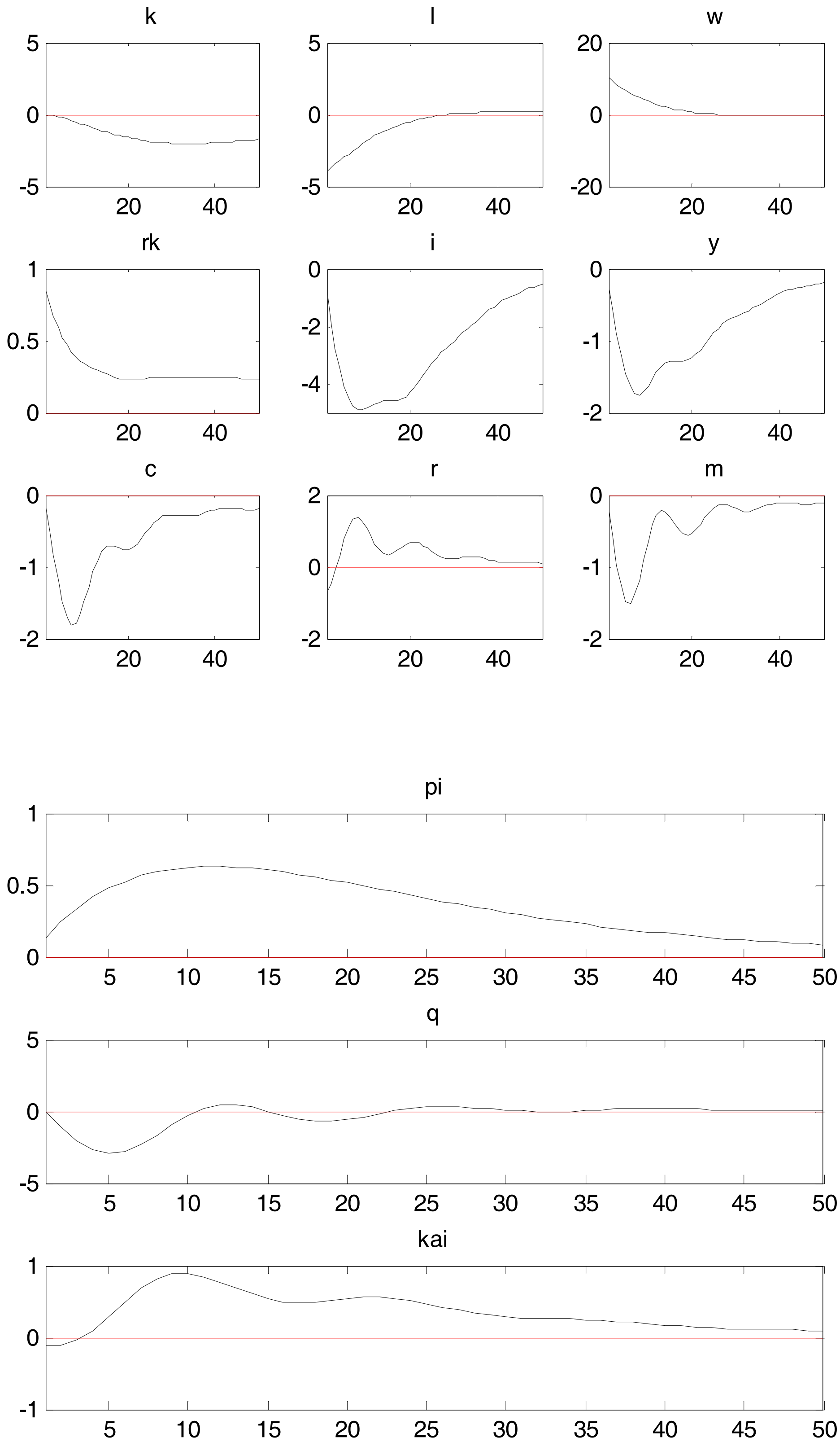
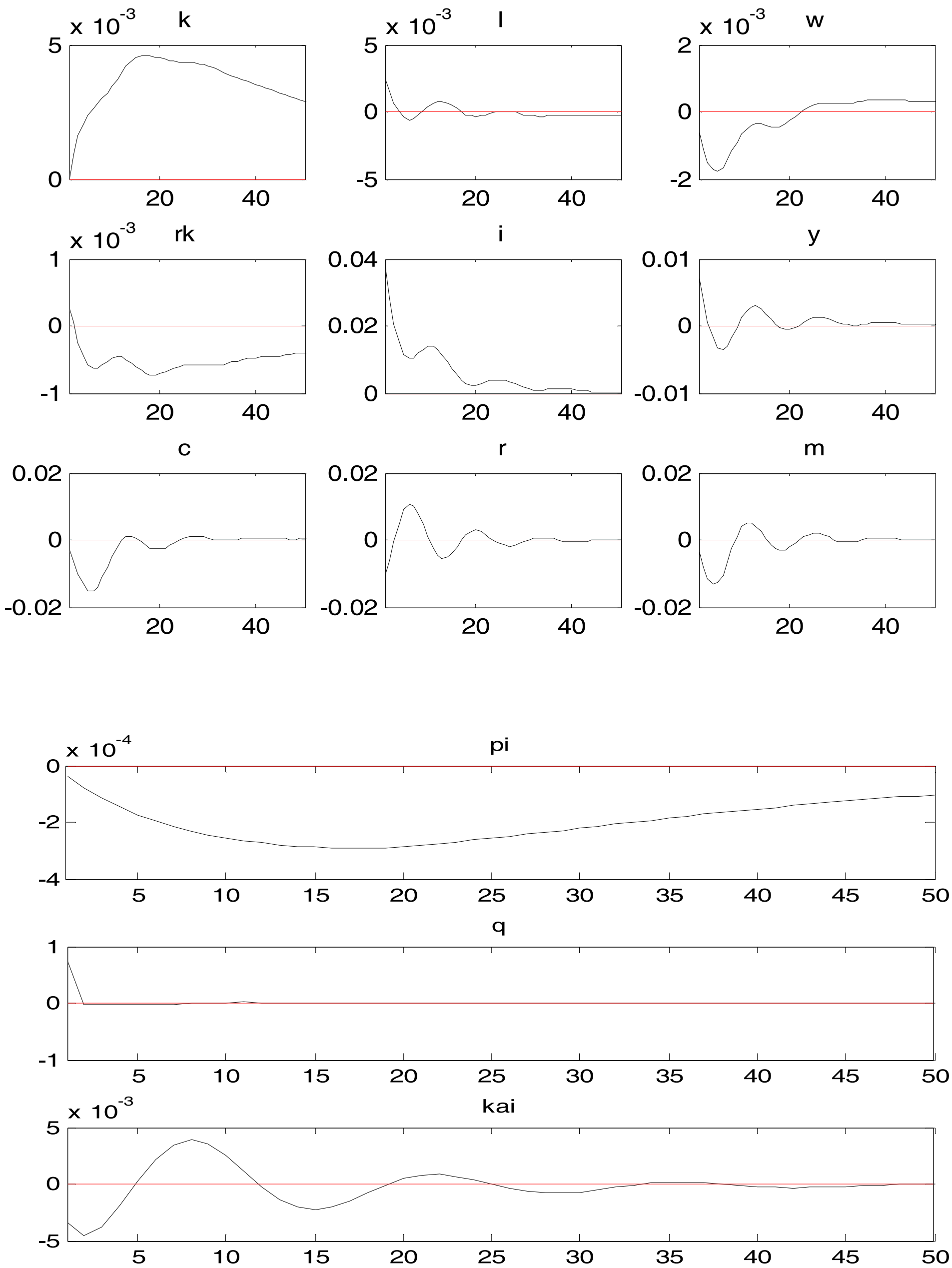


Figure 5.14 shows that a positive equity premium shock increases the asset price, the investment and thereby the output (the asset price channel), but decreases the consumption (crowding out effect). This shock decreases the money supply and the inflation and raises the interest rate. In the Taylor's rule model, no crowding effect can be found in this case. The responses of wage rate in two scenarios are different.

Figure 5.14 The Responses to the Return on Equity Market Shock (Money Growth Rule)



The Effects of Other Shocks

Following a positive productivity shock, similarly to Taylor's rule, the consumption, investment, asset price, money supply, capital increase and thereby the output increase. But the wage rate declines, which is different from that in the Taylor's rule. The inflation, interest rate and capital rent rate decrease which are similar as in Taylor's rule (Figure 5.15).

Figure 5.15 The Responses to the Productivity Shock (Money Growth Rule)

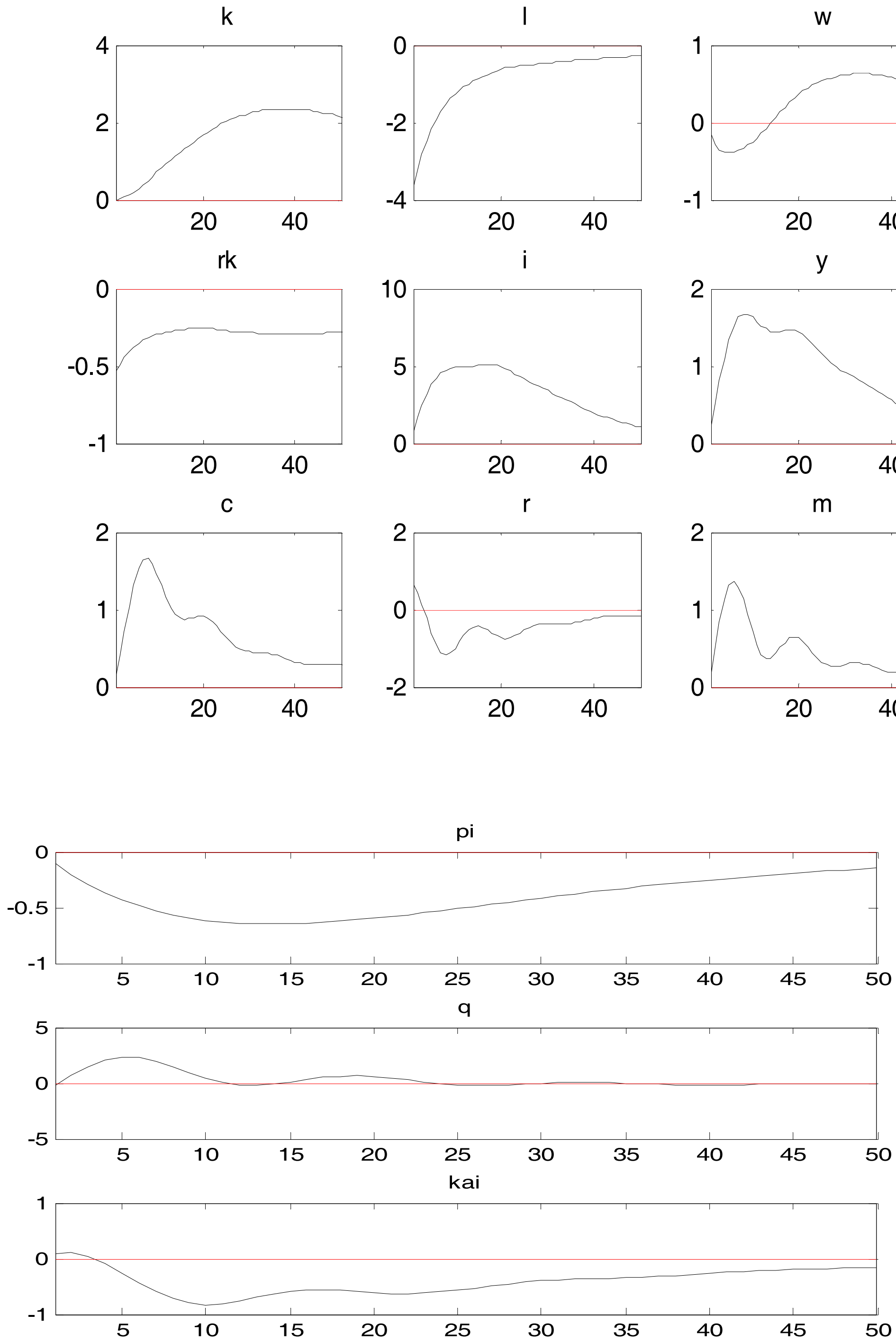


Figure 5.16 demonstrates the effects of a positive labour supply shock. The consumption, investment and thereby the output rise after this shock, similar effects as the productive shock. The wage rate declines and the labour supply rises. The effects are qualitatively the same as in the Taylor's rule model. The difference is that the asset price increases in the money growth rule.

Figure 5.16 The Responses to the Labour Supply Shock (Money Growth Rule)

