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IDENTIFYING THE MONETARY POLICY TRANSMISSION MECHANISM AND EVALUATING THE MCCALLUM RULE AS A MONETARY POLICY GUIDELINE FOR CHINA

A Thesis
Submitted in Partial fulfilment
of the requirements for the Degree of
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by
Shuzhang Sun

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Abstract

Abstract of a thesis submitted in partial fulfilment of the requirements for the
Degree of PhD

Identifying the Monetary Policy Transmission Mechanism and
Evaluating the McCallum Rule as a Monetary Policy
Guideline for China

by
Shuzhang Sun

Over the last thirty years there have been dramatic changes in the monetary policy transmission mechanisms in China. The People’s Bank of China (PBC) began functioning as the central bank in 1984 and since then monetary policy has been used to promote economic growth and control inflation rate. The PBC introduced the “credit growth quota system” in 1986, which was replaced by the window guidance system in January 1998. Meanwhile, financial markets (money market, bond market and stock market) have made significant progresses. During this transition, the intermediate and operating targets also switched to monetary aggregate (M2) and monetary supply respectively, with the adoption of a combination of monetary policy instruments. In this circumstance, China’s monetary policy transmission mechanisms have been one of the most studied topics.

First, we test whether an effective interest rate channel exists currently in China using a standard VAR method, because it is the core channel of policy transmission in neoclassical economics and short-term interest rates have been used as the operating target by central banks in all developed economies and most of emerging markets. We test the effects of weighted average 7-day interbank money market interest rate and 7-day repurchase rate on real output, general price level from 1996:Q1 to 2008:Q1 and find that changes in short-term interest rates could not impact on real output and general price level significantly as expected. However, an effective interest rate channel has not come into existence, though significant advancements in market-based interest rate reform have been made during the past two decades.
Secondly, we identify bank lending channel in China based on quarterly data covering 1997:Q1 to 2008:Q4. We construct a VECM model using commercial bank one-year lending rate, bank credit aggregate, required reserve ratio, inflation rate and real output. The Johansen cointegration tests identified two cointegration relationships among them. To disentangle the forces between credit demand and credit supply, which drives the changes in credit aggregate, we impose joint restrictions on the two-cointegration relationships simultaneously, and find that the PBC could affect the bank credit supply using required reserve ratio in the long-run equation. The corresponding loading matrix shows us that short-run disequilibria in the long-run relationship could be corrected through bank lending rate.

Thirdly, we evaluate the possibility of taking McCallum rule as a monetary policy guideline for the PBC using quarterly data from 1994:Q1 to 2009:Q1. A medium-term or long-term policy rule could provide a stable framework, which reduce uncertainty and increase the credibility and transparency of current and future government policies, monetary policy effectiveness would be improved if the policymaker were to follow a rule. We use a counterfactual simulation method to evaluate the original McCallum rule and an improved McCallum rule. The results show that following the McCallum rule could reduce the root mean square error between nominal GDP target and simulated nominal GDP significantly. Then, we use the historical analysis method to confirm this result. When the actual value of monetary base deviates from the rule-produced values dramatically, China’s economy encounters inflation or deflation problems. Therefore, this study argues for the McCallum rule as a policy guideline for China.

Keywords: Monetary Policy Transmission Mechanism, Operating Target, Market-based Interest rates, Bank Lending Channel, McCallum Rule
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<td>BL</td>
<td>Bank loan</td>
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<tr>
<td>CHIBOR</td>
<td>China’s interbank offered rate</td>
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<tr>
<td>CPCC</td>
<td>Communist Party Central Committee</td>
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<tr>
<td>DSGE</td>
<td>Dynamic stochastic general equilibrium</td>
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<tr>
<td>INTm</td>
<td>Interbank money market rate</td>
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<td>INTr</td>
<td>Bond market repo rate</td>
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<td>Libor</td>
<td>London interbank offered rate</td>
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<tr>
<td>NEER</td>
<td>Nominal effective exchange rate</td>
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<td>OMOs</td>
<td>Open market operations</td>
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<tr>
<td>PBC</td>
<td>People’s Bank of China</td>
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<tr>
<td>RC</td>
<td>China official benchmark annualized one-year loan interest rate</td>
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<tr>
<td>Repo</td>
<td>Repurchase agreement</td>
</tr>
<tr>
<td>RMB</td>
<td>Renminbi</td>
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<tr>
<td>RR</td>
<td>Required reserve ratio</td>
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<td>SHIBOR</td>
<td>Shanghai interbank offered rate</td>
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<tr>
<td>SOEs</td>
<td>State-owned enterprises</td>
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<td>Tibor</td>
<td>Tokyo interbank offered rate</td>
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Monetary policy is not easy. Central bankers have multiple objectives and, over time, must confront a variety of economic circumstances. They know their actions have powerful effects on the economy, but the timing, magnitude, and channels of those effects are not fully understood.

Monetary Policy: introduction
Mankiw N. Greorgy, 1994

CHAPTER 1
INTRODUCTION

1.1 Introduction

The monetary transmission mechanism describes how policy-induced changes in the policy instrument (for example nominal money stock or the short-term nominal interest rate) affect policy goals (real output and price level). The monetary authorities must have an accurate assessment of their policy effect on the economy to conduct monetary policy successfully, and require an understanding of the monetary transmission mechanism. Mishkin (1995), Kutter and Mosser (2002), and Ireland (2005) summarize the various monetary policy transmission channels through which monetary policy actions affect real variables. Much research (for example, Boivin et al., 2010; BIS, 2008; Angeloni et al., 2003; and Taylor 1999A) has been conducted on the different monetary transmission mechanisms in different countries. This chapter provides a general description of the monetary policy transmission framework to help us understand this research on identifying China’s monetary policy transmission mechanism. Section 2 describes some basic concepts of the monetary transmission mechanism. Section 3 produces monetary transmission channels and their basic principles as summarized by Kutter and Mosser (2002). Section 4 reports on the evolution of monetary policy transmission in China following its economic reform. Section 5 presents an overview of the current monetary policy framework in China. Section 6 states the role of credit in monetary policy transmission. Section 7 reviews the evolution of simple policy rules. The research objectives are then given in Section 8.
1.2 Definitions of Policy Instruments, Targets and Goals

Goals are substantive objectives, the achievement of which increases the material well-being of the population (Bain and Howells, 2003). The choice made by governments among the goals of macroeconomic policy has historically varied over past decades among full employment, full-employment output (or a high output growth rate), a stable price level (or a low inflation rate) and a stable exchange rate (or a desirable balance of payment position) (Handa, 2009). Since the 1980s, primacy was given almost everywhere to the control of inflation on the assumption that a low rate of inflation was a necessary condition for the achievement of low unemployment and high rates of economic growth. To achieve this, the central bank needs policy instruments that include variables that the central bank can operate directly and determine their value independently of other variables in the system. Among the instruments available to the central bank are open market operations, the discount rate at which the central bank lends to commercial banks and other financial institutions, the reserve requirement ratios that determine the level of reserves banks must hold against their deposit liabilities, and the overnight loan rate. The first two determine the economy’s monetary base. The third changes the monetary base multiplier, and the change in the overnight loan rate induces changes in various interest rates in the economy (Bain and Peter, 2003; Handa, 2009; Walsh, 2010).

Between the goals and instruments of monetary policy lie layers of intervening variables: generally classified into operating targets and intermediate targets. An operating target variable is one which the central bank can directly or almost directly operate through the instruments at its disposal, typically the monetary base or a very short-term interest rate (usually an overnight interbank rate) (Handa, 2009). The policy instruments are manipulated to achieve a pre-specified value of an operating target. Intermediate target variables – monetary aggregates, short-term and long-term interest rates, aggregate demand (nominal national income) and inflation forecast – fall between operating targets and goals in the sequence of links that run from the policy instrument to real economic activities and inflation (Handa, 2009). Instruments, operating targets, intermediate targets and goals have been described in a sequence running from the instruments to goals. Policy design operates in the reverse fashion, from the goals of policy, to the values of the intermediate targets consistent with the
goals, to the values of the operating targets needed to achieve the intermediate targets, and finally to the instrument settings that yield the desired values of the operating targets (Tinbergen, 1956).

Appropriate policy instruments, operating target, and intermediate target to fulfil government fixed policy goal(s) have three distinct features: (1) stable and predictable relationships between the ultimate goals, intermediate variables and operating targets; (2) achievable desired levels of the operating target through instruments at its disposal; and (3) predictable lags in these relationships and reasonable forecasts of the future course of the economy. Currently, two main operating targets – monetary aggregates and interest rates – are suggested for monetary policy. Two main goals of monetary policy are highlighted in recent literature: inflation rate (or price level) and output (Handa, 2009).

However, when actually implementing a monetary policy analysis, it is common practice to ignore the reserve market behaviour and treat an operating target variable, such as the overnight interest rate or a reserve aggregate, as the policy instrument (Walsh, 2010).

1.3 Monetary Transmission Mechanism

We first reproduce the key assumptions of the monetary policy transmission mechanism presented by Ireland (2005) before we turn to different monetary transmission mechanisms. Central bank liability includes both components of the monetary base: currency and bank reserves. Hence, the central bank controls the monetary base. Indeed, monetary policy action typically begins when the central bank changes the monetary base through an open market operation, purchasing other securities – most frequently, government bonds – to increase the monetary base and selling securities to decrease the monetary base.