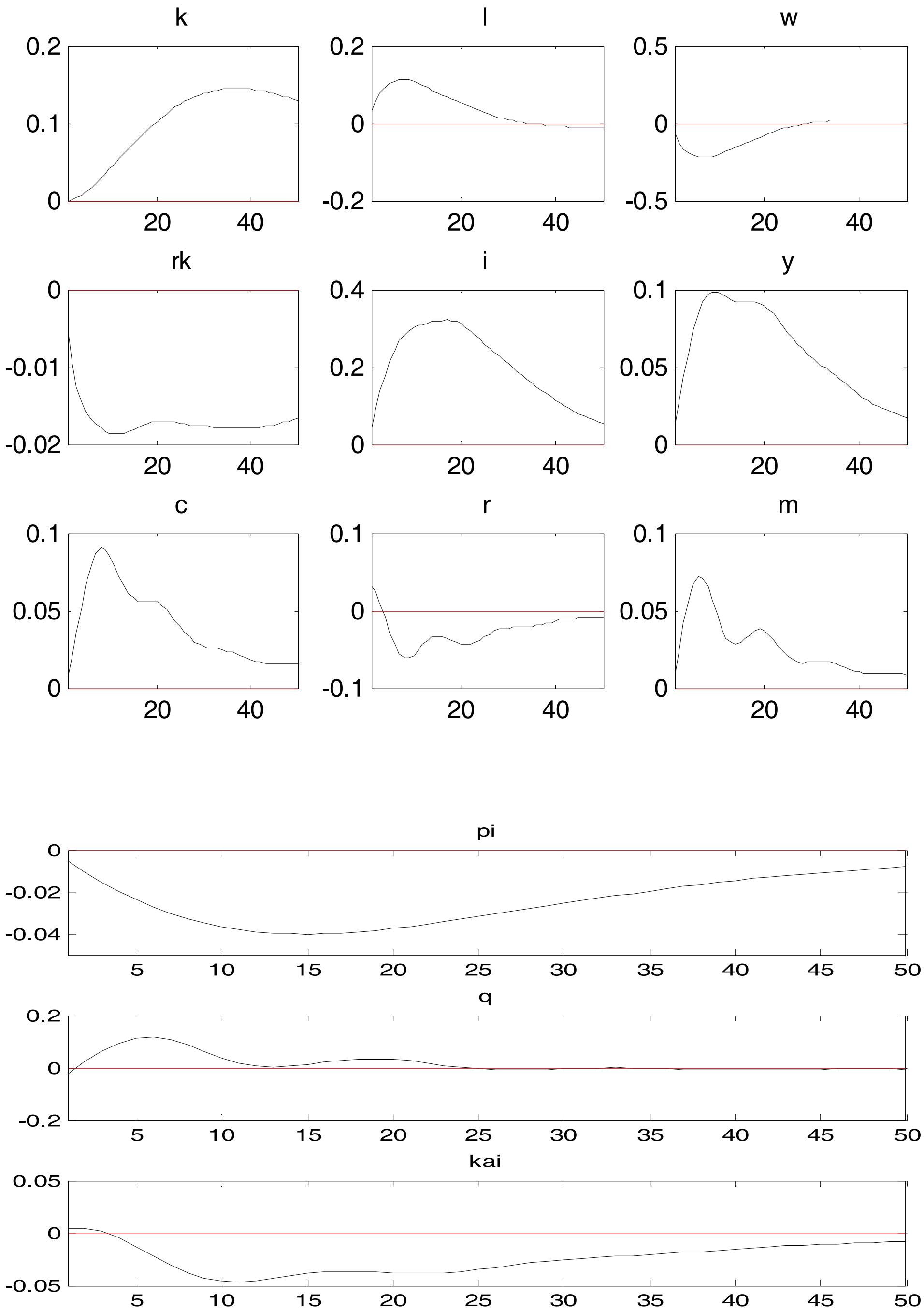
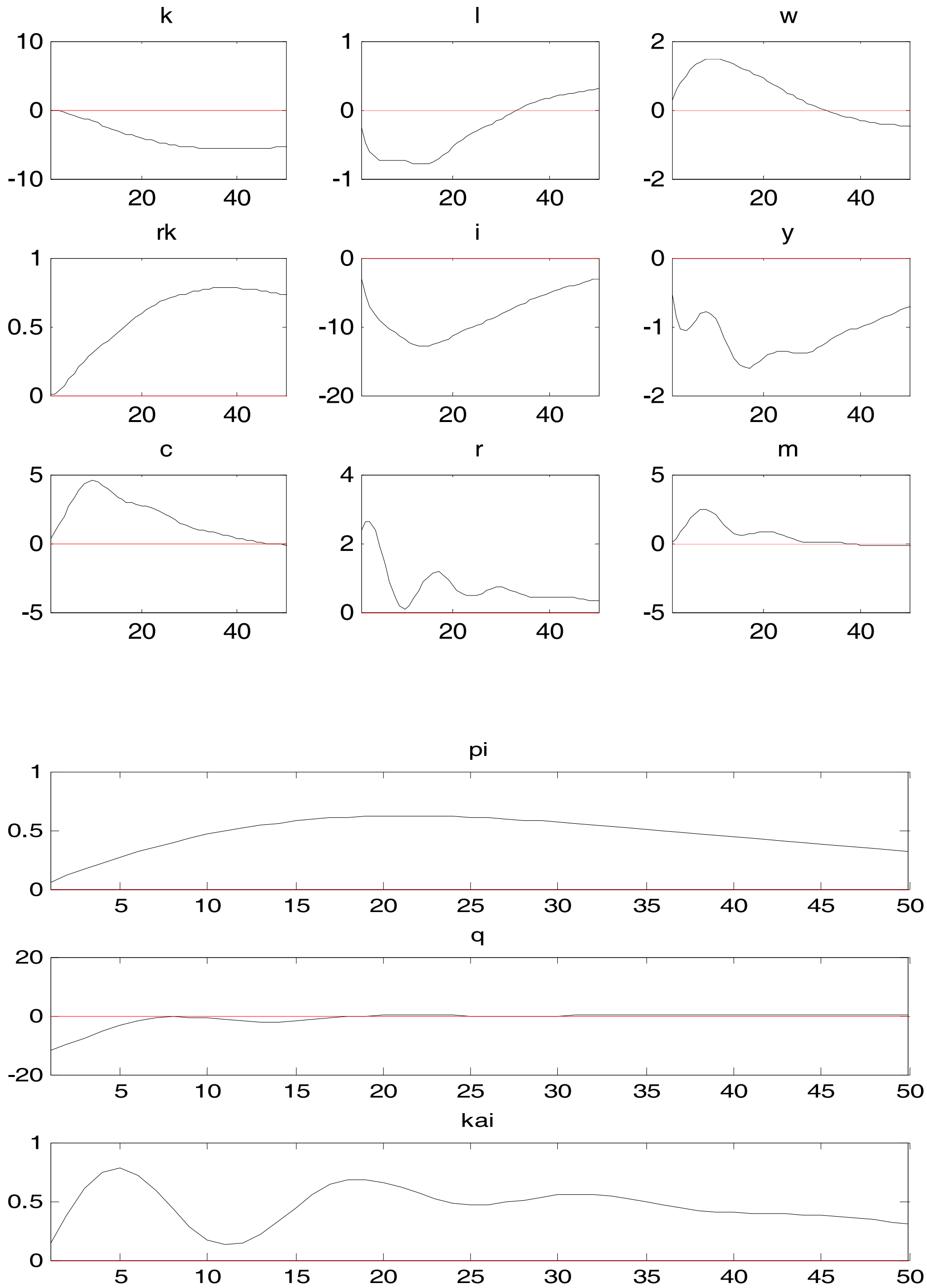


Figure 5.17 shows the responses to a preference shock. Although the consumption rises but the fall in the investment crowds out this effect and the output decreases, this is different to the Taylor's model, where the output increases. Also a different response in the asset price can be found here. The rises in the inflation and interest rate are same as that in Taylor's model.

Figure 5.17 The Responses to the Preference Shock (Money Growth Rule)



Following a positive government expenditure shock in the money growth model in Figure 5.18, the capital, private investment and consumption decrease but the output increases, showing a significant crowding out effects. These are qualitatively similar as that in the Taylor's model. The interest rate declines first and soon rises, money supply declines and the inflation rate declines at first and gradually rises, which is different to the effects in the Taylor's model.

Figure 5.18 The Responses to the Government Expenditure Shock (Money Growth Rule)

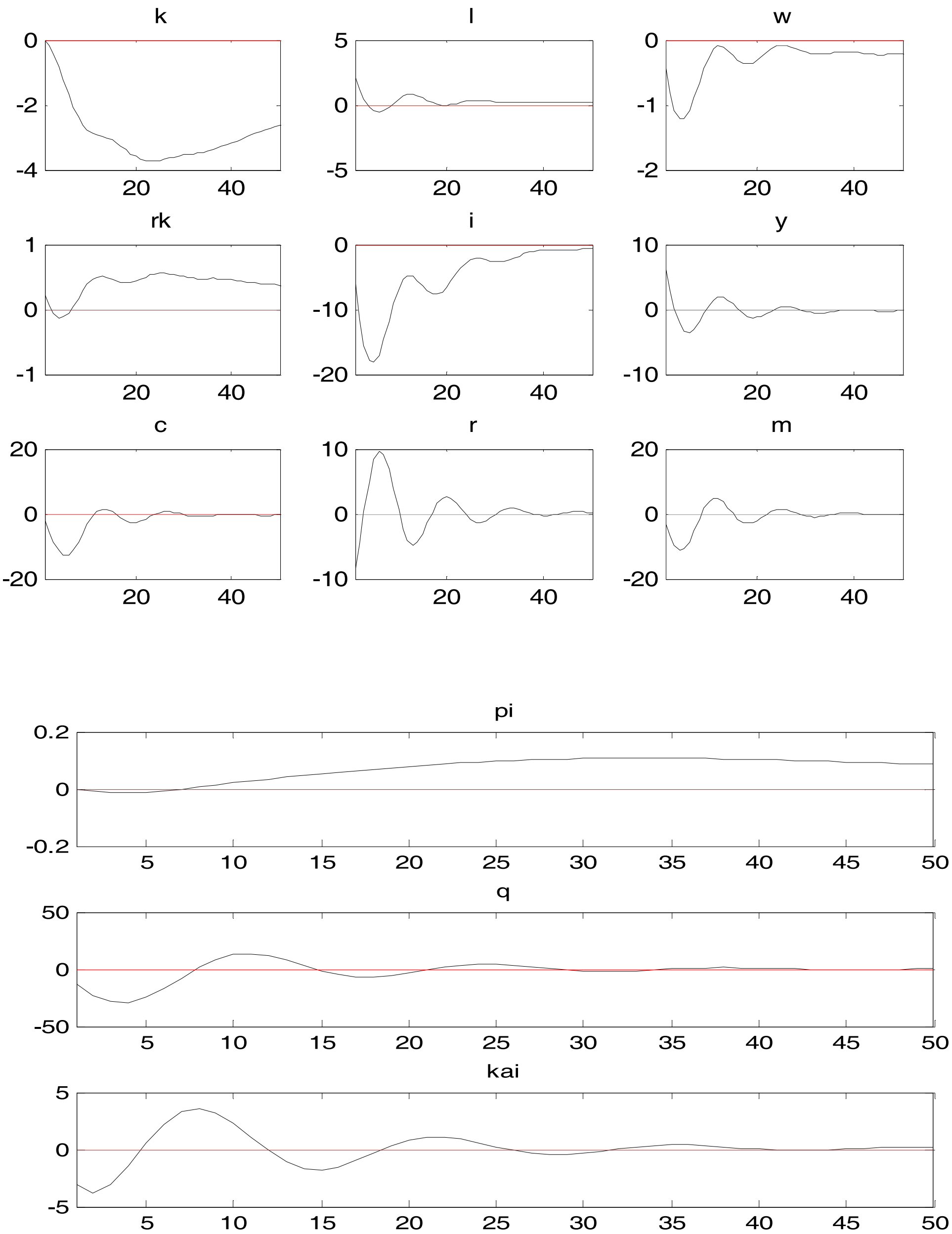
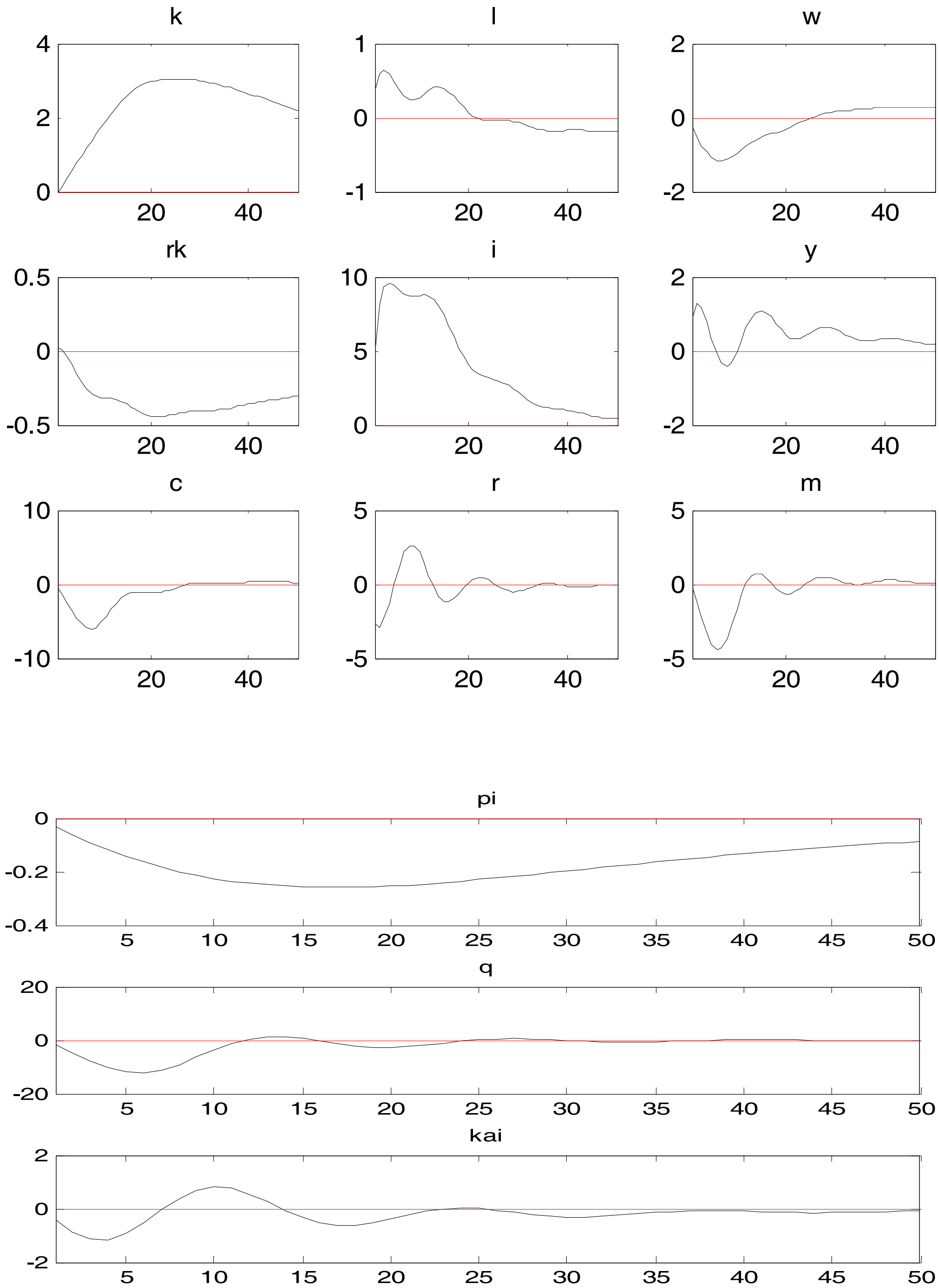


Figure 5.19 shows the effects of a positive investment shock. The investment, labour supply and output increase with a significant crowding out effect on consumption (In Taylor's rule the crowding out effect is weak). The wage rate, inflation rate and interest rate decline, showing different effects from that in Taylor's model (Figure 5.19).

Figure 5.19 The Responses to the Investment Shock (Money Growth Rule)



5.4.2 Variance Decomposition in Money Growth Model

Table 5.8 shows the variance decomposition in infinite horizon from the money growth rule model.

Table 5.8 Variance Decomposition (in percent) (Money Growth Rule)

	ε_t^L	ε_t^a	ε_t^c	ε_t^G	ε_t^M	ε_t^I	ε_t^P	ε_t^W	ε_t^Q
K	0.03	8.44	53.61	18.71	0.00	12.40	0.88	5.92	*0.00*
L	0.08	34.33	7.67	5.70	0.00	2.04	1.18	49.01	*0.00*
W	0.10	2.19	6.67	1.76	0.00	2.44	4.95	81.89	*0.00*
Rk	0.03	9.98	49.56	17.65	0.00	12.06	0.72	10.00	*0.00*
I	0.03	7.26	43.82	26.59	0.00	14.88	1.72	5.70	*0.00*
Y	0.06	17.62	21.98	31.30	0.00	4.72	10.03	14.28	*0.00*
C	0.01	2.27	17.90	55.78	0.00	17.21	4.79	2.04	*0.00*
r	0.01	2.11	6.67	72.81	0.00	7.69	8.66	2.06	*0.00*
M	0.01	1.83	5.38	71.59	0.00	11.76	7.64	1.78	*0.00*
Pi π	0.10	26.09	33.80	1.18	0.00	4.82	13.21	20.82	*0.00*
Q	0.00	0.46	6.32	72.20	0.00	13.22	7.11	0.69	*0.01*
Kai	*0.03*	*7.33*	*8.58*	*62.68*	*0.00*	*6.12*	*9.07*	*6.19*	*0.00*

From Table 5.8, on the contribution of each of the structural shocks to output, it can be found that the government expenditure, preference and productive shocks drive the forecasted GDP variances. They can explain about 31.3%, 21.98% and 17.62 of the output forecast error respectively (total 70%). The cost-push shocks (price mark up, wage mark up) also play distinguished roles; each contributes about 10% respectively. Money supply shock has no impact on output variance in the long run. These are different from that in Taylor's rule model, in which investment and preference shocks play significant roles.