If these policy-induced movements in the monetary base are to have any impact beyond their immediate effects on the central bank’s balance sheet, other agents must not be in a position to offset them exactly by changing the quantity or composition of their own liabilities. Thus, any theory or model of the monetary transmission
mechanism must assume that there exist no privately-issued securities that substitute perfectly for the components of the monetary base. This assumption holds if, for instance, legal restrictions prevent private agents from issuing liabilities having one or more characteristics of the currency and bank reserves.

Both currency and bank reserves are nominally denominated, their quantities being measured in terms of the economy’s unit of account. Hence, if policy-induced movements in the nominal monetary base are to have real effects, the nominal price must not be able to respond immediately to those movements in a way that leaves the real value of the monetary base unchanged. Thus, any theory or model of the monetary transmission mechanism must also assume that some friction in the economy works to prevent nominal prices from adjusting immediately and proportionally to at least some changes in the monetary base.

Monetary transmission is a complex topic because there is not one but many channels through which the monetary policy operates as mentioned above. We reproduce Kutter and Mosser’s (2002) summary of monetary policy transmission mechanisms to distinguish different channels. The process begins with the transmission of open market operations to market interest rates, either through the reserves market or through the supply and demand for money more broadly. From there, transmission may proceed through any of several channels.

The interest rate channel is the primary mechanism at work in conventional macroeconomic models. The basic idea is that an increase in nominal interest rates translates into an increase in the real rate of interest and the user cost of capital, given some degree of price stickiness. These changes, in turn, lead to a postponement in consumption or a reduction in investment spending. This is the mechanism embodied in the conventional specification of the “IS” curve – whether of the “old Keynesian” (Hicks, 1937), or the forward-looking equations at the heart of the “New Keynesian” models (Rotemberg and Woodford, 1997, Clarida, Gali and Gertler, 1999). Nevertheless, Bernanke and Gertler (1995) suggested that mechanisms (such as wealth channel, monetarist channel, exchange rate channel, etc.) other than the narrow interest rate channel may also be at work in the transmission of monetary policy.
One such alternative path is the wealth channel, built on the life-cycle model of consumption developed by Ando and Modigliani (1963), in which households’ wealth is a key determinant of consumption spending. The connection to monetary policy comes via the link between interest rates and asset prices: a policy-induced interest rate increase reduces the value of long-lived assets (stocks, bonds, and real estate), shrinking households’ resources and leading to a fall in consumption.

The third channel is the broad credit channel developed by Bernanke and Gertler (1989). In this channel, asset prices are especially important since they determine the value of the collateral that firms and consumers may present when obtaining a loan. In the presence of information or agency costs, declining collateral values will increase the premium borrowers must pay for external finance, which in turn will reduce consumption and investment. The impact of policy-induced changes in interest rates may be magnified through this “financial accelerator” effect.

The fourth channel is the bank lending channel, where banks play a more central role (Bernanke and Blinder, 1988). The essential insight is that, because the bank relies on reservable demand deposits as an important source of funds, contractionary monetary policy, by reducing the aggregate volume of bank reserves, will reduce the availability of bank loans. A significant subset of firms and households relies heavily or exclusively on bank financing, so a reduction in loan supply will depress aggregate spending.

The exchange rate channel is an important element in conventional open-economy macroeconomic models (Mishkin, 1995, Obstfeld and Rogoff, 1995). The chain of transmission is from interest rates to the exchange rate via the uncovered interest rate parity condition relating interest rate differentials to expected exchange rate movements. Thus, an increase in the domestic interest rate relative to foreign rates would lead to a stronger currency and a reduction both in net exports and in the overall level of aggregate demand.

The final channel is described as a monetarist channel (Brunner and Meltzer, 1972, Meltzer, 1995) that focuses on the direct effect of changes in the relative quantities of assets, rather than interest rates. The argument is that because various assets are
imperfect substitutes in investors’ portfolios, changes in the composition of outstanding assets brought about by monetary policy lead to relative price changes, which in turn can have real effects. Interest rates in this channel play no special role other than as one of many relative asset prices. These different monetary policy transmission mechanisms are illustrated in Figure 1.1 (Kutter and Mosser, 2002)

![Figure 1.1 Channels of Monetary Policy Transmission](image)

Source: Kutter and Mosser (2002)

The most popular channel in the current monetary policy literature in industrial countries is the interest rate channel. Kasman (1992), Morton and Wood (1993), Borio (1997, 2001), and Ho (2008) argued that central banks in the industrialized countries currently implement monetary policy through market-oriented instruments closely geared to influence short-term interest rates as operating targets. Ho’s (2008) research on emerging Asian countries confirmed a number of broad themes across central banks with respect to the main features of policy implementation: a focus on short-term money market interest rates as operating objectives, favouring averaging reserve requirements, using interest rate corridors with penalty rates, and searching for alternative instruments.

In the past three decades, the credit channel also attracted considerable attention from economists and policymakers, built on breakthroughs in the economics of imperfect
information in the 1970s, which implies the failure of the Modigliani-Miller theorem\(^1\), following Bernanke and Blinder’s (1988) presentation of their credit channel framework. Without necessarily denying that the interest rate channel of policy transmission plays an important role, the two channels can coexist and complement each other (Bernanke 1993; Kashyap and Stein 1994). The credit channel is often split into two sub-channels: the balance sheet channel (broad credit channel) and the bank lending channel (narrow credit channel). Central bankers have attached great importance to the role of bank credit in monetary transmission in developed and developing economies (Goodhart, 2007; Tucker, 2007; Bernanke, 2007; Bloor et al., 2008).

1.4 Evolution of China’s Monetary Policy Transmission Mechanism after Economic Reform

Following the 1978 economic reform, monetary policy in China moved away from administrative planned measures towards the use of indirect levers of monetary controls. The People’s Bank of China (PBC) began functioning as the central bank in 1984 and, since then, monetary policy has been used to balance the aggregates: economic growth and inflation rate. At the same time, direct controls on credit and cash were relied upon to curb inflation and to promote economic growth. The central bank’s branches were authorized to grant temporary credit up to a specified proportion of excess reserves. New policy instruments, such as reserve requirements, regulation of interest rates, rediscount facilities and open market operation played more and more important roles in monetary policy transmission. At same time, the fundraising pattern of state-owned enterprises (SOEs) in China changed dramatically from government capital injections to bank lending since the mid-1980s. To bring the bank lending under control, the PBC introduced the “credit policy” framework in 1986 called a “credit growth quota system”\(^2\). Lending by quota was a compulsory requirement for banks and based on central planning ideology (Ikeya, 2002). However, transition from direct monetary controls to indirect economic levers is not easy. Before 1990, even though a reserve requirement system existed, in practice a

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1. According to Modigliani-Miller theorem, the capital structure of a firm has no influence on its investment decisions.

2. This monetary policy framework directly controls bank lending based on central planning. The PBC first decided a national quota of credit growth in line with the government’s overall macroeconomic policy, allocating it to PBC branches in 31 provinces and major cities, which then distributed the quota to the local branches of commercial banks.
specialized bank could seek to have its lending targets adjusted retroactively so that the reserve ratio did not fully impose the intended restraints on lending. Similarly, the central bank does not appear to be able to influence the level of bank credit through a discount rate policy. Temporary credit borrowed from the central bank by specialized banks often ended up in capital investment by the ultimate enterprise borrowers. Interest rates did not seem to play a major role in either attracting savings deposits or rationing credit demand. This is because there is no real financial responsibility on the part of either the borrowers or local lenders. Specialized banks, as well as enterprises, are still not sensitive to economic levers due to their limited responsibility for profit and loss (Li, 1991). In addition, China lacked not only a body of effective, smoothly operating policy control instruments, but also a framework in which monetary policy could be conducted. The only tool at the time that had an effect on controlling the scale of credit to the specialized banks was the overall credit plan in which the central bank constrained the credit-expanding capability of the specialized banks. The “window guidance system” replaced the “credit growth quota system” in January 1998. Under this system, direct control by the PBC of bank lending is, in theory, against the new financial order stipulated in the Commercial Bank Law enacted in 1995, which supports banks’ independent decision-making based on the principle of self-responsibility (Ikeya, 2002).

With the abolition of credit ceilings on January 1, 1998, and the expansion of open market operations, monetary policy operations also moved from direct credit control to indirect measures. During this transition, the intermediate and operational targets also switched to money supply and the monetary base with the adoption of a combination of monetary policy instruments, such as open market operations, reserve requirements, central bank discount, central bank lending and deposit interest rates. An indirect management system was set up to stabilize and promote economic growth and money supply as the intermediate target, through the use of multiple monetary policy instruments. At the same time, with the development of a money market, a “central bank → money market → financial institutions → enterprises (individuals)” transmission system was taking shape. In addition, advances had been made in

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3. In light of window guidance, the PBC meets officers from commercial banks at set time intervals to check whether the operation of the banks is in line with the plan and, if necessary, to provide banks additional or adjusted guidance. Therefore, this system acts as a mechanism to control credit creation by banks and is a tool for PBC’s monetary control.
developing an indirect transmission mechanism, using monetary policy instruments to influence operation target, and, in turn, to influence the intermediate target and eventually to achieve the final goal – price stability and economic growth (Yi, 2006).

Currently, compared with developed countries and mature market economies, China’s monetary policy has its own distinct features (Zhou, 2006). First, although the essential function of the central bank is to keep the value of its currency stable and maintain low inflation, the PBC has multiple objectives because it monitors inflation and keeps an eye on economic growth, the balance of payments and employment. In particular, it needs to promote financial reform. Secondly, the monetary aggregate remains an important component in the monetary policy, but the money supply indicator cannot be used in a rigid or dogmatic way to evaluate or measure their impacts on the overall economy and inflation. A combination of quantity and the price instrument are employed, including open market operations, required reserves, interest rates and the exchange rate. Thirdly, pressure for financial reform has a high priority. When financial institutions are in distress, stability of the currency becomes impossible. If the transmission mechanism is not smooth, it is difficult to implement monetary policies effectively that are theoretically appealing. Lastly, in promoting financial reform, PBC operates under the leadership of the State Council, and coordinates and cooperates with other government agencies. This outweighs the importance of a central bank’s monetary policy independence.

1.5 Monetary Targeting Regime and Its Problems in China

The currently adopted monetary targeting regime in China has long been under debate. The theoretical foundation that supports the monetary targeting regime is the stability of money demand function. An effective monetary targeting framework requires a stable relationship between the monetary aggregate and output and price level. Otherwise, its value for predicting future money demand and for policy purposes is limited (Handa, 2009). Tobin (1958, 1969), Bruner (1968) and Friedman (1970) strongly held the view of stability of money demand function, but their viewpoints did not accord with the Keynesian view. Much of that debate rests on the dispute over the speculative demand for money.
Friedman et al. (1970) who supported the viewpoint of stable money demand function, accepting the central idea of the Quantity Theory of Money. The simplified model based on the equation of exchange and assuming a constant transaction velocity of income provides important policy messages that change in an exogenous money supply produces proportional changes in the general level of prices and that money is neutral in relation to real income. The quantity of money that people wishes to hold ($M$) is a stable fraction of total spending ($Py$). Velocity changes only slowly and thus the effect of changes in $P$ would be predictable changes in $Py$. This means the existence of a stable demand for money function. However, this was not true for Keynes who, in 1936, proposed a radically different theory of the demand for money based upon the motives for holding money: transaction demand, precautionary demand, speculative demand. The introduction of a speculative demand for money gives interest rates a much more important role and raises the possibility that the demand for money function might be unstable. According to Keynes, with an unchanged money supply, the demand for idle balance would increase and the income velocity of money would fall, causing a fall in nominal income. If individual-held views of normal interest rates were at all volatile, the speculative demand for money curve would be unstable (Bain and Howells, 2009).

Hall and Papell (2005, pp. 385) presented the source of the instability of money demand function from another angle. They argued that the reserve ratio and the currency ratio were assumed fixed, so a central bank controlled the money supply as accurately as it wanted by controlling the monetary base. In practice, the reserve ratio and currency ratio are not constant, which makes the money supply difficult to control in the short run.

According to Mishkin (2006), three related ideas, in the mid-1970s, are that expansionary monetary policy cannot produce higher output in the long run, that inflation is costly, and the advantages of a strong nominal anchor, all combined to help generate support for the ideas espoused by the monetarists that central banks needed to control the growth rate of monetary aggregates. Successful monetary aggregate targeting depends on one key assumption: there must be a strong and reliable relationship between the goal variable and the targeted aggregate. If there are large swings in velocity, so that the relationship between the monetary aggregate and
the goal variable is weak, then monetary aggregate targeting will not work. The weak relationship implies that hitting the target will not produce the desired outcome on the goal variable(s), thus the monetary aggregate will no longer provide an adequate signal about the central bank’s policy stance. The breakdown of the relationship between monetary aggregates and goal variables, such as inflation and nominal income, occurs frequently.

In practice, the monetary targeting regime was adopted by Britain, the USA and Canada for only a short period, starting in mid 1970s and fading in early 1980s when money demand became significantly more difficult to predict due to financial innovation (Goodhart, 1989; Friedman and Kuttner, 1996; Gomme, 1998). Only the Bundesbank and the Swiss National Bank continued to formulate policy in terms of money growth rates, and money formed one of the pillars in the two-pillar strategy of the European Central Bank (Laubach and Posen, 1997; Beck and Wieland, 2007A, 2007B; Lucas, 2007). Currently, many central banks have shifted to using inflation itself as an intermediate target (Bernanke et al, 1999; Bernanke and Woodford, 2005).

Many studies have examined China’s monetary policy transmission mechanism in recent years, focusing on the effectiveness of intermediate targets under the monetary targeting regime that started in 1994. For example, Xia and Liao (2001), Yu (2001), Xie (2004), and Geiger (2006, 2008) argued that monetary aggregates (M1 and M2) are no longer suitable as intermediate targets because the estimated demand for money function is not stable. Thus, whether China’s central bank could, like many industrial and emerging countries, switch to the short-term interest rate as its operating objective has attracted attention but is still being debated. In light of monetary theory, the precondition for adopting the short-term interest rate as an operating objective is the existence of an effective interest rate transmission mechanism in which a specific monetary framework and the operating objectives closely correlate to the final policy goal. However, whether short-run interest rates are highly correlated with China’s monetary policy goals – price stability and economic growth – remains ambiguous.

Xie and Luo (2002) examined for the first time the relationship between short-term interest rates and inflation and real GDP in a Taylor rule framework, using the
interbank money market 7-days interest rate between 1992:Q1 and 2001:Q4 as the proxy for the policy operating objective. Their analysis showed that the rule produced value of the interest rate and the actual interest rate were very close and, when the difference between the two values got larger, the operation of the money policy lagged behind the economy development. However, the estimation of the response function showed that the short-term interest rate accommodates the inflation rate. Therefore, the short-term interest rate is not suitable as an operating objective for PBC.

Xie and Yuan (2003) presented three characteristics of the institutional background of China’s interest rate policy. The first is the interest rate control where the games among enterprises, state-owned commercial banks, fiscal departments and PBC determine the interest rate level. The fixed deposit and loan interest rates only reflect the PBC’s expectation of future changes in the general price level but this expectation did not reflect the risk premium, depositors’, borrowers’ and enterprises’ expectation of the future general price level, hence limited the efficacy of the interest rate policy. The second characteristic is that the interest rate structure is not reasonable for two reasons. One is the zero or even negative difference between the loan and deposit interest rates. Another is that the interest rate on required reserves is higher than or equal to the one-year official deposit interest rate and, sometimes, the interest rate on PBC’s one-year loan (reloan rate) to commercial banks is higher or equal to the one-year interest rate on commercial banks’ loans to individuals (firms and personal loans) (see Table 1.1).

The third is the frequent negative real interest rate (nominal interest rate minus inflation rate) as reported in Table 1.2. According to Xie and Yuan’s (2003) research, the correlation coefficient was -0.976620 between the real one-year deposit interest rate and the retail price index. This indicates that adjustments in interest rates accommodate the inflation rate.

Based on the response function, Xie and Yuan drew their conclusions: (1) the effect of changes in the interest rate on the inflation rate are far from the effects of changes in the inflation rate on the interest rate; (2) it is certain that increases in the interest rate could curb rises in inflation rate; and (3) the nominal interest rate has little ability to forecast output.
Table 1.1 Interest Rates on Required Reserve and Commercial Bank One-Year Deposit Rate and One-Year Loan Rate

<table>
<thead>
<tr>
<th>Period</th>
<th>IR</th>
<th>ID</th>
<th>Difference(IR-ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/05/1993-30/06/1993</td>
<td>7.56</td>
<td>7.56</td>
<td>0</td>
</tr>
<tr>
<td>23/08/1996-22/10/1997</td>
<td>8.28</td>
<td>7.47</td>
<td>0.81</td>
</tr>
<tr>
<td>23/10/1997-24/03/1998</td>
<td>7.56</td>
<td>5.67</td>
<td>1.89</td>
</tr>
<tr>
<td>25/03/1998-30/06/1998</td>
<td>5.22</td>
<td>5.22</td>
<td>0</td>
</tr>
</tbody>
</table>

Interest rates on PBC’s one-year loans to commercial banks (IRL) and commercial bank one-year loans to individuals (IC)

<table>
<thead>
<tr>
<th>Period</th>
<th>IRL</th>
<th>IC</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/05/1996-22/08/1996</td>
<td>10.98</td>
<td>10.98</td>
<td>0</td>
</tr>
<tr>
<td>23/08/1996-22/10/1997</td>
<td>10.62</td>
<td>10.08</td>
<td>0.54</td>
</tr>
<tr>
<td>23/10/1007-24/03/1998</td>
<td>9.36</td>
<td>8.64</td>
<td>0.72</td>
</tr>
<tr>
<td>25/03/1998-30/06/1998</td>
<td>7.92</td>
<td>7.92</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Xie and Yuan (2003)