On the determinants of inflation, the preference and technology shocks also contribute significantly to the variations of the inflation. The cost-pushed shocks contribute about 40% of inflation variance. The results are different from that in Taylor's model, in which the cost-pushed shocks dominate the variations of the inflation.

The consumption variance is also dominated by the government expenditure shock (56%). The preference shock contributes about 20%.

It is worth noting that the wage mark-up shock determines 50% of labour supply variance in the long run. The productive shock also play important role in the labour supply in China.

5.6 Summary and Conclusions

In this chapter**,** we employ the bench-mark New Keynesian Model-The Smet-Wouters model with Taylor's rule and an improved Smets-Wouters model with a money growth rule to simulate the effects of monetary policy shocks on China's economy and the effects of the other determinants shocks in business cycle of China. This model incorporates many frictions that are enough to capture the empirical persistence in the main China's macro economic data.

We estimate this DSGE model using a Bayesian approach following Smets and Wouters (2002) with China's macro time series data from 1996q1-2006q4. The parameters estimated feature the unique characteristics and determinants of developments in China's macro economics. Comparing the estimated results with the parameters estimation for Europe and US with same model, we find the following special characters for China's economy: Chinese have the biggest habit consumption, which implies that an expected one percent increase in the short-term interest rate for four quarters has more impacts on consumption in Euro area and US than in China according to the consumption equation. China also has the biggest output elasticity of capital. This is in line with the large share of investment in GDP formation in China, but the adjustment cost parameter in China is also the biggest, showing the lowest efficiency of capital utilization. China's elasticity of labour supply is relatively smaller than that in Europe and US. China's interest rate is more persistent than that in Europe and US. This implies that China has a higher inertia in the implementation of monetary policy when the interest rate is taken as main policy tool. Our estimation delivers very lower values for the coefficients in the reaction function of China's monetary authority than that in US and Europe, implying that China's central bank does not completely follow Taylor's rule, which consists with the reality that the main policy tool is quantity tools other than price tools in China. China has the biggest degree of price indexation (γ_P), two times as in Europe and US, implying that inflation depends more on past inflation than expected future inflation in China referring to the inflation equation, namely, backward-looking plays more roles than forward-looking in inflation formation process. Moreover, China has the most considerable degree of Calvo price stickiness among three economies, reflecting that underdevelopment of market mechanism and high degree of regulation on the prices by the government. Finally, china's government expenditure shock, productivity shock, preference shock, investment shock and mark up in price and wage shocks are very significant compared with that in Europe and US.

Turning to simulation results of the benchmark Smets-Wouters model with Taylor's rule, several points are worth highlighting. First, *the transmission of monetary policy shocks and the liquidity effect* through the *interest rate channel* and *asset price channel* have been identified in China. Our estimates of the effects of an inflation objective shock (money supply shock) is in line with the canonical conclusion: the capital stock, consumption, investment and output rise, the real interest rate falls immediately, demonstrating a liquidity effect following an inflation effect: two years later the real interest rate begins to rise against the increase of inflation, which supports the existence of an *interest rate channel* in the monetary policy transmission. This result is different from that in Euro Area from Smets and Wouters (2002), where no liquidity effects are found without a persistent monetary policy shock. The interest rate shock makes real interest rate rise, and thereby reduces the consumption, investment, output, capital stock, labour supply, real wage level and the rate of inflation, but the rental rate of capital soon rebound after temporary decrease. This clearly confirms the existence of *interest rate channel* of monetary policy in China. The immediate decline in asset price (Q) following the decline of investment and consumption and thereby the output supports the existence of *asset price channel* in China's monetary transmission. The incorporation of rational expectation in inflation equation implies the effects of expectation in the monetary transmission. (*Expectation channel*)

Second, the transmission of non-monetary shocks is also significant. The cost-push shocks increase the rate of inflation significantly; a positive *productivity shock makes* the consumption, investment, output, capital stock and real wage rise, while labour supply (employment) falls. The rental rate of capital, return on equity market, interest rate and inflation rate also fall. These effects tell the same story identified as in US and Euro Area. As Smets and Wouters (2002) pointed out, the rise in productivity causes the fall in marginal cost, because the monetary policy does not react timely and strongly (interest rate falls slowly) to offset this fall in marginal cost, which decreases inflation gradually; the effects of a positive *labour supply shock* on consumption, investment, output, capital stock, inflation and interest rate are similar to those of a productivity shock. A *preference shock* increases the consumption and output significantly, while the investment increases initially and then begin to fall, demonstrating a delay significant crowding out effect; the labour supply and real wage also increase, which cause the rise in marginal cost and thereby increase the inflation rate, the interest rate rise following the rise in inflation. The *government expenditure shock* has significant effects in China: increase the labour supply, real wage and output immediately and thereby cause demand-pull inflation gradually. It decreases the private consumption and investment, also implying a significant crowing out effects on private consumption and private investments. The fall in consumption leads to the rise of marginal utility of working, which increases the labour supply. The return on equity market rises while the capital stock falls. The interest rate and rental rate of capital also increase. The effects of a positive *investment shock* are qualitatively similar as the government expenditure shock.

Third, we have measured the contributions of monetary policy shocks and non-policy shocks to the business cycle developments in China's economy. Depending on the results of variance decomposition in infinite horizon, we find that preference shock and investment shock play significant roles in china's business cycle, besides, the cost-pushed shocks, the technology shock, and the monetary policy (interest rate) shock also explain distinguished fraction of output, inflation, interest rate and consumption. To the variance decomposition of the inflation, it shows that the cost-push shock dominates the forecast errors of the inflation, which contributes about 50% of inflation variance, uncovering the special characteristics of inflation formulation in China. Preference shocks also account for 20%, technology shocks account for 12%, whereas monetary policy shock also contributes about 10%. On the determinants of labour supply, the wage mark-up shock and technology shock dominate 50% of labour supply variance in the long run, Investment and government expenditure shocks also play important role in labour supply in China.

The improved Smets-Wouters model with a money growth rule uncovers the same monetary policy transmission mechanisms: the existence of the monetary channel, the asset price channel and the expectation channel. The responses to the monetary policy shocks and non monetary policy shocks are qualitatively similar as in the Taylor's rule although there are some differences. The main differences emerge in the variance decomposition or the contributions to the business cycle of China's economy. In the money growth rule model, the government expenditure, preference and productive shocks play significant rules in the variations of output. On the determinants of inflation, the preference and technology shocks also contribute significantly to the forecast errors. The cost-pushed shocks contribute about 40% of inflation variance. Due to the reality of China's economy, in which government investment contributes significantly, it seems that the money growth rule model is more justified than Taylor's rule, but it's difficult to make this conclusion.

It is reasonable to suggest that the PBC follows both the interest rate rule (Taylor's rule) and a money growth rule with discretion.

In our exercise, we assume that the money is neutral in the long run, but in the short run it's not the case, this needs a further check by coding a new program for variance decomposition in finite horizon with Matlab. Although ten shocks are included in this model, it's not enough to simulate the frictions in the real China's economy, the financial market frictions, for example, is certainly important to explain the development of business cycle in China such as in Bernanke et al (1998), which should be given more consideration in our further research works.

Comparing the VAR/VEC models in Chapter 4 and DSGE Models in Chapter 5 for testing and simulating the monetary transmission mechanisms and the effects of monetary policy shocks and other shocks on the China's macroeconomy, we find that most of VAR/VEC models incorporate fewer variables than DSGE models, to examine different transmission channels of monetary policy needs to specify different VAR/VEC system. In an estimated DSGE model, the number of variables is unlimited theoretically. With elegant microfoundations the DSGE approach can be employed to simulate several channels simultaneously within one model.

Appendix 5.1 Estimation and Simulation Results for Benchmark Smets-Wouters Model.

(Taylor's rule)

Table 5.9 RESULTS FROM POSTERIOR MAXIMIZATION (Taylor's Rule)

parameters	prior mean	mode	s.d.	t-stat	prior	pstdev
psai ψ	6.000	6.2775	0.9483	6.6195	norm	1.0000
fai ϕ	3.000	3.5319	0.2174	16.2479	norm	0.2500
alfa α	0.300	0.4222	0.0470	8.9876	beta	0.1000
rho ρ	0.950	0.9854	0.0033	295.2250	beta	0.0300
rpi r_π	1.680	1.6757	0.0500	33.4860	norm	0.0500
ry r_y	0.010	0.0087	0.0048	1.8252	norm	0.0050
rdpi $r_{d\pi}$	0.100	0.0831	0.0210	3.9616	norm	0.0500
rdy r_{dy}	0.010	0.0033	0.0021	1.5869	norm	0.0050
h h	0.700	0.8099	0.0525	15.4166	beta	0.1000
deltac σ	1.200	1.3592	0.2271	5.9838	norm	0.2500
dfai φ	0.150	0.0613	0.0458	1.3394	norm	0.0500
gamp γ_p	0.800	0.9902	0.0192	51.4517	beta	0.1500
omegap ϖ_p	0.900	0.9516	0.0096	99.0334	beta	0.0500
gamw γ_W	0.750	0.6159	0.2384	2.5833	beta	0.1500
omegaw ϖ_W	0.700	0.7931	0.0441	17.9657	beta	0.0500
lamw λ_W	0.500	0.1521	0.1202	1.2658	beta	0.1500
deltal υ	2.000	2.1687	0.4684	4.6304	norm	0.5000
rhoel ρ_L	0.850	0.9222	0.0858	10.7544	beta	0.1000
rhoea ρ_a	0.800	0.9413	0.0355	26.5401	beta	0.1000
rhoeb ρ_c	0.850	0.9631	0.0183	52.5090	beta	0.1000
rhog ρ_G	0.850	0.9163	0.0415	22.1045	beta	0.1000
rhopi ρ_π	0.850	0.9218	0.0860	10.7210	beta	0.1000
rhoei ρ_I	0.850	0.8493	0.1064	7.9849	beta	0.1000

standard deviation of shocks

	prior mean	mode	s.d.	t-stat	prior	pstdev
delel ε_t^L	3.520	1.6239	0.6649	2.4424	invg	Inf
delea ε_t^a	3.000	2.6396	0.2983	8.8477	invg	Inf
deleb ε_t^C	1.200	0.6724	0.2972	2.2625	invg	Inf
delg ε_t^G	8.000	8.4378	0.8705	9.6927	invg	Inf
delpi ε_t^π	0.017	0.0078	0.0032	2.4522	invg	Inf

nr ε_t^R	0.150	0.1366	0.0155	8.8178	invg	Inf
delei ε_t^I	1.200	0.9929	0.3620	2.7427	invg	Inf
np ε_t^P	0.500	0.4195	0.0474	8.8558	invg	Inf
nw ε_t^w	5.000	4.7423	0.6190	7.6611	invg	Inf
nq ε_t^Q	0.700	0.3225	0.1317	2.4494	invg	Inf

Table 5.10 ESTIMATION RESULTS BY BAYESIAN APPROACH (Taylor's Rule)

parameters	prior mean	post. mean	conf. interval		prior	pstdev
psai	6.000	6.1839	4.5236	7.6779	norm	1.0000
fai	3.000	3.4945	3.1323	3.8353	norm	0.2500
alfa	0.300	0.4209	0.3416	0.4969	beta	0.1000
rho	0.950	0.9835	0.9780	0.9891	beta	0.0300
rpi	1.680	1.6731	1.5911	1.7524	norm	0.0500
ry	0.010	0.0090	0.0013	0.0169	norm	0.0050
rdpi	0.100	0.0906	0.0536	0.1270	norm	0.0500
rdy	0.010	0.0037	0.0001	0.0074	norm	0.0050
h	0.700	0.8142	0.7371	0.8970	beta	0.1000
deltac	1.200	1.3582	0.9649	1.7226	norm	0.2500
dfai	0.150	0.0633	0.0026	0.1196	norm	0.0500
gamp	0.800	0.9657	0.9288	1.0000	beta	0.1500
omegap	0.900	0.9529	0.9364	0.9696	beta	0.0500
gamw	0.750	0.6093	0.3203	0.9112	beta	0.1500
omegaw	0.700	0.7947	0.7322	0.8590	beta	0.0500
lamw	0.500	0.2667	0.0380	0.4894	beta	0.1500
deltal	2.000	2.2095	1.4533	2.9451	norm	0.5000
rhoel	0.850	0.8533	0.7063	0.9952	beta	0.1000
rhoea	0.800	0.9228	0.8658	0.9788	beta	0.1000
rhoeb	0.850	0.9332	0.8887	0.9788	beta	0.1000
rhog	0.850	0.9019	0.8384	0.9670	beta	0.1000
rhopi	0.850	0.8429	0.6846	0.9945	beta	0.1000
rhoei	0.850	0.7810	0.6208	0.9457	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
delel	3.520	3.6627	0.7654	8.5130	invg	Inf
delea	3.000	2.7720	2.2490	3.2871	invg	Inf

deleb	1.200	1.2392	0.4158	2.1375	invg	Inf
delg	8.000	8.7388	7.2692	10.1926	invg	Inf
delpi	0.017	0.0149	0.0041	0.0264	invg	Inf
nr	0.150	0.1457	0.1175	0.1720	invg	Inf
delei	1.200	1.2805	0.6902	1.8504	invg	Inf
np	0.500	0.4482	0.3596	0.5343	invg	Inf
nw	5.000	5.0508	3.9890	6.1190	invg	Inf
nq	0.700	0.6511	0.1542	1.4246	invg	Inf

TABLE 5.11 MATRIX OF COVARIANCE OF EXOGENOUS SHOCKS (Taylor's Rule)

Variables	delel ε_t^L	delea ε_t^A	deleb ε_t^c	delg ε_t^G	delpi ε_t^π	nr ε_t^R	delei ε_t^I	np ε_t^P	nw ε_t^W	nq ε_t^Q
Delel ε_t^L	2.637036	0.000000	0.000000	0.000000	0.00000	0.000000	0.00000	0.000000	0.000000	0.000000
delea ε_t^A	0.000	6.967512	0.000	0.000	0.000	0.000	0.000	0.000000	0.000000	0.000000
deleb ε_t^c	0.000	0.000000	0.452087	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
delg ε_t^G	0.000000	0.000000	0.000000	71.196945	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
delpi ε_t^π	0.000000	0.000000	0.000000	0.000000	0.000061	0.000000	0.000000	0.000000	0.000000	0.000000
nr ε_t^R	0.000000	0.000000	0.000000	0.000000	0.000000	0.018672	0.000000	0.000000	0.000000	0.000000
delei ε_t^I	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.985785	0.000000	0.000000	0.000000
np ε_t^P	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.175939	0.000000	0.000000
nw ε_t^W	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	22.489841	0.000000
nq ε_t^Q	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.103987

TABLE 5.12 VARIANCE DECOMPOSITION (in percent) (Taylor's Rule)

	delel	delea	deleb	delg	delpi	nr	delei	np	nw	nq
k	0.04	10.83	35.14	0.64	0.00	4.54	28.01	6.88	13.93	0.00
l	0.03	24.91	7.83	12.26	0.00	3.06	17.22	1.99	32.69	0.00
w	0.03	11.77	14.48	0.26	0.00	2.97	6.01	14.05	50.44	0.00
rk	0.04	10.60	34.75	0.90	0.00	4.60	28.36	6.75	14.01	0.00
i	0.03	9.81	26.67	0.55	0.00	6.12	33.79	9.05	13.97	0.00
y	0.04	11.53	22.23	10.40	0.00	7.39	22.96	9.79	15.66	0.00
c	0.04	11.72	52.60	0.76	0.00	8.21	5.14	7.70	13.84	0.00

r	0.04	11.83	45.41	1.26	0.00	10.63	4.84	11.05	14.94	0.00
pi	0.04	12.06	20.42	0.22	0.00	8.45	2.47	36.20	20.15	0.00
q	0.03	7.78	15.34	0.15	0.00	24.05	27.31	13.09	12.24	0.02

TABLE 5.13 POLICY AND TRANSITION FUNCTIONS (Taylor's Rule)

		k	l	w	rk	i	y	c	r	pi	q
k	(-1)	0.975000	-0.064063	-0.000789	-0.146321	-0.054033	-0.009243	0.006958	-0.000164	-0.001591	-0.125662
y	(-1)	0	0.003497	0.005094	0.001180	0.048833	0.018187	0.019588	-0.003154	0.000531	0.082091
r	(-1)	0	-1.057256	-1.540013	-0.356889	-14.763985	-5.498439	-5.922007	0.953415	-0.160564	-24.818946
eg	(-1)	0	0.270350	0.007512	0.038181	-0.013105	0.909116	-0.011409	0.003135	0.000667	0.004201
ea	(-1)	0	-0.994194	-0.011707	-0.138220	-0.045654	0.001905	0.031444	-0.001680	-0.020292	-0.658334
eb	(-1)	0	0.205005	0.581715	0.108103	0.973967	1.430324	3.200135	0.009202	0.052424	3.363028
el	(-1)	0	0.005766	-0.015898	-0.001392	-0.010841	-0.001267	0.002941	-0.000090	-0.001027	-0.056359
epi	(-1)	0	0.110425	0.183594	0.040401	1.655603	0.603544	0.629767	-0.005354	0.020528	2.381843
ei	(-1)	0	0.452641	0.072798	0.072200	7.357344	1.599573	-0.050112	0.005609	0.002298	-1.442532
w	(-1)	0	-0.355456	0.914974	0.076883	-0.009020	-0.005645	-0.009633	0.000756	0.009323	0.236436
i	(-1)	0.025000	0.061315	0.002281	0.008739	0.941812	0.206928	-0.000713	0.000697	-0.000042	-0.039302

c	(-1)	0	0.091426	0.001842	0.012816	-0.002667	0.306543	0.808236	0.001048	0.000114	-0.001958
pi	(-1)	0	0.108867	-0.319465	-0.028938	-0.494897	-0.048735	0.158269	0.017650	0.919652	3.019456
delel		0	0.006252	-0.017239	-0.001510	-0.011755	-0.001374	0.003189	-0.000097	-0.001114	-0.061114
delea		0	-1.056173	-0.012437	-0.146837	-0.048500	0.002024	0.033405	-0.001785	-0.021557	-0.699375
deleb		0	0.212867	0.604025	0.112249	1.011321	1.485180	3.322866	0.009555	0.054434	3.492007
delg		0	0.295035	0.008198	0.041667	-0.014302	0.992122	-0.012451	0.003421	0.000728	0.004584
delpi		0	0.119790	0.199166	0.043827	1.796018	0.654732	0.683179	-0.005808	0.022269	2.583852
nr		0	-1.072939	-1.562857	-0.362183	-14.982985	-5.580000	-6.00985	0.967557	-0.162946	-25.187096
delei		0	0.532980	0.085719	0.085015	8.663197	1.883481	-0.059006	0.006604	0.002706	-1.698566
np		0	0.529778	-1.949157	-0.195036	-2.735154	-0.744686	-0.376191	0.147799	1.808579	2.794384
nw		0	-0.707358	1.820798	0.152997	-0.017949	-0.011233	-0.019170	0.001504	0.018552	0.470507
nq		0	0.003762	0.000141	0.000536	0.057814	0.012698	-0.000055	0.000043	0	0.997788

TABLE 5.14 THEORETICAL MOMENTS (Taylor's Rule)

VARIABLE	MEAN	STD. DEV.	VARIANCE
k	0.0000	144.9438	21008.7050
l	0.0000	16.2123	262.8392
w	0.0000	28.3058	801.2200
rk	0.0000	18.5822	345.2970
i	0.0000	221.2217	48939.0471
y	0.0000	60.4105	3649.4232
c	0.0000	41.9115	1756.5769
r	0.0000	1.1112	1.2349
pi	0.0000	2.7411	7.5138
q	0.0000	22.0788	487.4730

TABLE 5.15 MATRIX OF CORRELATIONS (Taylor's Rule)

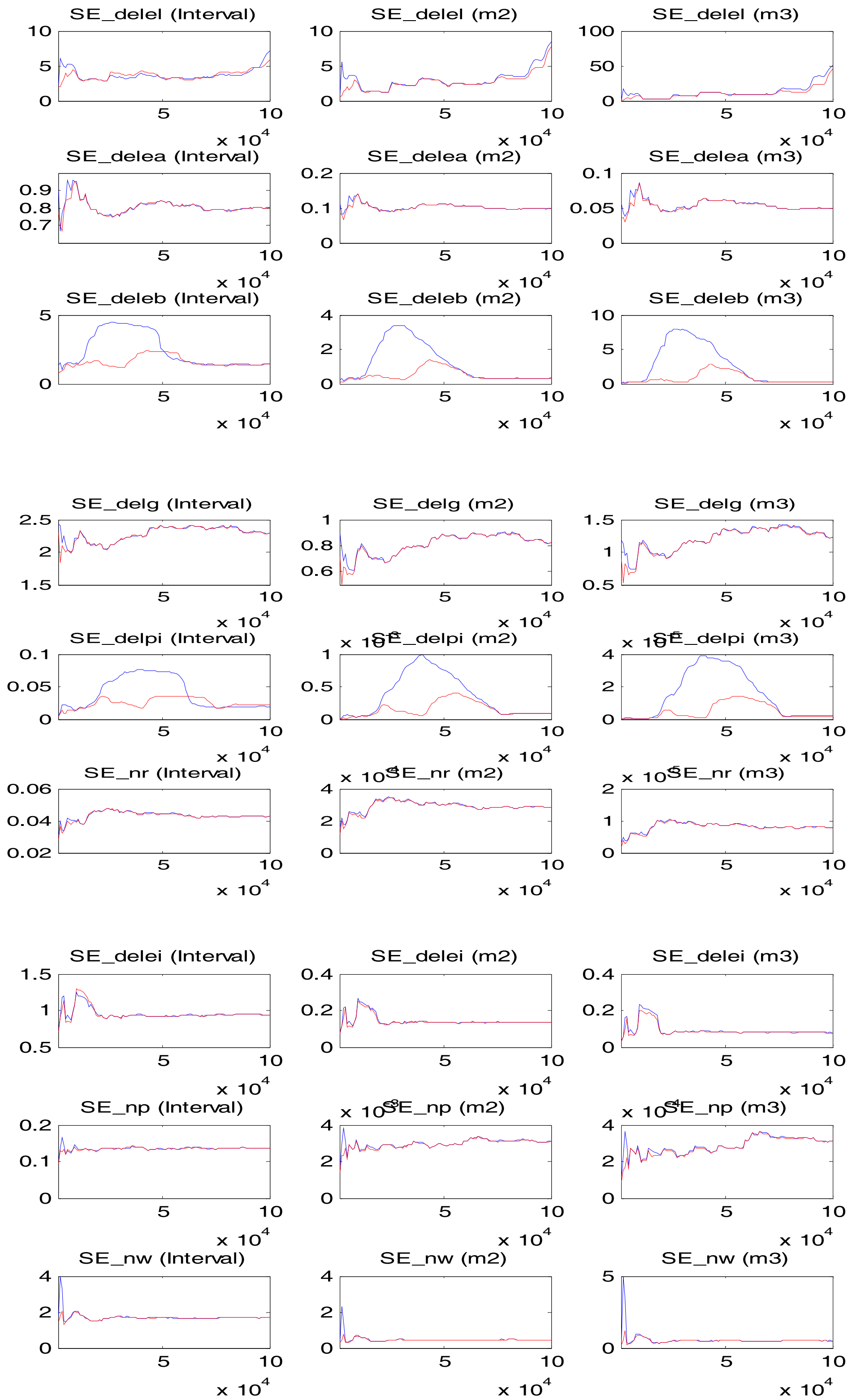
Variables	k	l	w	rk	i	y	c	r	pi	q
k	1.0000	-0.2265	0.5594	-0.9814	0.6440	0.6532	0.5222	-0.5399	0.0167	-0.1503
l	-0.2265	1.0000	-0.4170	0.2919	0.2607	0.3055	-0.0960	0.0304	0.0235	0.0738
w	0.5594	-0.4170	1.0000	-0.4336	0.5145	0.5729	0.5809	-0.3659	0.2747	0.3598
rk	-0.9814	0.2919	-0.4336	1.0000	-0.5272	-0.5234	-0.4454	0.4950	0.0422	0.2516
i	0.6440	0.2607	0.5145	-0.5272	1.0000	0.9100	0.4335	-0.6292	-0.0226	0.0664
y	0.6532	0.3055	0.5729	-0.5234	0.9100	1.0000	0.5971	-0.5565	0.0692	0.1601
c	0.5222	-0.0960	0.5809	-0.4454	0.4335	0.5971	1.0000	-0.3147	0.2869	0.4140
r	-0.5399	0.0304	-0.3659	0.4950	-0.6292	-0.5565	-0.3147	1.0000	0.3983	-0.3957
pi	0.0167	0.0235	0.2747	0.0422	-0.0226	0.0692	0.2869	0.3983	1.0000	0.2686
q	-0.1503	0.0738	0.3598	0.2516	0.0664	0.1601	0.4140	-0.3957	0.2686	1.0000

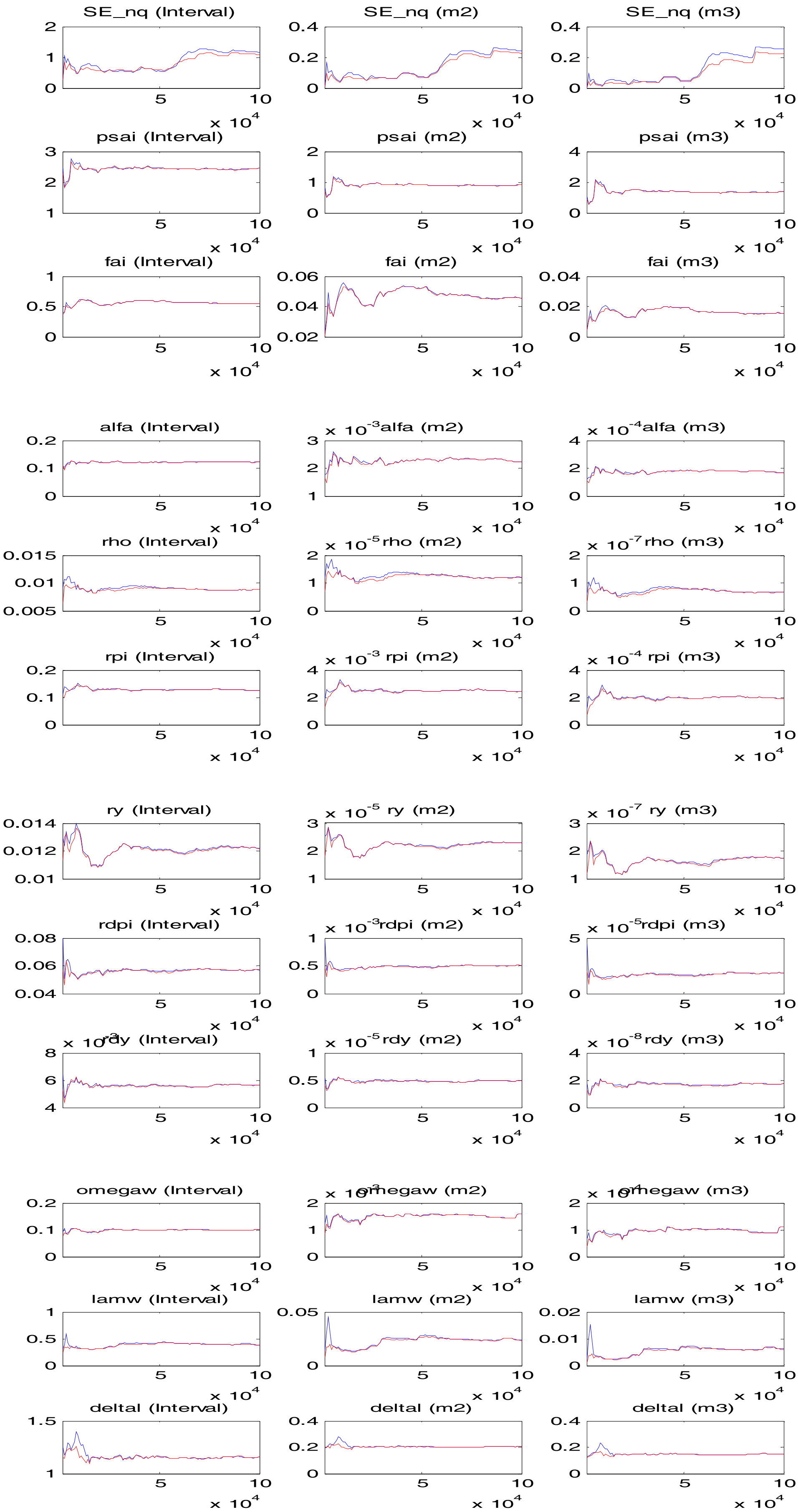
TABLE 5.16 COEFFICIENTS OF AUTOCORRELATION (Taylor's Rule)

Order	1	2	3	4	5
k	0.9996	0.9983	0.9962	0.9933	0.9895
l	0.9479	0.8964	0.8460	0.7969	0.7492
w	0.9487	0.8974	0.8463	0.7958	0.7462
rk	0.9982	0.9953	0.9915	0.9868	0.9812
i	0.9968	0.9880	0.9746	0.9572	0.9365
y	0.9869	0.9696	0.9487	0.9247	0.8983

c	0.9951	0.9823	0.9631	0.9389	0.9108
r	0.9895	0.9761	0.9603	0.9423	0.9223
pi	0.9539	0.9016	0.8443	0.7830	0.7190
q	0.9644	0.9226	0.8753	0.8235	0.7681

Figure 5.20 MCMC Diagnostics: Univariate convergence diagnostic, Brooks and Gelman (1998)