Table 1.2 Negative Real Interest Rate Periods

<table>
<thead>
<tr>
<th>Periods</th>
<th>Band of negative interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/1986 - 02/1986</td>
<td>-10% ~ 0</td>
</tr>
<tr>
<td>05/1987 – 06/1988</td>
<td>-10% ~ 0</td>
</tr>
<tr>
<td>07/1988 – 06/1989</td>
<td>&lt;=-10%</td>
</tr>
<tr>
<td>07/1989 – 09/1989</td>
<td>-10% ~ 0</td>
</tr>
<tr>
<td>01/1993 – 06/1994</td>
<td>-10% ~ 0</td>
</tr>
<tr>
<td>07/1994 – 01/1995</td>
<td>&lt;=-10%</td>
</tr>
<tr>
<td>02/1995 – 09/1995</td>
<td>-10% ~ 0</td>
</tr>
</tbody>
</table>

Source: Xie and Yuan (2003)

Recent research on China’s interest rate policy showed that the interest rate has already played a role in monetary policy transmission in China. According to Song (2008), changes in the real interest rate have a strong effect on the wealth distribution; reducing the real interest rate will lead to an increase in consumption expenditure. Yi (2009) examined the relationship between the real interest rate and real GDP. The
author found that the one-year deposit real interest rate had a negative relationship with real GDP. After 1993, due to the reform in enterprises’ and financial institutions’ ownership and the relaxation in price control, the effectiveness of the interest rate policy has increased dramatically. The correlation coefficient between the real one-year deposit interest rate and real GDP was -0.75 during 1993-2007, but -0.29 during 1978-2007. In light of China’s interest rate adjustments between 1978 and 2007, Yi (2009) stated that the business cycle in China, to a large extent, coincided with real interest rate fluctuations.

1.6 Role of Credit in China’s Monetary Policy Transmission

Another variable that has always played an important role in China’s monetary policy is credit, even before the inception of the credit policy in 1986. Under the “credit growth quota system”, two types of credit rationing coexist in China: (1) potential borrowers are not able to obtain a loan irrespective of the interest rate they are willing to pay; (2) a loan of a given amount is offered at a specified interest rate with no possibility of obtaining a higher loan at a higher interest rate. This implies that those money markets are in disequilibrium with the demand for loans being greater than the supply from the financial institutions.

Although the PBC abandoned the “credit growth quota system” in 1998, it still closely monitors the changes in credit aggregate in deciding on and implementing monetary policy and, over the past 10 years, published monthly data on the credit of financial institutions. When the money aggregate as an intermediate target was under question, Sheng and Wu (2008) proposed the adoption of the two-target money-and-credit framework put forward by Friedman (1981). In this framework, Friedman suggested using the credit aggregate as another intermediate target to complement the monetary aggregate as the intermediate target. Though this framework has never been publicly announced by any central bank, it cannot be denied that most central banks around the world pay attention to the role of credit in monetary policy making and implementation.

Because of the important role played in Keynesian models by the level of credit, Keynesian economists have often argued that money policy may operate not only
through interest rate changes but also through changes in credit availability. In theory, Bernanke (1993) defined the “broad credit creation process”. This process includes most of the value-added of the financial industry, including the information-gathering, screening, and monitoring activities required to make sound loans or investments. In addition, it includes much of the risk-sharing, maturity transformation, and liquidity provision services that attract savers and thus support basic lending and investment actions. This process also includes activities undertaken by potential borrowers to transmit information about themselves to lenders. The presumption of traditional macroeconomic analysis (typical IS-LM model) is that the credit creation process, through which funds are transferred from ultimate savers to borrowers, works reasonably well and therefore can usually be ignored. Bernanke and Blinder’s (1988) research on the correlations among credit, money and aggregate demand provided a theoretical analysis framework (IS-LM-CC) for the role of credit in monetary policy transmission mechanism. Since then, much research on the role of the credit channel in the monetary transmission mechanism concerning different countries has been conducted. However, in current dominant New Keynesian model, money and credit have essentially no constructive role to play in monetary policy (Woodford, 1998).

Christiano et al. (2008)) described two examples that illustrate differently how money and credit may be useful in conducting monetary policy. The authors’ first example showed that monitoring money and credit can help anchor private sector expectations about inflation. The second example showed that monetary policy that focused too narrowly on inflation may inadvertently contribute to welfare-reducing boom-bust cycles in real and financial variables and, in this example, the authors showed that a policy of monetary tightening when credit growth is strong can attenuate this unintended effect of too-narrow inflation stabilization. Christiano et al. concluded that, as the models used for monetary policy analysis become realistic, money and credit will play a direct role in monetary policy.

The eruption of the financial crisis in the summer of 2007 refocused attention on the channel of monetary policy that works through the supply of credit and overall capital market conditions (Adrian and Shin, 2009). In the light of the Adrian and Shin study, central banks liquidity facilities that attempted to counter the shrinking of intermediary balance sheets have become a key plank of policy, especially after short-
term interest rates were pushed close to their zero lower bound. In the U.S., the Federal Reserve has put into place various lender-of-last resort programmes in order to cushion the strains on balance sheets and thereby target the unusually wide spreads in a variety of credit markets. While classic monetary policy targets a price (e.g., the federal funds rate), the liquidity facilities affect balance-sheet quantities. The balance-sheet expansion of the Federal Reserve has refocused the monetary policy debate on the role of quantities in the monetary policy transmission mechanism.

Compared with developed countries, credit/bank loans play a more important role in China. Handa (2009) classified the monetary transmission mechanisms into two categories: the direct transmission channel and the indirect transmission channel. In the direct transmission channel, increases in the money supply cause undesired money balances that are then directly spent on commodities. The mode of transmission of money supply increases, through interest rates and investment, to national expenditure and income increases are known as the indirect transmission channel. According to Handa (2009), in less-developed economies, a large informal financial sector and large, legally unaccounted funds enhance the significance of the lending and direct transmission channels, and reduce the significance of the indirect channel based on market interest rates.

As we will discuss in Chapter 2, the financial sector in China has made much progress in past two decades but an effective yield curve has not been developed (Wu, 2008A). Under this circumstance, to examine the credit channel of monetary transmission mechanism appears to be more important than in developed countries. Research on the credit channel in China’s monetary policy transmission has been conducted in recent years (see Wang and Wang, 2000; Jiang, Liu and Zhao, 2005). However, several important questions remain in the current literature.

1.7 Following a Monetary Policy Rule: Commitment and Credibility

The current consensus regarding monetary policy ultimate objectives is low inflation and stable growth of real output at full employment. However, the question about how a central bank fulfils its long-run monetary policy objectives, whether following a policy rule or with discretion has been debatable since Simons’ seminal paper in 1936.
In light of Woodford’s (2003) study, the rule about monetary policy could date back to Wicksell’s (1898) work. Wicksell’s original statement of the proposed rule was as follows: *so long as prices remain unaltered, the banks’ rate of interest remains unaltered. If prices rise, the rate of interest is to be raised; and if prices fall, the rate of interest is to be lowered; and the rate of interest is henceforth to be maintained at its new level until a further movement of prices calls for a further change in one direction or the other* (Wicksell, 1898, p.189). Later, after studying the severe monetary mistakes of the Great Depression, Friedman (1959) proposed his constant growth rate rule with the aim of avoiding a repeat of those mistakes. Friedman’s rule requires the central bank to set the rate of growth of money supply equal to the rate of growth of real income plus the desired rate of inflation. The typical modern-day simple policy rules include the Taylor Rule (1993) and McCallum Rule (1987). According to the Taylor Rule, central bank’s operating target interest rate is set as a linear function of the current inflation rate and the current gap between real output and potential output. The McCallum Rule argues that a central bank would adjust the monetary base growth rate each month or quarter, increasing the rate if the nominal GDP is below its target path and vice versa.

The literature in contemporary macroeconomics provides good reasons why monetary policy should be evaluated and conducted as a policy rule rather than as a one-time change in policy. First, the literature on time-inconsistency shows that without a commitment to a rule, policymakers will be tempted to choose a suboptimal inflation policy that will result in a higher average inflation rate and no lower unemployment than if a rule is followed in choosing a policy (see Kydland and Prescott 1977; Barro and Gordon 1983, Woodford, 2003). Second, the credibility of the monetary policy appears to improve its performance; the effectiveness of the monetary policy depends on the public’s expectations about a future policy as much as on the bank’s actual actions, sticking to a policy rule increases the credibility about future policy action. The policy rules help market participants forecast future policy decisions and therefore reduce uncertainty. Policy rules increase accountability and potentially require policymakers to account for the difference between their actions and the rules (Taylor, 1998, Woodford, 2003).
The McCallum Rule is currently much less prominent than Taylor’s Rule, primarily because central banks in industrial countries focus on the interest rate instead of the monetary base growth rate in designing their policy (McCallum, 2002A). The new Keynesian Taylor Rule reveals that a central bank follows an inflation target with short-term interest rate as its policy instrument, it ignores monetary aggregate (Cochrane, 2007). The McCallum Rule is a nominal income target rule with the monetary base as its policy instrument. A major advantage of the McCallum Rule over Taylor Rule is that it does not include unobservable variables such as the real interest rate and the output gap.