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SE_nq (m2)
SE_nq (m3)
psai (Interval)
psai (m2)
psai (m3)
fai (Interval)
fai (m2)
fai (m3)
alfa (Interval)
alfa (m2)
alfa (m3)
rho (Interval)
rho (m2)
rho (m3)
rpi (Interval)
rpi (m2)
rpi (m3)
ry (Interval)
ry (m2)
ry (m3)
rdpi (Interval)
rdpi (m2)
rdpi (m3)
rdy (Interval)
rdy (m2)
rdy (m3)
omegaw (Interval)
omegaw (m2)
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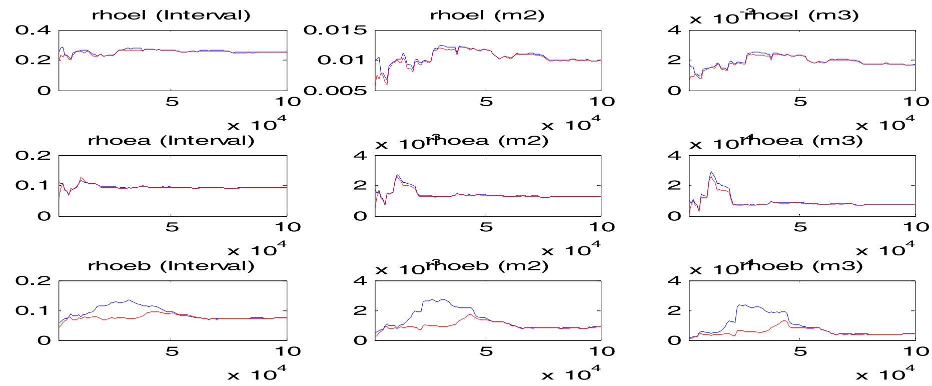
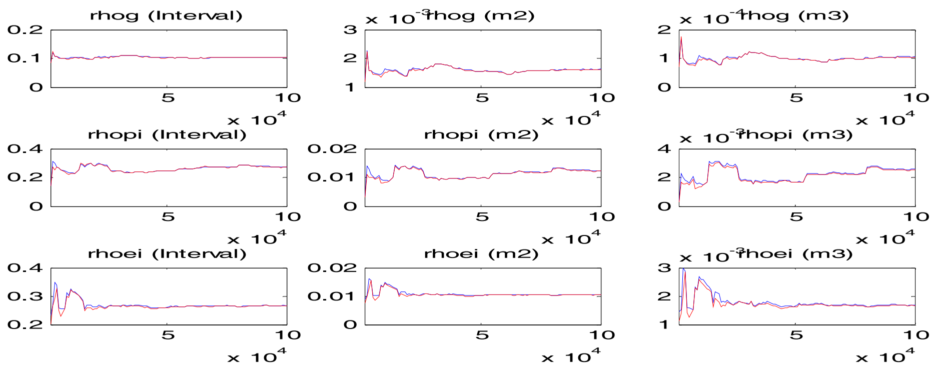




Multivariate's Diagnostic

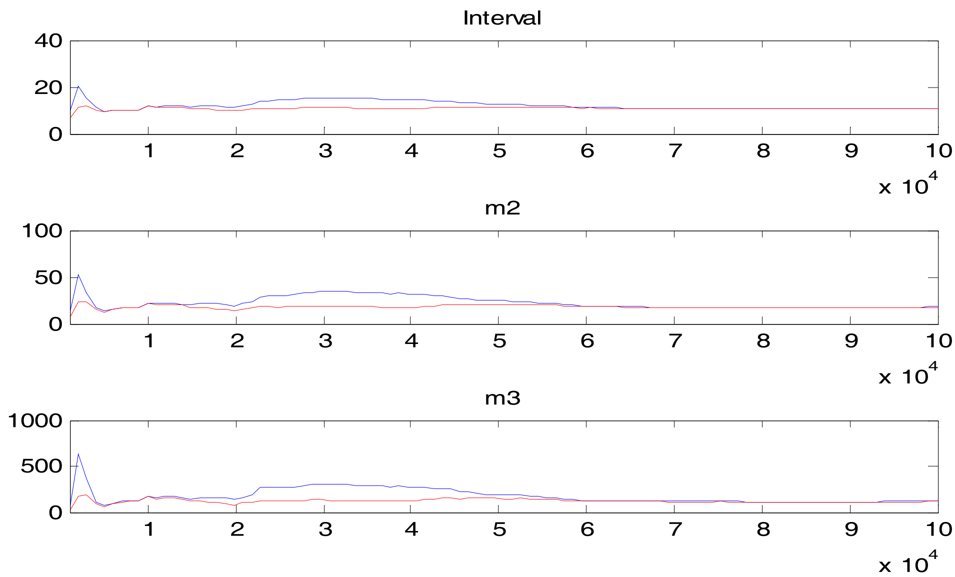


Figure 5.21 Priors of the parameters

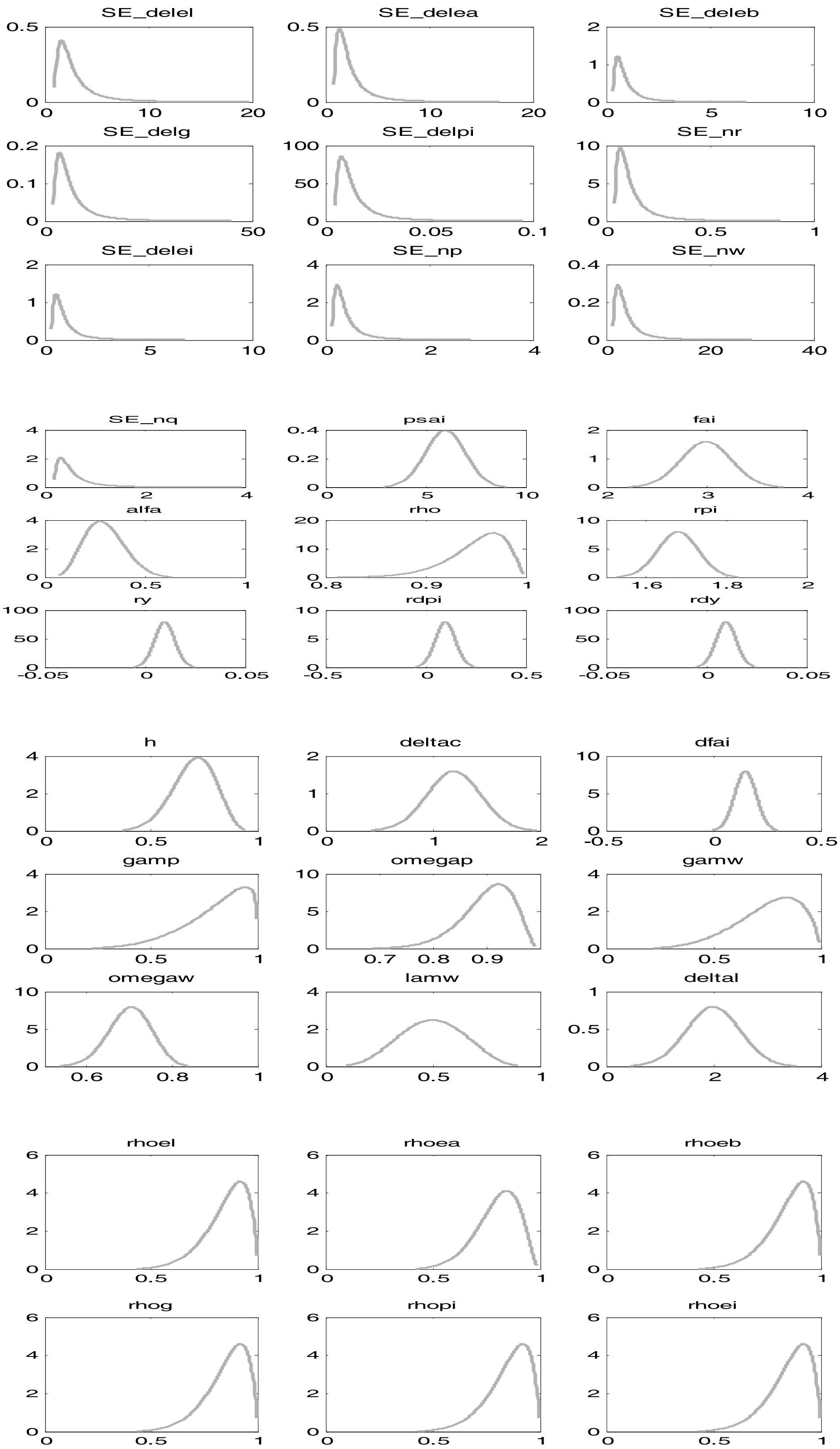
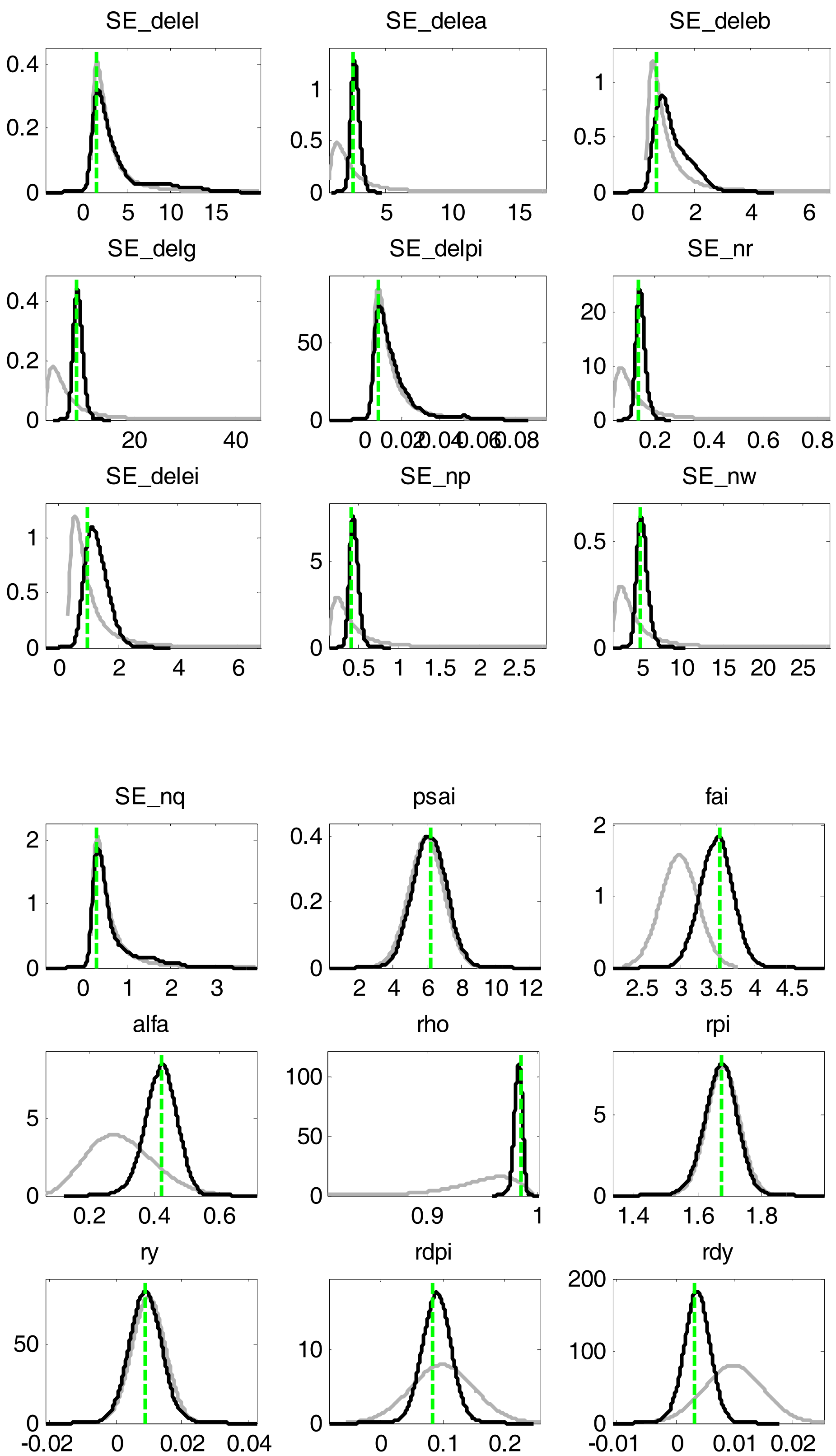
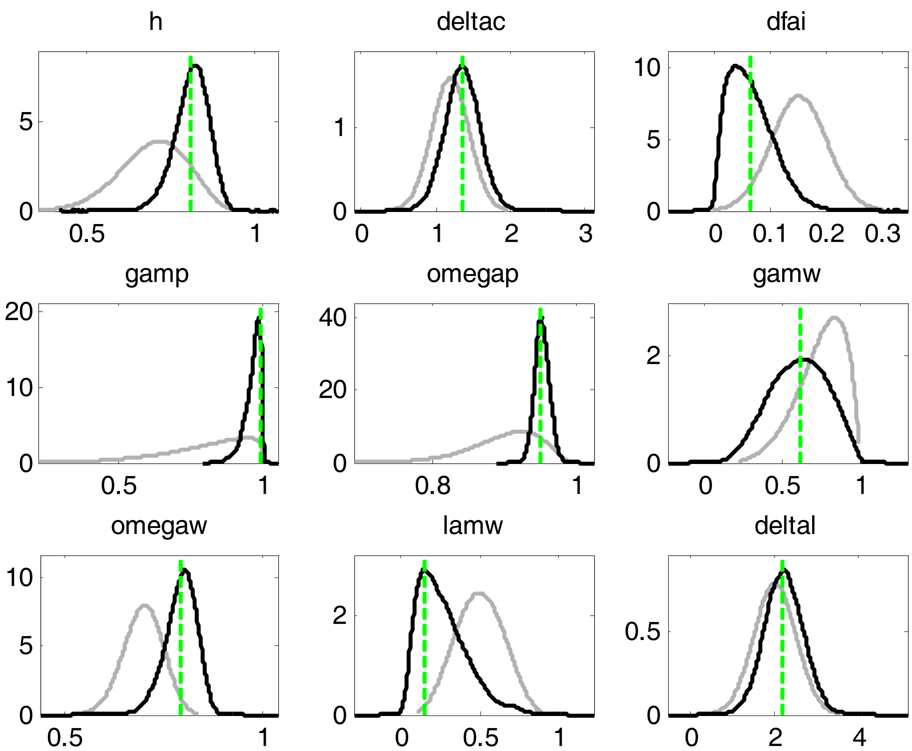


Figure 5.22 The Priors and Posteriors of Parameters (dark line is the posteriors)

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dfai
gamp
omegap
gamw
omegaw
lamw
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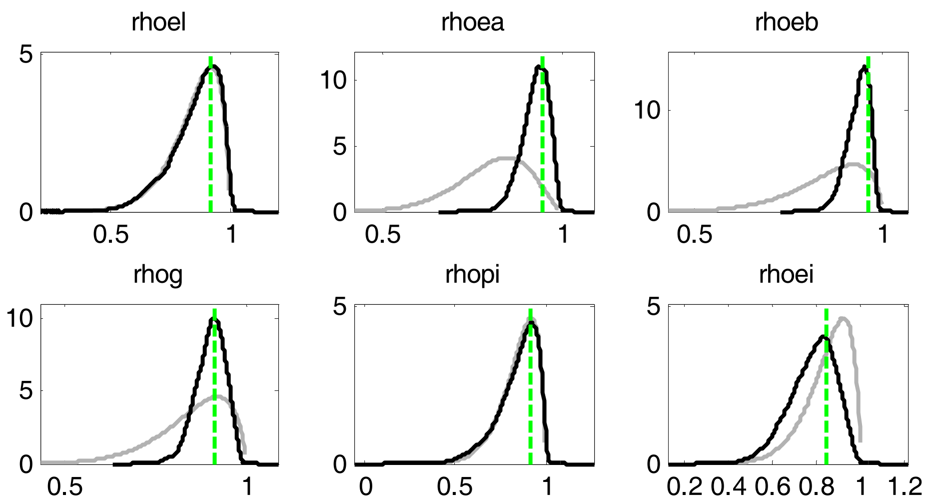
10
0.1
0.2
0.3
20
40
0.8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rhoea
rhoeb
rhog
rhopi
rhoei
0.5
1
0
5
10
0.2 0.4 0.6 0.8 1 1.2