Taylor does not deny that a monetary base or some other monetary aggregate can be a reasonable monetary instrument in emerging economies. In Taylor’s early research (Taylor, 1979A) on policy rules, he used the money supply as the instrument but, since 1980s, he has found the interest rate to be a more practical instrument in policy rules for the U.S. and other G-7 countries. The reason he chose the interest rate as the policy instrument is that the countries he examined used the interest rate as their policy instrument. As Taylor (2000A) said “it is important to point out – especially in a discussion of emerging market economies – that the instrument in a policy rule could be the monetary base or some other monetary aggregate”. The choice of the policy instrument in a policy rule is essentially the same choice originally pointed out by Pool (1970). If there is too much uncertainty in measuring the real interest rate or if there are relatively big shocks to investment or net exports, then the monetary aggregate is the preferred instrument; the same is true if it is difficult to measure the equilibrium real interest rate. In contrast, if velocity shocks are big then the interest rate is the better instrument. Clearly, in emerging markets where the over-night nominal interest rate is not a very good guide, policy makers might want to give greater consideration to policy rules with monetary aggregates (Taylor, 2000A). Beck and Weiland (2008) also supported the importance of a monetary base variable in policy-making. With regard to the feasibility of adopting monetary policy rules in emerging economies, Meltzer (1995) and Taylor (2000A) stated that policy rules are applicable to countries both with and without developed financial markets.

One reason why monetary policy rules are useful for designing a monetary policy is that the expectations of future changes in the policy instruments affect financial
markets and thus the rest of economy. Expectations of future short-term interest rates can affect long-term interest rates immediately through the term structure of the interest rate. The rule itself affects these expectations. For this reason, a monetary policy rule is more important than any single change in the monetary policy instrument. As for how policy makers in emerging markets without highly liquid longer maturity markets take advantage of the merit of the policy rule, Taylor (2000A) stated that the term structure is not the only place in the economy where expectations of the future matter. Even in situations where financial markets are not fully developed and there are few long-term securities, expectations of the future can affect movements in the exchange rate, the price of land, even wages. It is easier for the private sector to form expectations if the central bank is clear in its intentions through some kind of policy rule. According to Meltzer (1995), monetarists typically favour rules for monetary policy to reduce the costs of acquiring information. Monetary impulse have transitional effects on output and lasting effects on price even where commercial paper, long-term bonds and Treasury bills do not exist. One effect of a sustained increase in money growth is on the prices of durable assets. Land is the most durable asset, so monetarist analysis implies that land prices rise in anticipation of inflation. The public can purchase land most readily by buying houses, so the price of new and existing houses anticipates future inflation and disinflation.

Money supply is still a dominant policy instrument under the monetary targeting regime in China; the McCallum Rule appears to be an appropriate choice for China’s central bank. The possibility of following the McCallum Rule for China has been examined, but there are some problems with that research: the research method and misunderstanding of the McCallum Rule itself. These shortcomings will be discussed in Chapter 2.

1.8 Research Objectives

The general objective of this research is to identify the monetary transmission mechanism in China starting from the mid-1990s. We chose the mid-1990s as the starting point, because, under the planned economy, even after the establishment of the PBC in 1984, there was actually no monetary policy in China. Before the Law on the People’s Bank of China was promulgated in 1995, monetary and fiscal policies
were not clearly delineated. In the move from having no monetary policy to formulating and implementing such a policy, China carefully studied the theory and practice of monetary policy of developed economies. The PBC has been a learner in monetary policy decision making and conduct (Zhou, 2006). Specifically, we identify our research objectives as follows:

Objective 1:
Most of industrial economies and emerging markets choose the short-term interest rate as their policy operating objective. Whether China could switch to the short-term interest rate as its policy operating objective is worth examining after the interest rate system reform has made great progress in China. The precondition of taking short-term interest rate as a policy instrument is that changes in short-term interest rates have significant impacts on the goal variables – price level, real output. In this research, using a standard VAR and based on the results of the impulse response function and variance decomposition, we examine the impacts of changes in typical short-term interest rates on general price level, real output and a financial variable – exchange rate. We can then identify the possibility of an effective interest rate channel.

Objective 2:
In the past 30 years, bank credits/loans have played a more important role in China than in the developed countries due to a relatively undeveloped capital market and will continue to be an important policy indicator for the PBC. Nevertheless, existing research has not clearly identified whether the PBC could effectively implement its monetary policies via controlling commercial banks’ loan ability. This research will use modern econometric techniques to distinguish the loan demand and loan supply forces, to provide policy makers with a clear picture of the role of the bank lending channel in policy transmission.

Objective 3:
A central bank policy rule could provide a clear and transparent guide to the conduct of monetary policy. The last 30 years have seen extensive research on simple instruments rules in different economies (see, for example, Clarida, Gali and Gertler, 1998; McCallum, 1999; Taylor 1999A, Taylor and Williams, 2010). Considering that money supply is still a policy instrument in China, we evaluate the possibility of
adopting the McCallum Rule as a policy guide for the PBC, in order to improve the PBC policy effectiveness.

The thesis is organized as follows. In Chapter 2, we review the stylized facts of China’s monetary policy instruments, intermediate targets and policy objectives since the 1990s, and look at the impacts of advances in financial markets, the development of financial institutions and the reform in exchange rate regime on China’s monetary policy transmission mechanism. We then review the research on the credit channel, especially the bank-lending channel, in monetary policy transmission mechanism and the remaining problems in the research on the role of credit in monetary policy transmission in China. Finally, we review the principles of the McCallum Rule and some empirical studies of it in different countries. These reviews provide us with a good base for studying the role of short-term interest rates, credit and monetary policy in China’s monetary policy transmission.

Chapter 3 focuses on the integration properties of our data. We separately discuss in detail the selection of variables for research on the different monetary policy transmission channels and test the order of integration of our time series variables using both the Augmented Dickey-Fuller (Dickey and Fuller, 1981) test and the Dickey-Fuller test with GLS detrending (Elliott et al. 1996).

In Chapter 4, we discuss three different research methodologies – standard VAR (Sims, 1980A); Johansen Cointegration Procedure (Johansen 1991, 1995); and the Counterfactual Simulation method. The VAR method is appropriate for testing the shock of short-term interest rates on real macroeconomic variables. The Johansen Cointegration Procedure test and the identifying restrictions of linear equations technique will be used to disentangle the forces between bank credit demand and bank credit supply. The Counterfactual Simulation method will be used to evaluate the effectiveness of adopting McCallum Rule as a monetary policy guideline in China.

Chapter 5 reports the empirical results. In section 5.2, we show that the impact of changes in the short-term interest rate on price levels, real GDP and exchange rate by reporting results of the Granger causality test, impulse response function and the
variance decomposition. Sections 5.3 and 5.4 report the empirical results of the bank lending channel and the simulation results of the McCallum Rule and nominal GDP.

Chapter 6 summarizes the main findings of this study and their policy implications and presents the conclusions and the limitations of the study.
CHAPTER 2
AN OVERVIEW OF CHINA’S MONETARY POLICY TRANSMISSION MECHANISM

2.1 Introduction

This chapter provides a critical literature review of the three aspects of China’s monetary policy transmission mechanism. Section 2.2 reviews China’s monetary policy instruments, intermediate target and goals. Section 2.3 reviews research on the credit channel; with the review of McCallum Rule in Section 2.4.

2.2 China’s Monetary Policy Instruments, Intermediate Target, Goals and the Stylized Fact

The People’s Bank of China (PBC) states that the aim of its monetary policies is to maintain stability in the value of the currency and thereby promote economic growth. Therefore, the PBC is committed to two objectives: price stability and economic growth. The PBC claims to pursue currency stability as the sole target of its monetary policy but it is impossible to ignore the goal of economic growth given its decision process is not independent of the state council’s directives.

Since exchange rate unification in 1994, China has maintained a managed floating exchange rate regime, a de facto peg of the renminbi (RMB) to the U.S. dollar (USD), with different floating bandwidths during different periods. A crawling peg regime from 1994 to 1996 followed a de facto peg of the RMB against the USD with a trading band of 0.4% (about RMB/USD 8.28). The trading band tightened to 0.01% around the parity of RMB/USD 8.277. Following an immediate appreciation of the RMB against the USD of around 2% on July 21, 2005, China’s exchange rate regime switched to pegging to a basket of currencies with a fluctuation bandwidth of up to 0.3% of the previous day’s exchange rate (Anderson, 2005). On May 21, 2006, the daily floating band of the RMB against the USD trading price expanded to 0.5% (People’s Bank of China, 2007). However, the RMB was pegged again more or less to a fixed rate against the U.S. dollar in July 2008 (McNally, 2010). Based on this account, one can conclude that another objective of China’s monetary policy is to maintain the stability of exchange rate vis-a-vis the USD.
Concerns about the risks of financial sector reform have led to a gradual interest rates’ liberalization that took place relatively late in the economic reform. The liberalization of the interest rates was announced on November 1993 at the Third Plenum of the Fourteenth Communist Party Central Committee (CPCC). The Party recognized that the central bank should promptly adjust the benchmark interest rates according to changes in market supply and demand. This allowed commercial banks to set their loan and deposit rates within a specific range. In 2002, the Sixteenth National Congress reiterated the need to advance interest rate reforms and optimize financial resource allocation. Furthermore, the Third Plenary Session of the Sixteenth Central Committee in 2003 argued the need to establish a robust mechanism for market-based interest rates and monetary policy actions consistent with the country’s economic objectives (Bernard and Maino, 2007).