Figure 5.23 Smoothed Shocks

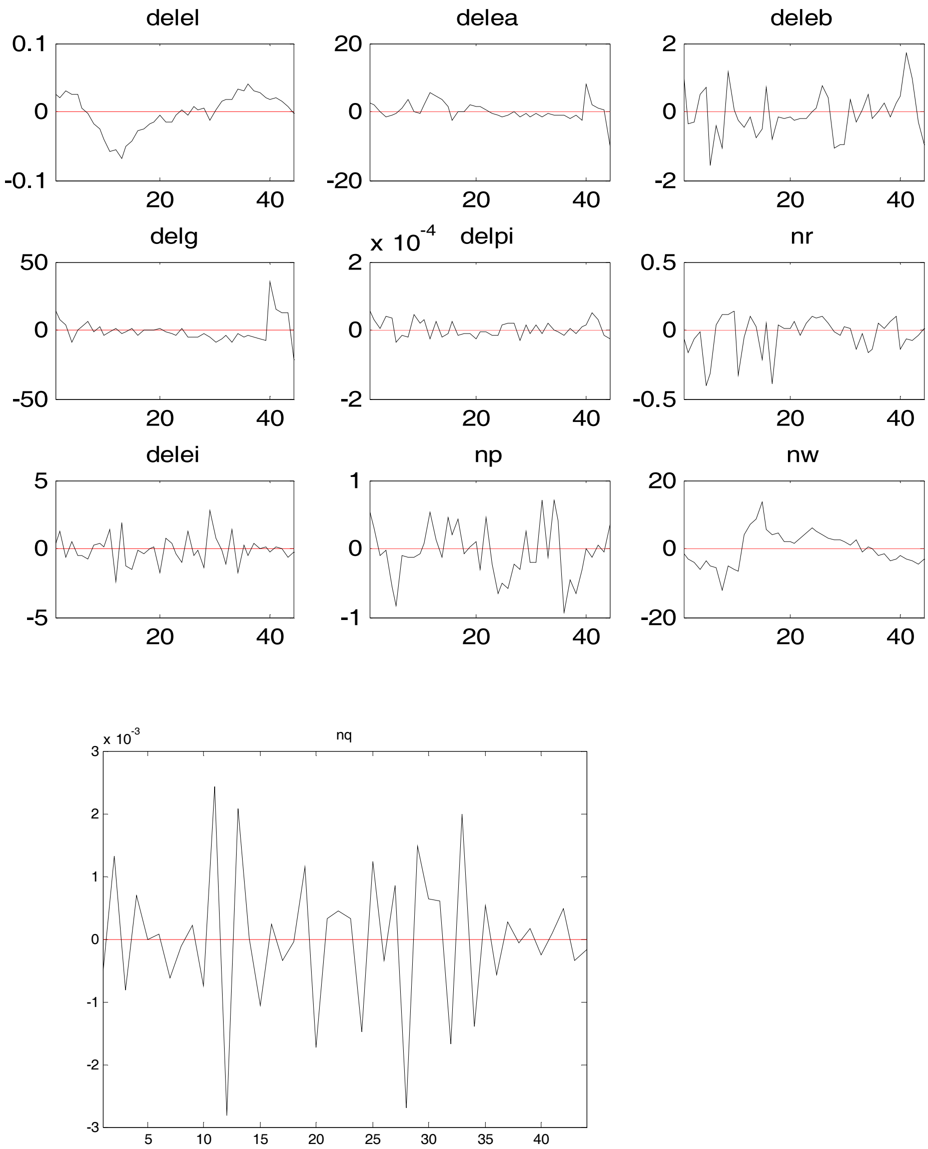
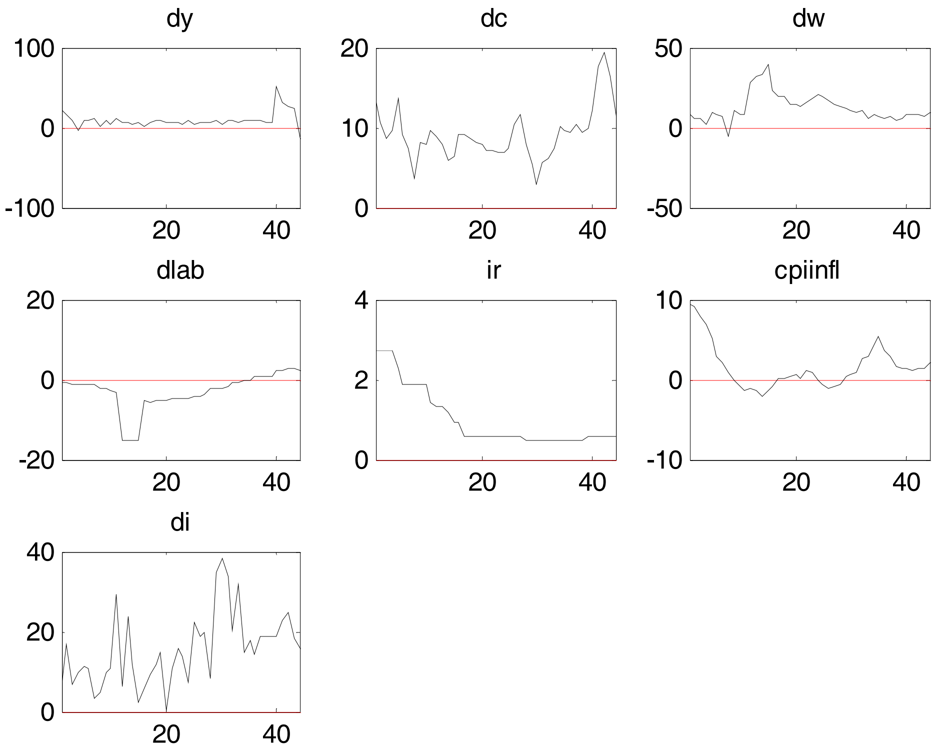


Figure 5.24 Historical and Smoothed Variables



Appendix 5.2 Estimation and Simulation Results for the Improved Smets-Wouters Model. (Money Growth Rule)

Table 5.17 EIGENVALUES: (Money Growth Rule)

Modulus	Real	Imaginary
0.6012	0.6012	0
0.781	0.781	0
0.8429	0.8429	0
0.8533	0.8533	0
0.8915	0.8915	0
0.9019	0.9019	0
0.9136	0.8181	0.4065
0.9136	0.8181	-0.4065
0.9166	0.9156	0.04175
0.9166	0.9156	-0.04175
0.9228	0.9228	0
0.9332	0.9332	0
0.9751	0.9751	0
1.014	1.014	0.01823
1.014	1.014	-0.01823
1.134	1.134	0
1.357	1.357	0
2.26	2.26	0
Inf	Inf	0

There are 6 eigenvalue(s) larger than 1 in modulus
for 6 forward-looking variable(s)

The rank condition is verified.

MODEL SUMMARY

Number of variables:	18
Number of stochastic shocks:	9
Number of state variables:	13
Number of jumpers:	6
Number of static variables:	3

Table 5.18 MATRIX OF COVARIANCE OF EXOGENOUS SHOCKS (Money Growth Rule)

Variables	delel	delea	deleb	delg	delem	delei	np	nw	nq
delel	14.9769	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
delea	0.0000	12.6736	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
deleb	0.0000	0.0000	1.4400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
delg	0.0000	0.0000	0.0000	69.1808	0.0000	0.0000	0.0000	0.0000	0.0000
delem	0.0000	0.0000	0.0000	0.0000	0.000121	0.0000	0.000	0.000	0.0000
delei	0.0000	0.0000	0.0000	0.0000	0.0000	1.4641	0.0000	0.0000	0.0000
np	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	0.0000
nw	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	30.9136	0.0000
nq	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5625

Table 5.19 POLICY AND TRANSITION FUNCTIONS (Money Growth Rule)

	k	l	w	rk	i	y	c	r	m	pi	q	kai
k (-1)	0.9750	-0.062124	-0.000066	-0.147857	-0.011706	0.000284	0.007525	0.034355	0.006598	-0.002324	-0.135743	0.004274
eg (-1)	0	0.217103	-0.047280	0.023639	-0.671831	0.654354	-0.262482	-0.899072	-0.325774	-0.000488	-1.474636	-0.326262
ea (-1)	0	-0.943734	-0.044846	-0.137610	0.212529	0.063289	0.043506	0.157005	0.051445	-0.028878	-0.050397	0.022567
eb (-1)	0	-0.211282	0.224398	0.001826	-2.360151	-0.410956	0.284940	1.863365	0.070144	0.045602	-9.187577	0.115747
el (-1)	0	0.007058	-0.016097	-0.001258	0.009806	0.002840	0.001796	0.006631	0.002076	-0.001184	-0.004757	0.000892
em (-1)	0	0.092664	0.097537	0.026476	1.108668	0.428333	0.485330	1.601005	0.621970	0.002337	2.949316	0.624307
ei (-1)	0	0.251093	-0.178587	0.010093	3.319080	0.599926	-0.342821	-1.756258	-0.239542	-0.020398	-1.112258	-0.259940
m (-1)	0	0.041611	0.013911	0.007729	0.172498	0.154503	0.306720	-0.646053	0.922740	0.000014	2.233167	-0.077246
kai(-1)	0	0.053456	0.031275	0.011795	0.379739	0.215453	0.347133	0.372645	0.691662	0.000227	2.417507	0.691889
w (-1)	0	-0.357123	0.907919	0.076671	-0.084612	-0.025336	-0.017688	-0.062740	-0.021265	0.011933	-0.007178	-0.009332
i (-1)	0.025	0.050359	-0.012562	0.005261	0.783316	0.149764	-0.059382	-0.207987	-0.072236	-0.000894	-0.359138	-0.073130
c (-1)	0	0.075875	-0.013439	0.008691	-0.194979	0.232597	0.724979	-0.288898	-0.116072	-0.000080	-0.547414	-0.116152
pi (-1)	0	-0.097352	-0.331480	-0.059694	-1.907062	-0.739952	-0.843153	-1.715966	-1.420925	0.929411	-5.126751	-0.491514
delel	0	0.008272	-0.018865	-0.001475	0.011492	0.003328	0.002105	0.007770	0.002433	-0.001388	-0.005575	

												0.001045
delea	0	-1.022685	-0.048598	-0.149123	0.230308	0.068583	0.047145	0.170140	0.055749	-0.031294	-0.054613	0.024455
deleb	0	-0.226405	0.240461	0.001957	-2.529094	-0.440373	0.305337	1.996748	0.075165	0.048867	-9.845239	0.124032
delg	0	0.240717	-0.052423	0.026211	-0.744907	0.725528	-0.291032	-0.996864	-0.361209	-0.000541	-1.635033	-0.361750
delem	0	0.109935	0.115716	0.031411	1.315302	0.508165	0.575786	1.899401	0.737893	0.002773	3.499011	0.740666
delei	0	0.321501	-0.228665	0.012923	4.249782	0.768151	-0.438951	-2.248730	-0.306711	-0.026118	-1.424146	-0.332830
np	0	0.243553	-1.791926	-0.215534	-3.758364	-1.467517	-1.685993	-3.398291	-2.851864	1.867811	-10.375469	-0.984053
nw	0	-0.710674	1.806759	0.152575	-0.168377	-0.050419	-0.035200	-0.124853	-0.042318	0.023747	-0.014284	-0.018571
nq	0	0.003188	-0.000796	0.000333	0.049604	0.009480	-0.003771	-0.013221	-0.004583	-0.000053	0.977488	-0.004636

Table 5.20 THEORETICAL MOMENTS (Money Growth Rule)

VARIABLE	MEAN	STD. DEV.	VARIANCE
k	0.0000	57.1514	3266.2835
l	0.0000	14.2722	203.6954
w	0.0000	24.7930	614.6928
rk	0.0000	8.2393	67.8861
i	0.0000	95.1516	9053.8321
y	0.0000	18.5012	342.2945
c	0.0000	39.0716	1526.5925
r	0.0000	27.0564	732.0496
m	0.0000	29.3655	862.3327
pi	0.0000	6.2373	38.9044
q	0.0000	76.0917	5789.9425
kai	0.0000	12.3880	153.4616

Table 5.21 VARIANCE DECOMPOSITION (in percent) (Money Growth Rule)

	delel	delea	deleb	delg	delem	delei	np	nw	nq
k	0.03	8.44	53.61	18.71	0.00	12.40	0.88	5.92	0.00
l	0.08	34.33	7.67	5.70	0.00	2.04	1.18	49.01	0.00
w	0.10	2.19	6.67	1.76	0.00	2.44	4.95	81.89	0.00
rk	0.03	9.98	49.56	17.65	0.00	12.06	0.72	10.00	0.00
i	0.03	7.26	43.82	26.59	0.00	14.88	1.72	5.70	0.00
y	0.06	17.62	21.98	31.30	0.00	4.72	10.03	14.28	0.00
c	0.01	2.27	17.90	55.78	0.00	17.21	4.79	2.04	0.00
r	0.01	2.11	6.67	72.81	0.00	7.69	8.66	2.06	0.00
m	0.01	1.83	5.38	71.59	0.00	11.76	7.64	1.78	0.00
pi	0.10	26.09	33.80	1.18	0.00	4.82	13.21	20.82	0.00
q	0.00	0.46	6.32	72.20	0.00	13.22	7.11	0.69	0.01
kai	0.03	7.33	8.58	62.68	0.00	6.12	9.07	6.19	0.00

Table 5.22 MATRIX OF CORRELATIONS(Money Growth Rule)

Variables	k	l	w	rk	i	y	c	r	m	pi	q	kai
k	1.0000	-0.1636	0.1080	-0.9592	0.5870	0.5279	0.0185	-0.1814	0.0599	-0.6682	-0.0275	-0.3532
l	-0.1636	1.0000	-0.7499	0.0940	0.1170	0.1551	-0.1246	-0.1862	-0.0449	-0.0263	0.0261	-0.1198
w	0.1080	-0.7499	1.0000	0.1247	-0.1758	-0.1536	0.1972	-0.0231	0.1204	0.1796	0.0553	0.0568
rk	-0.9592	0.0940	0.1247	1.0000	-0.5860	-0.5200	0.0363	0.1062	-0.0130	0.7002	0.0642	0.3252
i	0.5870	0.1170	-0.1758	-0.5860	1.0000	0.6866	0.0507	-0.4179	0.2057	-0.7325	0.2636	-0.3821
y	0.5279	0.1551	-0.1536	-0.5200	0.6866	1.0000	0.2363	-0.7575	0.3263	-0.7992	0.2229	-0.7012
c	0.0185	-0.1246	0.1972	0.0363	0.0507	0.2363	1.0000	-0.5290	0.8093	0.0176	0.5826	-0.1838
r	-0.1814	-0.1862	-0.0231	0.1062	-0.4179	-0.7575	-0.5290	1.0000	-0.4752	0.2711	-0.3576	0.7152
m	0.0599	-0.0449	0.1204	-0.0130	0.2057	0.3263	0.8093	-0.4752	1.0000	-0.0993	0.8882	0.1124
pi	-0.6682	-0.0263	0.1796	0.7002	-0.7325	-0.7992	0.0176	0.2711	-0.0993	1.0000	-0.0748	0.4801
q	-0.0275	0.0261	0.0553	0.0642	0.2636	0.2229	0.5826	-0.3576	0.8882	-0.0748	1.0000	0.2835
kai	-0.3532	-0.1198	0.0568	0.3252	-0.3821	-0.7012	-0.1838	0.7152	0.1124	0.4801	0.2835	1.0000

Table 5.23 COEFFICIENTS OF AUTOCORRELATION (Money Growth Rule)