During 1986-1993, China’s monetary policy targeted currency in circulation and banks’ loan portfolios. In September 1994, the PBC defined and announced three levels of money supply indicators: M0, M1, and M2. In 1996, the PBC formally treated money supply as an intermediate target. The elimination of credit ceilings in 1998 left M2 (money supply) as the single major intermediate target. The theoretical assumptions underlying China’s monetary policy are that the objectives such as the GDP growth rate and the inflation rate correlate with the intermediate targets (money supply) that are firmly connected to the monetary base. Furthermore, the money multiplier is assumed to be stable, and the central bank can influence intermediate targets by adjusting policy instruments.

Several researchers have devised classification schemes to describe the mechanism central banks have at their disposal for controlling financial activity. For example, Bernard (2004) noted that monetary policy instruments fall into two broad categories: rules-based instruments and monetary market operations. The first category refers to the regulatory power of the central bank, which includes liquidity asset ratio, reserve requirements, and standing facility. The second category, market operations, is used at the discretion of the central bank. These include an interest rate linked to money market conditions and aims to influence the underlying demand and supply conditions.
of the central bank. This includes open market–type operations, auction techniques, and fine–tuning operations (Bernard, 2004).

Xie (2004) classified the PBC’s 13 monetary policy instruments used between 1983–2002 into four categories: (1) ratio instruments such as required reserve ratios; (2) interest rates, such as rediscount rates, central bank interest rates on reserve requirements, central bank lending rates, deposits and lending interest rates of financial institutions; (3) quantity instruments, such as central bank lending, open market operations (on treasury bonds and foreign exchange) and rediscounting; and (4) other instruments, such as central bank bills, central bank bonds, special deposits to the central bank, standing facilities and moral suasion.

Geiger’s (2006, 2008) classification of the PBC’s monetary policy instruments is different from Xie’s classification. Ginger identified two main categories of the PBC’s instruments; price-based and quantity-based. Price-based instruments are indirect and incorporate the PBC lending and deposit rates, discount and rediscount rates, reserve requirements and open market operations (OMOs). Quantity based instruments are direct and include window guidance, direct PBC lending and capital control.

Bernard and Maino (2007) summarized China’s main monetary policy instruments as standing facilities, OMOs, reserve requirements, interest rate control, window guidance, and other administrative measures. “The PBC has developed a set of monetary instruments which conform to best practices and place the PBC in a relatively strong position to rely primarily on market-based instruments in the conduct of money policy. Open market operations in the form of issuance of the PBC’s bills play an important role in the sterilization of excess liquidity and reserve requirements provide important support to OMOs” (Bernard and Maino, 2007, pp. 14).

Based on Bernard’s (2004) theoretical framework, we can conclude that the current choice of China’s monetary policy is a mix of rules-based instruments and money market operations. In 1993, the PBC introduced the OMO into its monetary policy toolbox. Following the abolition of the credit rationing policy in 1998, OMOs became
the PBC’s main monetary policy instrument. The PBC benchmark lending rates, -
rediscount rates, the interest rate on required reserves and excess reserves constitute
an upper and a lower limit in money market interest rates. The central bank bill rates
serve as a target rate in setting the money market interest rate, such as the federal fund
rate in the U.S. (Xie, 2004; Wu, 2008A). Automatic collateralized lending and the
excess reserves facility constitute China’s standing tools for monetary control.

Xie (2004) investigated the relationship between the monetary aggregate (M1, M2)
and the monetary base, from the first quarter of 1994 through to the fourth quarter of
2002. The results indicated that the impact of the monetary base on M1 is not strong,
and the impact of the monetary base on M2 is even weaker. Among the four different
liquidity injecting channels, namely, the PBC’s lending to financial institutions,
foreign exchange purchase by the monetary authority, OMOs on treasury bonds, and
the rediscount window, only the central bank lending Granger caused M1, and none
Granger caused M2. Therefore, monetary aggregates are endogenously determined
and have strong correlations with monetary policy.

Xie (2004) also explored the dynamic relationships between monetary aggregates,
economic growth and inflation rates using data from the first quarter of 1992 to the
third quarter of 2002. He argued that the money supply affects output and, in the
short run, money is not neutral. Nevertheless, the impacts of money supply on output
last no more than 11 quarters. Money is neutral in the long run and the impacts of
money supply on output are not permanent. In both the short and long run, money
supply and inflation correlate, where changes in the money supply have permanent
effects on the inflation rate and the price level. Geiger (2006, 2008) documented
severe deviations of the targeted and the actual values from 1994 to 2006.

Table 2.1 compares the targeted with the actual values of China’s monetary
aggregates, M1 and M2, from 1994 to 2006. The targeted and the actual values
decreased only three times for M1, and four times for M2. Strong deviations of about
4% occurred several times for both M1 and M2 raising doubts about the
controllability of the monetary aggregates.
Table 2.1: Targeted and Actual Values of PBC Monetary Aggregates

<table>
<thead>
<tr>
<th>Year</th>
<th>M1 growth (per cent)</th>
<th>M2 growth (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>1994</td>
<td>21</td>
<td>26.2</td>
</tr>
<tr>
<td>1995</td>
<td>21-23</td>
<td>16.8</td>
</tr>
<tr>
<td>1996</td>
<td>18</td>
<td>18.9</td>
</tr>
<tr>
<td>1997</td>
<td>18</td>
<td>16.5</td>
</tr>
<tr>
<td>1998</td>
<td>17</td>
<td>11.9</td>
</tr>
<tr>
<td>1999</td>
<td>14</td>
<td>17.7</td>
</tr>
<tr>
<td>2001</td>
<td>13-14</td>
<td>12.7</td>
</tr>
<tr>
<td>2002</td>
<td>13</td>
<td>16.8</td>
</tr>
<tr>
<td>2003</td>
<td>16</td>
<td>18.7</td>
</tr>
<tr>
<td>2004</td>
<td>17</td>
<td>13.6</td>
</tr>
<tr>
<td>2005</td>
<td>15</td>
<td>11.8</td>
</tr>
<tr>
<td>2006</td>
<td>14</td>
<td>17.5</td>
</tr>
</tbody>
</table>

This table compares the targeted and the actual values of the China’s monetary aggregates of the M1 and M2 from 1994 to 2006 (Geiger, 2008).

The systematic liberalization of interest rates involved the lifting of the restrictions on wholesale transactions followed by liberalization of the retail transactions. Interest rates on foreign currency deposits and lending were eliminated for local currency (Bernard and Maino, 2007). The reform of market interest rates progressed steadily from 1996. By the end of 1999, the interbank borrowing rates, discount rates for commercial paper, and repos and spot trading rates in the interbank bond market were fully liberalized. The purchasers’ bids determined the interest rates on policy financial bonds and treasury bonds (Xie, 2004). The PBC also adjusted the refinancing rate to a reference rate for the money market.

Reform of retail banking operations involved first allowing banks to price counterpart risks of customers within a floating margin before fully liberalizing the lending and deposit rates (Mehan, Quintyn, Nordman, and Laurens, 1996). The authorities reduced the number of administered interest rates, adjusted bank lending rates on industrial and commercial enterprises more frequently to reflect changes in the PBC benchmark rate, and allowed financial institutions to price their lending operations within a floating margin. The discretionary bands on lending rates expanded in 1998 (Xie, 2004). In October 2004, the PBC removed the ceilings on lending rates and the floors on deposit rates. A floor for lending rates and a ceiling for deposit rates
protected the banks’ intermediation margins. From 1996 to 2007, the PBC removed about 120 administered interest rates (Wu, 2008A).

Both the depth and breadth of the money markets in China have improved significantly over the past decade. Currently, China’s money market comprises three sub-markets. The first sub-market is the interbank money market. Originating in the 1980s and modified in 1993, a reformed and unified national interbank market began operation in January 1996. Banks lent and borrowed funds among themselves for terms from overnight to four months. The amount of lending and borrowing is fixed in proportion to the balance of their deposits. In contrast, non-bank financial institutions lent and borrowed funds among themselves for a maximum of seven days and the trading volumes depend on the capital level. The seven-day loan rate is China’s interbank offered rate (CHIBOR) (Xie, 2002).

By the end of 2007, the number of market participants reached 717, fourteen times greater than when the markets began operation. As of November 28, the trading volume reached RMB13700 billion. The interbank market rules and regulations were enforced in August 2007. Green (2007a, 2007b) argued that the introduction of more market driven reference rates such as the Shanghai interbank offered rate (SHIBOR) for the onshore money market was a critical step in terms of improving China’s money market.

The second sub-market is the interbank bond market, which functions as a liquidity market. The China interbank bond market began operating in June 1997. By the end of 2007, there were 7095 participants (The People’s Bank of China Annual Report, 2007). Both the turnover and the liquidity of the interbank bond market have expanded significantly, with total turnover exceeding RMB100000 billion in 2008. The tradable stocks increased from RMB72.3 billion in 1997 to RMB9024 billion by June 2008 (China Monetary Policy Report, 2008). It is currently the biggest bond market in China.

China’s interbank bond market currently has had three characteristics added since its initial development. First, the trading participants in the interbank bond market have been diversified by allowing non-banking financial institutions (such as funds
companies, securities companies and insurance companies) and other enterprises to trade in this market. Second, with Treasury bonds and PBC bills as the main trading products, the debts issued by policy banks and commercial banks, and commercial paper issued by the finance companies and other big corporations have increased significantly. Issuers of bonds in this market include the Ministry of Finance, the central bank, policy banks, commercial banks, non-banking financial institutions, and corporations. The central bank uses the term structure of bond yields and long-term interbank rates as reference rates to predict inflation trends. This also serves as an important basis for pricing other financial products in the market in China.

Finally, the bond repo market, the third sub-market of the money market, is used for short-term borrowing. The turnover reached RMB51580 billion by the end of November 2008. Since 1997, the repo rate has been set by the market, with the most active contracts between one and seven days. The seven-day repo rate, in effect, became the bond market benchmark rate and it became the official reference indicator for the money market from October 12, 2004. Because commercial banks, securities companies and other financial institutions trade in this market, frequent changes in the repo rate reflect changes in the stock and money loan markets (ChinaNet). This market is less volatile and liquid than the CHIBOR and its successor SHIBOR. Compared with the interbank markets, repo markets are more active and the interest rates are more stable (Xie, 2002; Loretan and Wooldridge, 2008).

The segmentation of the money markets is the result of regulations because the initial operations of the money markets led to disorder in the financial industry in the early 1990s. Instead of using it as a means to manage reserves by commercial banks, it was abused by both financial and other nonfinancial institutions to obtain short-term funds to invest in securities and real estate (Xie, 2002; Bernard and Maino, 2007). In order to prevent bank funds being used to participate in the stock market, the PBC barred commercial banks from repo trading on the stock exchange. Beginning in 1997, commercial banks were allowed to carry out repo trading only on the interbank market, with the goal of building a firewall between the money and capital markets (Xie, 2002; Bernard and Maino, 2007). Short-term borrowing by securities companies in the interbank market led to contagion because changing conditions in the capital market had a direct impact on interbank markets. From 2000, securities companies,
funds management companies and other non-banking financial institutions were permitted to trade into the interbank markets under certain conditions. However, the coexistence of the interbank bond market and the stock exchange bond market, and the limits on RMB interbank market activity for commercial banks funded in foreign currencies remained the source of market segmentation (Wu, 2005; Bernard and Maino, 2007).

In 1994, China adopted a managed floating exchange rate regime against the USD, coupled with a move to partial convertibility on the current account (Zhang, 2001). Further, in December 1996, China adopted current account convertibility but maintained administrative controls on the capital account (Xie, 2004). Following the 1997 Asian financial crisis, China implemented a fixed foreign exchange regime. This was in place until July 2005, when Chinese authorities announced a switch to a new exchange rate regime. The exchange rate was pegged to a basket of currencies with numerical weights unannounced (on 10 August, the PBC published the composition of the currency basket, which includes the U.S dollar, Euro, Japanese Yen, Korean Won as well as the currencies of other countries such as Singapore, UK, Malaysia, Russia, Australia, Thailand and Canada). This allowed movement within any given day to increase flexibility (Frankle, 2009). However, some researchers argued that China’s current foreign exchange policy was still “fixed” instead of “floating” (see McKinnon and Schnabl, 2006; Frankle and Wei, 2007; Prasad, 2007).

Previous studies argued that, for one country, unfettered movement of international capital, independent monetary policy and a fixed exchange rate policy cannot coexist. In theory, capital controls can prevent large inflows (outflows) when domestic interest rates are higher (lower) than foreign rates. This allows the PBC to operate an independent monetary policy. In practice, it is difficult to maintain effective capital controls over time, particularly in an economy like China’s that is not only open to international trade but trades across world extensively (Goldstein and Lardy, 2007; Wu, 2006). With a large current account surplus, the PBC faces the challenge of sterilizing the increase in the domestic money supply resulting from the large purchase of foreign exchange (i.e. the sale of domestic currency).
China’s balance of payments has remained strong since 1996 and its global current account surplus has expanded substantially over the years. The current account surplus was $7.24 billion in 1996, rising to $68.7 billion (3.6% of GDP) in 2004, $160.8 billion (7.2% of GDP) in 2005 and $371.8 billion in 2007 (11.3% of GDP) (National Bureau of Statistics, 2008; IMF Statistic Database, 2007; State Administration of Foreign Exchange). Since then, China’s account surplus (in absolute terms) has been the largest of any country.

The build-up of official holdings of foreign exchange reserves has accelerated since 2005. In the 12-months to June 2005 and June 2006, foreign exchange reserves rose by $240 billion and $230 billion, respectively (Goldstein and Lardy, 2008). In the 12 months to June 2007, foreign exchange reserves rose by $391 million, about three-fifths more than in the previous two 12-month periods. In the 12 months to June 2008, foreign exchange reserves rose by an astonishing $467 billion. At the end of September 2008, total foreign exchange reserves reached $1905.5 billion (People’s Bank of China, 2008) (see Table 2.2).

<table>
<thead>
<tr>
<th>Time</th>
<th>Volume (million in US$)</th>
<th>Ratio of GDP to FER (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>7.24</td>
<td>1.06</td>
</tr>
<tr>
<td>2004</td>
<td>68.7</td>
<td>3.6</td>
</tr>
<tr>
<td>2005</td>
<td>160.8</td>
<td>7.2</td>
</tr>
<tr>
<td>2008</td>
<td>371.8</td>
<td>11.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Increased Volume (million in US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/2004-06/2005</td>
<td>240</td>
</tr>
<tr>
<td>07/2005-06/2006</td>
<td>230</td>
</tr>
<tr>
<td>07/2006-06/2007</td>
<td>391</td>
</tr>
<tr>
<td>07/2007-06/2008</td>
<td>467</td>
</tr>
</tbody>
</table>


Since the unification of China’s exchange rate in 1994, except during the 1997 Asian financial crisis, the RMB has been under pressure to appreciate. To maintain stability in the RMB, the PBC adopted several comprehensive measures. These included improving the foreign exchange purchase-and-sale system via foreign exchange designed banks, changing interest rate policy and shifting to OMOs (Xie, 2004).
Following 2000, the appreciation pressure was fuelled by expanding capital inflows and foreign trade surpluses. Thus, the PBC had more pressure to intervene in the market.

Anderson (2004, 2005) and Green (2007a, 2007b) suggested that China can run an independent monetary policy under any foreign exchange regime and have little difficulty in retaining control of the growth of its domestic money supply. They argued that this can be absorbed with an effective capital control system and successful stabilization via the sale of central bank bills and an increase in the required reserve ratio for banks. In contrast, Goldstein and Lardy (2006), Lardy (2006), and Prasad, Rumbaugh & Wang (2005) argued that China’s (quasi) fixed exchange rate has weakened the effectiveness of its monetary policy. They believed that the resulting policy mix has left China with an interest rate structure that is far from optimum. Since a low real interest rate contributes to an underlying excess demand for credit and rapid growth of lending from banks, low deposit interest rates have been a major contributing factor to the boom in the property market.

2.3 Reviews on Credit Channel

2.3.1 Interest Rate Channel and Credit Channel Theory

There are two assets in the interest channel: money and bonds (which include government bills and bonds, commercial paper, corporate bonds, stocks, bank loans, consumer credit, etc.). Monetary non-neutrality arises if the movements in reserves affect real interest rates. In a monetary contraction, the central bank reduces reserves, limiting the banking system’s ability to sell deposits. Depositors must then hold more bonds and less money in their portfolios. If prices do not instantaneously adjust to changes in the money supply, the fall in household money holdings represents a decline in real money balances. To restore equilibrium, the real interest rate on bonds increases, increasing the user cost of capital for a range of planned investment activities and interest-sensitive spending falls. The effect of a change in the money supply on the short-term interest rate decreases over time as prices adjust to this change. However, real effects are possible in the short run. In an interest rate channel, supply and demand for money determine the short-term interest rate, which in turn affects investment and output. The financial condition of commercial banks and firms
plays no role in affecting investment or other types of spending (Bernanke 1993; Kashyap and Stein, 1994; Hubbard, 1995)

The balance sheet channel involves changes in the net worth of bank-dependent borrowers, which leads to an increase in their cost of raising external finances. The key mechanism involves the link between “external finance premium” (the difference between the cost of funds raised externally and the opportunity cost of funds internal to the firm) and the net worth of potential borrowers (defined as the borrowers’ liquid assets plus collateral value of illiquid assets less outstanding obligations). With the presence of credit market frictions and the total amount of financing required held constant, standard models of lending with asymmetric information imply that the external finance premium depends inversely on borrowers’ net worth. This inverse relationship arises because when borrowers have limited wealth to contribute to project financing, the potential divergence of interests between the borrower and the supplier of external funds is greater, implying an increase in agency cost; lenders must be compensated for higher agency costs by a larger premium to be in equilibrium. To the extent that borrowers’ net worth is pro-cyclical (for example, pro-cyclicality of profits and asset prices), the external finance premium will be countercyclical, enhancing the swings in borrowing and thus in investment, spending, and production (Bernanke et al., 1989, 1996, 1999).