Order	1	2	3	4	5
k	0.9994	0.9977	0.9950	0.9913	0.9866
l	0.9088	0.8215	0.7410	0.6695	0.6080
w	0.9111	0.8265	0.7467	0.6720	0.6027
rk	0.9906	0.9804	0.9699	0.9595	0.9496
i	0.9884	0.9597	0.9203	0.8764	0.8329
y	0.8904	0.7497	0.6068	0.4867	0.4060
c	0.9699	0.8861	0.7638	0.6232	0.4850
r	0.8398	0.5483	0.2069	-0.1075	-0.3366
m	0.9315	0.7458	0.4878	0.2125	-0.0287
pi	0.9863	0.9698	0.9511	0.9305	0.9084
q	0.9102	0.7037	0.4286	0.1426	-0.1020
kai	0.8943	0.6479	0.3415	0.0509	-0.1661

Appendix 5.3 The First-order Solutions and the Linearized Equations-Model Analysis

1 First-order Conditions for Household

Max. $U_t^j = E_t \sum_{i=0}^{\infty} \beta^i e_t^c [\frac{(C_t^j - H_t^j)^{1-\sigma}}{1-\sigma} + \frac{e_t^M}{1-\sigma_m} (\frac{M_t^j}{P_t})^{1-\sigma_m} - e_t^l \frac{(l_t^j)^{1+\upsilon}}{1+\upsilon}]$

s.t. $\frac{M_t^j}{P_t} + \frac{B_t^j}{R_t P_t} = \frac{M_{t-1}^j}{P_t} + \frac{B_{t-1}^j}{P_t} + Y_t^j - C_t^j - I_t^j, \quad Y_t^j = (w_t^j l_t^j + A_t^j) + (r_t^k z_t^j K_{t-1}^j - \psi(z_t^j) K_{t-1}^j) + D_t^j - T_t^j$

And $K_t^j = K_{t-1}^j (1-\tau) + [1 - S(e_t^I I_t^j / I_{t-1}^j)] I_t^j$

The Lagrange function

$$\underbrace{L(...)}_{C,K,l,r^k,z,I} = E_t \sum_{i=0}^{\infty} \beta^i \{ e_{t+i}^c [\frac{(C_{t+i}^j - H_{t+i}^j)^{1-\sigma}}{1-\sigma} + \frac{e_t^M}{1-\sigma_m} (\frac{M_{t+i}^j}{P_{t+i}})^{1-\sigma_m} - e_{t+i}^l \frac{(l_{t+i}^j)^{1+\upsilon}}{1+\upsilon}]$$

$$+\lambda_{t+i}[-(w_{t+i}^j l_{t+i}^j + A_{t+i}^j) - (r_{t+i}^k z_{t+i}^j K_{t+i-1}^j - \psi(z_{t+i}^j) K_{t+i-1}^j) - D_{t+i}^j + T_{t+i}^j + \frac{M_{t+i}^j}{P_{t+i}} - \frac{M_{t+i-1}^j}{P_{t+i}} + \frac{B_{t+i}^j}{R_{t+i} P_{t+i}} - \frac{B_{t+i-1}^j}{P_{t+i}} + C_{t+i}^j + I_{t+i}^j] \quad \text{(A-0)}$$

$$+\mu_{t+i}[K_{t+i}^j - K_{t+i-1}^j (1-\tau) - [1 - S(e_{t+i}^I I_{t+i}^j / I_{t+i-1}^j)] I_{t+i}^j]\}$$

FOC (Ignoring the superscript j)

$$\frac{\partial L}{\partial C_t} = e_t^c (C_t - hC_{t-1})^{-\sigma} + \lambda_t = 0$$

$$\frac{\partial L}{\partial C_{t+1}} = e_{t+1}^c E_t \beta (C_{t+1} - hC_t)^{-\sigma} + \lambda_{t+1} = 0 \quad \text{(A-1)}$$

$$\frac{\partial L}{\partial M_t} = e_t^M (\frac{M_t}{P_t})^{-\sigma_m} + \frac{\lambda_t}{P_t} - \frac{\lambda_{t+1}}{P_{t+1}} = 0$$

$$\frac{\partial L}{\partial B_t} = \lambda_t \frac{1}{P_t R_t} - E_t \beta \lambda_{t+1} \frac{1}{P_{t+1}} = 0 \quad \text{(A-2)}$$

From (A-1), (A-2) we obtain

$$E_t \beta (\frac{\lambda_{t+1} P_t R_t}{\lambda_t P_{t+1}}) = 1 \quad \text{(A-3)}$$

Or $$e_t^c (C_t - hC_{t-1})^{-\sigma} \frac{1}{P_t R_t} = \beta E_t e_{t+1}^c (C_{t+1} - hC_t)^{-\sigma} \frac{1}{P_{t+1}} \quad \text{(A-4)}$$

And $$e_t^M (\frac{M_t}{P_t}) = \frac{R_t - 1}{R_t} (C_t - hC_{t-1})^{-\sigma}$$

Defining $\pi_{t+1} = \frac{P_{t+1}}{P_t}$, linearizing (A-4)

From $\hat{\lambda}_t = -\hat{e}_t^c - \frac{\sigma}{1-h}(\hat{C}_t - h\hat{C}_{t-1})$, we have

$$\hat{e}^c_{t+1} + \frac{\sigma}{1-h}(E_t\hat{C}_{t+1} - h\hat{C}_t) - \hat{e}^c_t - \frac{\sigma}{1-h}(\hat{C}_t - h\hat{C}_{t-1}) + \hat{R}_t - E_t\hat{\pi}_{t+1} = 0$$

Therefore the linear consumption equation is

$$\hat{C}_t = \frac{h}{1+h}\hat{C}_{t-1} + \frac{1}{1+h}E_t\hat{C}_{t+1} - \frac{1-h}{(1+h)\sigma}(\hat{R}_t - E_t\hat{\pi}_{t+1}) + \frac{1-h}{(1+h)\sigma}(\hat{e}^c_{t+1} - \hat{e}^c_t) \quad \text{(A-5)}$$

Defining the real price of capital (marginal value of capital, namely Tobin's Q)

$$Q_t = \frac{\mu_t}{\lambda_t} \quad \text{(A-6)}$$

$$\frac{\partial L}{\partial K_t} = \mu_t + E_t\lambda_{t+1}\beta[r^k_{t+1}z_{t+1} - \psi(z_{t+1})] - \mu_{t+1}\beta(1-\tau) = 0$$

Using A-6, Then

$$Q_t\lambda_t = \lambda_{t+1}Q_{t+1}\beta(1-\tau) - E_t\lambda_{t+1}\beta[r^k_{t+1}z_{t+1} - \psi(z_{t+1})]$$

Rearranging, we have

$$Q_t = E_t\beta\frac{\lambda_{t+1}}{\lambda_t}[Q_{t+1}(1-\tau) + r^k_{t+1}z_{t+1} - \psi(z_{t+1})] \quad \text{(A-7)}$$

Because in steady state, deriving the Lagrange equation with respect to investment, $\frac{\partial L}{\partial I} = \lambda - \mu = 0$ implying $Q = 1$ in steady state; Also $\overline{r}^k = \frac{1}{\beta} - 1 + \tau$ and the relationship $r^k_t = \psi'(z_t)$, $\hat{f}(x_t) \approx \frac{f'(\overline{x})\overline{x}}{f(\overline{x})}$, substituting out z_t and $\psi(z_t)$ with r^k_t; also from A-3, $E_t\beta\frac{\lambda_{t+1}}{\lambda_t} = \frac{E_t\pi_{t+1}}{R_t}$; linearising A-7, we get the Q equation

$$\hat{Q}_t = -(\hat{R}_t - E_t\hat{\pi}_{t+1}) + \frac{1-\tau}{1-\tau+\overline{r}^k}E_t\hat{Q}_{t+1} + \frac{\overline{r}^k}{1-\tau+\overline{r}^k}E_t\hat{r}^k_{t+1} + \varepsilon^Q_t \quad \text{(A-8)}$$

Taking derivative with respect to investment

$$\frac{\partial L}{\partial I} = \lambda_t + \mu_t[1 - S(e^I_t I^j_t / I^j_{t-1}) - S'(e^I_t I^j_t / I^j_{t-1})e^I_t I_t / I^j_{t-1}] +$$
$$E_t\beta\mu_{t+1}[S'(e^I_{t+1}I^j_{t+1} / I^j_t)(e^I_{t+1}I^j_{t+1} / I^j_t)(-I^j_{t+1} / I^j_t)] = 0$$

Using again A-6, we have

$$1 + Q_t[1 - S(e^I_t I^j_t / I^j_{t-1}) - S'(e^I_t I^j_t / I^j_{t-1})e^I_t I_t / I^j_{t-1}] - E_t\beta Q_{t+1}\frac{\lambda_{t+1}}{\lambda_t}[S'(e^I_{t+1}I^j_{t+1} / I^j_t)(e^I_{t+1}I^j_{t+1} / I^j_t)(I^j_{t+1} / I^j_t)] = 0$$

Using inter-temporal investment, we obtain the investment equation:

$$\hat{I}_t = \frac{1}{1+\beta}\hat{I}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{I}_{t+1} + \frac{\varphi}{1+\beta}\hat{Q}_t + \hat{e}^I_t \quad \text{(A-9)}$$

The standard capital accumulation linear equation can be easily shown as:

$$\hat{K}_t = (1-\tau)\hat{K}_{t-1} + \tau \hat{I}_{t-1} \tag{A-10}$$

2 First-order Conditions and Linearizing Equations for Firms

2.1 Minimize $TC_t^j = r_t^k z_t K_t^j + W_t L_t^j$

S.t. $Y_t^j = e_t^a (z_t K_t^j)^\alpha (L_t^j)^{1-\alpha} - \Phi$

$$\underbrace{L(...)}_{K,L} = r_t^k z_t K_t^j + W_t L_t^j + \lambda_T [Y_t^j - e_t^a (z_t K_t^j)^\alpha (L_t^j)^{1-\alpha} + \Theta]$$

$$\frac{\partial L(...)}{\partial K_t^j} = r_t^k z_t - \lambda_T e_t^a \alpha z_t (z_t K_t^j)^{\alpha-1} (L_t^j)^{1-\alpha} = 0 \tag{A-11}$$

$$\frac{\partial L(...)}{\partial L_t^j} = W_t - \lambda_T e_t^a (1-\alpha)(z_t K_t^j)^\alpha (L_t^j)^{-\alpha} = 0 \tag{A-12}$$

A-11 $\times K_t^j$ / (A-12$\times L_t^j$), we can obtain

$$\frac{r_t^k z_t K_t^j}{W_t L_t^j} = \frac{\alpha}{1-\alpha} \tag{A-13}$$

From A-13, $W_t L_t^j = \dfrac{1-\alpha}{\alpha} r_t^k z_t K_t^j$, substituting into $TC_t^j = \dfrac{1}{\alpha} r_t^k z_t K_t^j$

And $Y_t^j = e_t^a (z_t K_t^j)^\alpha (L_t^j)^{1-\alpha} = e_t^a z_t K_t^j (\dfrac{1-\alpha}{\alpha})^{1-\alpha} (\dfrac{r_t^k}{W_t})^{1-\alpha}$

Therefore

$$mc_t = \partial TC_t^j / \partial Y_t^j = \frac{\partial TC_t^j}{\partial K_t^j} \frac{\partial K_t^j}{\partial Y_t^j} = \frac{1}{e_t^a} (\frac{1}{1-\alpha})^{1-\alpha} (\frac{1}{\alpha})^\alpha [r_t^k]^\alpha [W_t]^{1-\alpha} \tag{A-14}$$

Therefore $\hat{m}c_t = \alpha \hat{r}_t^k + (1-\alpha)\hat{W}_t - \hat{e}_t^a$

From A-13 and $r_t^k = \psi'(z_t)$, $\hat{f}(x_t) \approx \dfrac{f'(\bar{x})\bar{x}}{f(\bar{x})}$, we obtain the labour demand equation:

$$\hat{L}_t = -\hat{W}_t + (1+\psi)\hat{r}_t^k + \hat{K}_{t-1} \tag{A-15}$$

The linearizing production function is standard (Assuming the fixed cost is a fraction of total output, then log-linearizing the production function):

$$\hat{Y}_t = \phi e_t^a + \phi\alpha \hat{K}_{t-1} + \phi\alpha\psi \hat{r}_t^k + \phi(1-\alpha)\hat{L}_t \tag{A-16}$$

From the goods market clearing condition,

$$Y_t = C_t + G_t + I_t + \psi(z_t) K_{t-1}$$

In steady state, $\overline{I} = \tau \overline{K}$, assuming that $\overline{G} = g_y \overline{Y}, \overline{K} = k_y \overline{Y}, then, \overline{C} = (1 - g_y - \tau k_y)\overline{Y}$,

We have

$$\hat{Y}_t = (1 - \tau k_y - g_y)\hat{C}_t + \tau k_y \hat{I}_t + e_t^G \tag{A-17}$$

2.2 Wages and Inflation Equations:

From A-0,

$$\frac{\partial L}{\partial l} = -e_t^c e_t^l (l_t^j)^\upsilon - \lambda_t w_t^j = 0 \,,$$

The nominal wage is $\frac{W_t^j}{P_t} = -e_t^c e_t^l (l_t^j)^\upsilon \frac{(C_t - hC_{t-1})^\sigma}{e_t^c} = -e_t^l (l_t^j)^\upsilon (C_t - hC_{t-1})^\sigma$

Adding the wage mark-up shock, we obtain

$$W_t^j = -P_t(1 + \lambda_{w,t}) e_t^l (l_t^j)^\upsilon (C_t - hC_{t-1})^\sigma$$

The indexation of wage implying in t+i:

$$W_{t+i}^j = (\frac{P_{t-1+i}}{P_{t-1}})^{\gamma_w} W_t^j \overline{\pi}^{1-\gamma_w}$$

And the Law of motion for the wages:

$$(W_t)^{-1/\lambda_{w,t}} = \omega_w ((\frac{P_{t-1}}{P_{t-2}})^{\gamma_w} W_{t-1})^{-1/\lambda_{w,t}} + (1 - \omega_w)(\tilde{w}_t)^{-1/\lambda_{w,t}}$$

The optimal real wage

$$\frac{\tilde{w}_t}{P_t} E_t \sum_{i=0}^{\infty} \beta^{t+i} \omega_w^{t+i} (\frac{P_t / P_{t-1}}{P_{t+i} / P_{t+i-1}})^{\gamma_w} \frac{e_t^c (C_{t+i}^j - hC_{t+i-1}^j)^{-\sigma} l_{t+i}^j}{1 + \lambda_{w,t+i}} = -E_t \sum_{i=0}^{\infty} \beta^{t+i} \omega_w^{t+i} e_{t+i}^c e_{t+i}^l (l_{t+i}^j)^{\upsilon+1}$$

Combing above three equations, Following Appendix 1 in CEE(2001), we can obtain

$$\begin{aligned} \hat{W}_t = & \frac{\beta}{1+\beta} E_t \hat{W}_{t+1} + \frac{1}{1+\beta} \hat{W}_{t-1} + \frac{\beta}{1+\beta} E_t \hat{\pi}_{t+1} - \frac{1+\beta\gamma_w}{1+\beta} \hat{\pi}_t + \frac{\gamma_w}{1+\beta} \hat{\pi}_{t-1} \\ & - \frac{1}{1+\beta} \frac{(1-\beta\omega_w)(1-\omega_w)}{(1+\frac{(1+\lambda_w)\upsilon}{\lambda_w})\omega_w} [\hat{W}_t - \upsilon \hat{L}_t - \frac{\upsilon}{1-h}(\hat{C}_t - h\hat{C}_{t-1}) + \hat{e}_t^L) + \varepsilon_t^W \end{aligned} \tag{A-18}$$

Referring to the above process and Appendix 1 in CEE (2001), the inflation equation can be obtained as

$$\hat{\pi}_t = \frac{\beta}{1+\beta\gamma_p} E_t \hat{\pi}_{t+1} + \frac{\gamma_p}{1+\beta\gamma_p} \hat{\pi}_{t-1} + \frac{1}{1+\beta\gamma_p} \frac{(1-\beta\omega_p)(1+\beta\omega_p)}{\omega_p} [\alpha \hat{r}_t^k + (1-\alpha)\hat{W}_t - \hat{e}_t^a] + \varepsilon_t^p \tag{A-19}$$

Chapter 6 Summaries, Suggestions and Further Research

The time around the turn of 21st century, especially the period from 1996 to 2006, contributes many aspects to the successes in China's economy transformation since 1978, which will mark China's history and impact the global as its integration with the world. Within the development process of China's economy, monetary policy has played important roles in stabilizing the economy, which has spurred various academic debates on effects of the monetary policy regime in China. In this thesis, we use monthly and quarterly data of China's economy during this period to explore and identify the transmission mechanism of monetary policy, test the effects of monetary policy on real economy, and measure the roles of exogenous monetary shocks and other shocks in China's business cycle by employing VAR/VEC model and a Bayesian DSGE model. Our study covers more than 10 years from January 1996 to December 2006, which consists of a weak recession period (1996-2001) with a deflation threat and a rapid recovery period (2002-2006) with high economic growth and a low inflation rate. The reshaping of China's economic structure and financial regulations (or deregulations) has taken place during this period together with the development and openness of China.

First, in Chapter 1, we have summarized the framework of China's monetary policy by presenting the history of the central bank in China, the PBC, the components and the characteristics of the banking system, the theory and practice of the implementations of China's monetary policy. We've discussed the goals, intermediate targets and instruments of China's monetary policy; the economic and institutional background of china's monetary policy and the financial markets through which the monetary policy takes effect. We have also discussed the independence of the PBC and the efficiency of China's monetary policy.

In Chapter 2, we have provided a comprehensive overview of the monetary policy transmission mechanism (MTM) and the research methods. First the diverse monetary policy transmission channels are discussed including the so-called "Money view", working through the interest rate and monetary channels, and the "Credit view", operating through bank lending channel and balance sheet channel; the asset price channel, the expectation channel and the exchange rate channel are also reviewed. Second, the research methods on MTM are summarized. We provide detail discussions on the VAR approach and DSGE models (the New Keynesian Models) for the MTM including the price stickiness and wage stickiness by introducing a simple New Keynesian model.

On the basis of Chapter 1 and Chapter 2, the empirical evidence for the transmission channels of China's monetary policy is summarized in the first part of Chapter 3. In the second part, we've demonstrated the long run trend and the business cycles (stylized facts) of China's macro economy by HP filter during the period from 1996 to 2006 on which our research focuses.

By specifying VAR/VEC models for china' economy in Chapter 4, we have examined the differential effects of monetary policy shock on the banks balance sheets variables (deposits, loans, securitises) across bank categories (aggregate banks, state banks, non-state banks) and the macro economic variables (output, consumer price index, exports, imports, foreign exchange reserves) to uncover the transmission mechanism of China's monetary policy. Our study identifies and tests the existence of the *bank lending channel*, the *interest rate channel* and the *asset price channel* by using the aggregate banks date and disaggregated data in term of bank types and loans types. We tested and discussed the distribution and growth effects of China's monetary policy by using the data of bank loans to different sectors. We investigate the effects of China's monetary policy on China's foreign trade under a contractionary and an expansionary operation respectively. We identify the cointegrating relationships and set up VEC Models to explore the long run relationships between these variables. The results of this study revealed many implications for implementations of China's monetary policy.

In this chapter, the significant responses are presented in term of aggregate bank data, bank type data and loan type data; these comply with the asymmetric-information-based and finance-friction-based monetary transmission theories. Both the impulse responses functions from the aggregate banks data and from the disaggregated data simulations confirm the existence of the *bank lending channel* in China's monetary policy transmission whether under a contractionary operation or an expansionary operation. In particular, a monetary policy shock does influence the bank behaviours across the bank types and the loans types. The heterogeneous behaviours across the bank type and the loans type (borrowers) reflect that the asymmetric information and the frictions in the loan market, supporting the theoretical base on which the bank lending channel was developed. This empirical evidence implies that China's monetary policy can affect the macroeconomic activities by constraining or augmenting loan supply through the bank lending channel. Moreover, given the immature and tiny scale of China's capital markets in which the direct capital raising is rationed and difficult and most of China's firms obtain external capital mainly depend on the banks loans, the bank lending channel does and will play a great role in the implementations of China's monetary policy to achieve its multiple goals. The diverse responses of bank loans to different sectors on China's monetary policy shocks either in an expansionary or a contractionary operation qualitatively and quantitatively indicate that China's monetary policy plays distribution and growth roles besides the stabilization role in economic activity; this can provide some possible explanations for the rapid economic growth in China since 1978. This also implies the importance of improving the effects and efficiencies of China's monetary policy's transmission. We examine the influence of China's monetary policy on exports and imports and thereby on the foreign reserves and output by impacting on the terms of trade even if China conducted a fixed exchange rate system prior to the May of 2005. The long term current account surplus and the huge accumulation of foreign exchange reserves cannot be sustainable in the long run according to the world economy history especially the advanced economic practice due to the adoption of managed floating exchange rate system after the May of 2005 in China. Therefore, reducing the dependence of China's economic growth on international trades especially on exports, and seeking more sustainable and sound economic growth models are main challenges to the policy makers in China. Finally, we identify the cointegrating vectors among these variables and set up VEC Models. The identified cointegrating relationships and the VEC Models descibe the long run relationships between the indicators of China's monetary policy, the bank balance sheet variables (total deposits, total loans, and bank Securities) and the real economic variables (output, CPI inflation, export, import, foreign exchange reserve), this confirm again that the bank loans play a significant role in the transmission effects of monetary policy on the real economy in China.

In Chapter 5, we have estimated a benchmark DSGE model with Taylor's rule using a Bayesian approach following Smets and Wouters (2002) with China's macro time series data from 1996q1-2006q4. We also set up an improved Smets-Wouters model with a money growth rule. The estimated parameters feature the unique characteristics and determinants of developments in China's macro economics. Comparing the results with the estimated parameters for Europe and US with the same model, we find that Chinese have the biggest habit consumption, this implies that an expected one percent increase in the short-term interest rate for four quarters has more impact on consumption in the Euro area and the US than in China according to the consumption equation. China also has the biggest output elasticity of capital. This is in line with the large share of investment in GDP formation in China. The adjustment cost parameter in China is the biggest, showing the lowest efficiency of capital utilization. China's elasticity of labour supply is relatively smaller than that in Europe and US. China's interest rate is more persistent than that in Europe and US, implying that China has a higher inertia in the implementation of monetary policy when the interest rate is taken as main policy tool. Our estimation delivers lower values for the coefficients in the reaction function of China's monetary authority than that in US and Europe, indicating that China's central bank does not completely follow Taylor's rule. This result consists with the reality that the main policy tool is quantity tools other than price tools in China. China has the biggest degree of price indexation (γ_P), two times as in Europe and US, implying that inflation depends more on past inflation than expected future inflation in China due to the inflation equation. This implies that the backward-looking plays a more important role than the forward-looking in the inflation formation process in China. Moreover, China has the most considerable degree of Calvo price stickiness among three economies, reflecting that underdevelopment of market mechanism and high degree of regulation of prices by the government. Finally, China's government expenditure shock, productivity shock, preference shock, investment shock and mark up in price and wage shocks are very significant compared with those in Europe and the US.

The simulation results of our benchmark DSGE model with Taylor's rule and an improved Smets-Wouters model with a money growth rule in Chapter 5 have shed light on the transmission mechanism of China's monetary policy and the roles of monetary and non monetary exogenous shocks in China's business cycle. From the results of the benchmark Smets-Wouters model with Taylor's rule, first, *the transmission of monetary policy shocks and the liquidity effect* through the *interest rate channel, asset price channel* and *expectation channel* have been identified in China. A money supply shock increases the capital stock, consumption, investment and output. The real interest rate falls immediately, demonstrating a liquidity effect following an inflation effect: two years later the real interest rate begins to rise against the increase of inflation; this supports the existence of interest rate channel in the monetary policy transmission. This result is different from that in Euro Area from Smets and Wouters (2002), where no liquidity effects are found without a persistent monetary policy shock. The interest rate shock makes the real interest rate rise and thereby reduces the consumption, investment, output, capital stock, labour supply, real wage level and the rate of inflation. But the rental rate of capital soon rebound after temporary decrease. This clearly confirms the existence of the *interest rate channel* of monetary policy transmission in China. The immediate decline in the asset price (Q) following the decline of investment and consumption and thereby the output supports the existence of the *asset price channel* in China's monetary transmission. The incorporation of rational expectation in the inflation equation implies the effects of expectation in the monetary transmission (the *expectation channel*). *Second, the transmission of non-monetary shocks is also significant*. The cost-pushed shocks increase the rate of inflation significantly; a positive *productivity shock* makes the consumption, investment, output, capital stock and real wage rise, while labour supply (employment) falls. The rental rate of capital, return on equity market, interest rate and inflation rate also fall. These effects tell the same story identified as in US and Euro Area. As Smets and

Wouters (2002) pointed out, the rise in productivity causes a fall in marginal cost, because the monetary policy does not reacts timely and strongly (interest rate falls slowly) to offset this fall in marginal cost, this decreases inflation gradually. The effects of a positive *labour supply shock* on consumption, investment, output, capital stock, inflation and the interest rate are similar to those of a productivity shock. A *preference shock increases* consumption and output significantly, while the investment increases initially and then begins to fall, demonstrating a delay significant crowing out effects; the labour supply and real wage also increase, which cause the rise in marginal cost and thereby increase the inflation rate. The interest rate rises following the rise in inflation. The *government expenditure shock* has significant effects in China: increasing the labour supply, real wage and output immediately and thereby causing the demand-pull inflation gradually. It decreases private consumption and investment, also implying a significant crowing out effects on private consumption and private investments. The fall in consumption leads to the rise of marginal utility of working, which increases the labour supply. The return on equity market rises while the capital stock falls. The interest rate and rental rate of capital also increase. The effects of a positive *investment shock* are qualitatively similar as the government expenditure shock. *Third, we have measured the contributions of monetary policy shocks and non-policy shocks to the business cycle developments in China's economy.* Depending on the results of variance decomposition in infinite horizon, we find that the preference shock and the investment shock play significant roles in china's business cycle. Besides, the cost-push shocks, the technology shock and the monetary policy (interest rate) shock also explain distinguished fraction of output, inflation, interest rate and consumption. Turning to the variance decomposition of the inflation, it shows that the cost-push shock dominates the forecast errors of the inflation; it contributes about 50% of inflation variation, uncovering the special characteristics of inflation formulation in China. The preference shock accounts for 20%, technology shocks account for 12%, whereas the monetary policy shock also contributes about 10% of the variation of inflation. On the determinants of labour supply, the wage mark-up shock and the technology shock contribute 50% of labour supply variance in the long run. Investment and government expenditure shocks also play an important role in the labour supply in China.

The improved Smets-Wouters model with a money growth rule uncovers the same monetary policy transmission mechanisms: the existence of the monetary channel, the asset price channel and the expectation channel. The responses to the monetary policy shocks and non monetary policy shocks are qualitatively similar as in the Taylor's rule although there are some differences. The main differences emerge in the variance decomposition or the contributions to the business cycle of China's economy. In the money growth rule model, the government expenditure, preference and productive shocks play significant rules in the variations of output. On the determinants of inflation, the preference and technology shocks also contribute significantly to the forecast errors. The cost-push shocks contribute about 40% of inflation variance. Due to the reality of China's economy, in which government investment contributes significantly, it seems that the money growth rule model is more justified than Taylor's rule, but it's difficult to make this conclusion.

It is reasonable to suggest that the PBC follows both the interest rate rule (Taylor's rule) and a money growth rule with discretion.

On the basis of our study, referring to the theories and practices of monetary policy in the advanced economy, the following implications and suggestions can be provided to the China's monetary policy regime:

·Given the existence of *interest rate channel* in China's monetary policy transmission, it is necessary to develop and improve money markets for enhancing the effectiveness of China's monetary policy transmission because a more efficient money market helps strengthen the interest rate monetary policy transmission channel. To this end, further liberation of the interest rate control is necessary to transform the banking industry into more profits-maximizing and market-oriented modern commercial banks. Further deregulation on the money markets is also a precondition for eliminating the market segments. Moreover, creating a short-medium treasury (government debt) market is crucial for the PBC to implement OMOs. On the other hand, lowering the excessive reserves level of commercial banks in the PBC may lead to a more effective interest rate transmission channel.

·Given the identification of *bank lending channel* in China by our research (Chapter 4) and the important roles of banking loans in China's real economy (underdeveloped capital market), it is very important for China to reform the banking system and make the state banks follow the market principles to credit prudently to their most valued uses, improve accounting and disclosure standards and assess asset quality to foster the lending practice. Also, following the key three pillars of BASEL (II), strengthening the regulation on the risks of the loan market and formulating comprehensive supervisory review process in banking system can provide a robust financial environment in which monetary policy takes effect efficiently.

·The identified *asset pricing channel* through wealth effects and Tobin's Q effect in Chapter 4 and 5 implies that a more mature capital market is essential for monetary policy transmission to take roots and strengthen the effectiveness. Current stock markets and bond markets in China are underdeveloped and suboptimal. Many attempts are needed to foment broader and deeper capital markets.

·Our study in Chapter 4 has shown that China's monetary policy has at least one year lag. Given the implications of the inflation equation (5.41, New Keynesian Philips Curve, rational expectation) in Chapter 5, it is feasible and desirable for the PBC to formulate and implement a *forward-looking* monetary policy discretely to match the economic fluctuations in the future, rather than only react to the current exogenous shocks as it did. This requires the PBC to enhance the research abilities and conduct broader data statistics.

·Referring to the theory and experiences from both the advanced economies and the emerging market economies, it is a better policy scheme for the PBC to take the low inflation as the main objective of its monetary policy, namely adopting the inflation targeting regime. This can best accommodate the fluctuations in China's economic growth. The current policy strategy of the PBC is targeting monetary aggregate (money base and the growth of broad money), which can still play a useful operational role to stabilize the inflation. But on the other hand, with the rapid financial innovations and the changing trend velocity of money circulation, the monetary aggregate targeting cannot constitute a stable anchor. The success and lessons of the inflation targeting can be learned from the experiences of the ECB, the Bank of England, The central bank of New Zealand (explicit inflation targeting) and the FED (implicit inflation targeting).

·Taking flexible floating exchange rate regime and deregulating the control of capital flow can provide more room for the implementations of China's monetary policy and improve the efficiencies of monetary policy transmission in China.

·With the developments in the reform of China's political system, the broader independence of the PBC, for example instruments independent and operational independent, is necessary to maintain the stability of China's economy.

·More effective communications, either domestic or international communications are essential for PBC to implement a transparent and accountable monetary policy.

Many interesting and important issues on China's monetary system remain for study. In our further research, we will incorporate the financial market frictions in our DSGE model as in Bernanke et al (1998) to provide new information to our VAR/VEC model in chapter 4. We will also increase the variables in our VAR/VECM system to improve the estimation of the parameters and the fit of the model. On the China's monetary policy, on the basis of the précised

DSGE and VEC model, we will conduct analysis on the optimal monetary policy rules and provide more explanations to China's business cycle.

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