The bank lending channel attached a specific role to the bank, unlike the balance sheet channel that is concerned about a borrower’s ability to meet payments. According to Anders (2003), the bank lending channel can be explained from two perspectives. One is the “deposit explanation”, which refers to the conventional bank lending channel, and the other is “capital-adequacy explanation”, which is called bank capital channel. Bernanke and Blinder (1988) and Stein (1998) presented the logic of the bank lending channel in light of the “deposit explanation”. Markovic (2006) and van den Heuvel (2007) presented the bank lending channel logic from the “capital-adequacy explanation” perspective.

Bernanke and Blinder (1988) modified the traditional IS-LM framework to accommodate the role of credit in a macro-economy. Their model yields a simple construction of a bank lending channel in the transmission of monetary policy. They
assume that banks hold three assets – reserves, loans, and short-term bonds – and issue one liability – bank deposits. Loans and bonds are imperfect substitutes, both as sources of finance to borrowers and as assets held in a bank portfolio. Therefore, the stock of bank credit depends on the spread between the bank and bond market rates of interest. In the Bernanke-Blinder model, a contraction of monetary policy results in simultaneous leftward shift in the LM and IS curves, because the bank loan rates increase in response to the monetary policy contraction thus reducing the supply of investible funds to the market. In this way, the impact of bank balance sheets amplifies the transmission of monetary policy. According to Bernanke and Blinder, the IS curve will be affected by disturbances to the supply or demand for bank credit (both of which will affect bank loan rates independently of market rates of interest) and a more symmetric treatment of money and credit is feasible and appears warranted.

Unlike Bernanke and Blinder who focused on the asset side of the bank’s balance sheet, Stein (1998) focused on the liability side of the bank’s balance sheet in an adverse-selection model of bank asset and liability management. In Stein’s model, the banks hold three assets – reserves, new loans and old assets (loans made previously and still in the banks’ books) – and three liabilities – insured deposits, previously raised non-deposit finance and incremental non-deposit finance. Because asymmetric information on the old loan value exists, adverse selection matters when the bank wants to raise non-deposit external finance. In Stein’s analysis, smaller banks with lower asset values face difficulties in raising non-deposit external finance during monetary contraction compared with the large banks with higher asset values. Large banks depend exclusively on insured deposits to finance their lending. The author concluded that banks are subject to adverse-selection problems that constrain their lending and insured deposits can help banks to circumvent such problems and allow them to lend more freely. With regard to monetary policy, Stein’s model showed that central banks can still influence both bonds rates and loan-bond spreads and thereby have a direct impact on both firms that finance themselves in the open market and those that borrow from the banks.

Monetary policy affects bank loans through two distinct channels (Stein, 1998). First, a cutback in reserves by the central bank forces banks to move away from insured
deposit financing toward adverse-selection-prone forms of non-deposit finance. This in turn leads to a decrease in aggregate bank lending and hence to an increase in the relative cost of bank loans. The second channel focuses solely on frictions at the bank level, completely ignoring the frictions at the household level. Even if money plays no special role for households, the central bank can still influence both bond rates and loan-bond spreads and thereby has a direct impact on both firms that finance themselves in the open market and those that rely on banks. Stein’s model can be viewed as providing micro foundations for the lending channel. The key distinction in Stein’s model is the difference between reservable and non-reservable bank liabilities. Lending is affected by reserve shocks only if all non-reservable bank liabilities are subject to the adverse selection problem.

Three necessary conditions must hold for the existence of the traditional lending channel of monetary policy transmission (Kashyap and Stein, 1994): (1) intermediate loans and open market bonds must not be a perfect substitute for some firms on the liability side of their balance sheet so these firms are unable to offset a decline in the supply of loans by borrowing directly from the household sector in the public markets; (2) by changing the quantity of reserves available to the banking system, the central bank must be able to affect the supply of intermediate loans. That is, the intermediate sectors must not be able to completely insulate their lending activities from shocks to reserves, either by switching from deposits to less reserve-intensive forms of finance or by reducing their net holding of bonds; and (3) there must be some form of imperfect price adjustment that prevents any monetary policy shock from being neutral. If either of the first two conditions does not hold, bonds and loans effectively become perfect substitutes, and then the bank lending view reduces to the pure money view.

Van den Heuvel (2007) developed a dynamic model of bank asset and liability management that incorporates risk-based capital requirement and an imperfect market. In van den Heuvel’s model, bank lending depends on the bank’s financial structure as well as the lending opportunities and market interest rates. Van den Heuvel focused on bank capital equity not on any particular role of bank reserves. This mechanism seems to fall outside the conventional bank lending channel. However, the impact of monetary policy shocks on the macroeconomy is still effective even though the supply
of bank loans is constrained. According to the van den Heuvel (2007) analysis, monetary policy effects on bank lending depend on the capital adequacy of the banking sector; lending by banks with low capital has a delayed amplified reaction to monetary policy shocks, relative to well-capitalized banks. In addition, van den Heuvel stated that bank capital affects lending even when the regulatory constraint is not binding and that shocks to bank profits, such as loans defaults, can have a persistent impact on lending.

In the van den Heuvel model (2007), the risk-based capital requirements of the Basel Accord and imperfect market for bank equity imply a failure of the Modigliani-Miller theorem for the bank. When equity is sufficiently low, due to loan losses or some other adverse shock, the bank will reduce lending because of the capital requirement and the cost of issuing new equity. Even when the capital requirement is not currently binding, van den Heuvel’s model showed that a bank with low capital may optimally forgo profitable lending opportunities to lower the risk of future capital inadequacy. Another crucial feature of the van den Heuvel model is the maturity transformation performed by banks, exposing them to interest rate risk. A monetary tightening by raising short-term interest rate lowers bank profits.

2.3.2 Empirical Evidence of the Bank Lending Channel in Other Countries

Empirical studies on the bank lending channel in the U.S. focused on the correlations among aggregate output, bank debt and indicators of monetary policy. Bernanke and Blinder’s (1992) study concluded that monetary policy works in part through the bank lending channel. However, their result is plagued by the problem of identifying shifts in loan demand from shifts in loan supply. Ramey (1993) concluded that the money channel is much more important than the credit channel in the direct transmission of policy shocks. Kashyap, Stein and Wilcox (1993) bypassed this identification problem by examining relative movements in bank loans and commercial paper following monetary policy shocks. The authors found supportive evidence for the bank lending channel. Using the dates identified by Romer and Romer (1989) that signal contractionary shifts in monetary policy, Kashyap, Stein and Wilcox found that the financing mix shifts away from bank loans following a monetary contraction. In other words, the contractionary policy reduced the supply of bank credit and resulted in an
increase in the demand for non-bank credit. However, Gertler and Gilchrist (1993),
Eichenbaum (1994) and Oliner and Rudebusch (1996) conducted a series of studies
using disaggregated data and found no evidence to support a bank lending channel in
monetary policy transmission.

Considering the borrowers’ heterogeneity in their sensitivity in the business cycle and
the types of credit they use, evidence based on Ramey (1993), Kashyap et al. (1993)
showed the aggregate credit measure can be problematic. To avoid this problem,
Kashyap and Stein (1995) used quarterly data on individual banks’ operating in the
U.S. from 1976:Q1-1992:Q2. They classified banks by their asset size and used the
Federal Reserve Fund rates as the monetary policy instrument. Their results showed:
(1) a tightening in monetary policy reduced deposits across all different sizes of banks
in a similar fashion; and (2) loan volume is much more sensitive to monetary policy
for small banks than big banks. That is, an increase in the Federal Reserve Fund rate
has a negative and statistically significant effect on the growth rate of total loans for
small banks. They obtained similar results using commercial and industrial loans.
They also found that small bank holdings of securities are more sensitive to changes
in monetary policy. Kashyap and Stein (2000) conducted another study on the bank
lending channel using bank level data that included quarterly observations of every
insured U.S. commercial bank from 1976 to 1993. They reported that, within the class
of small banks, changes in monetary policy mattered more for banks’ lending with the
least liquid balance sheets. Kashyap and Stein concluded that it is difficult to answer
how important the bank lending channel is for aggregate activity quantitatively but
could not deny the existence of a lending channel in monetary transmission. Kishan
and Opiela (2000), Peek et al. (2003), and Cetorelli and Goldberg (2008) supported
the existence of a bank lending channel in U.S based on bank level data.

According to Kashyap and Stein (2000), even if the identification problem could be
solved by using bank level data, aggregation problems made it difficult to quantify the
impact of monetary policy on aggregate credit. To avoid this aggregation problem,
vector error correction models (VECM) have been widely used. Within the VECM
framework, the relationships of supply and demand for loans can be identified by
testing for the presence of multiple cointegrating relationships and by testing
exclusions, and exogeneity and homogeneity restrictions on the cointegrating
relationships. Loan supply and demand can therefore be modelled jointly, rather than in a one-equation reduced-form format (Mello and Pisu, 2009).

Research on the bank lending channel in other countries includes Kashyap and Stein (1997) for European banks, Farinha and Marques (2001) for Portuguese banks, and Alfaro, Franken, Garcia and Jara (2004) for Chilean banks. Their findings supported the existence of a bank lending channel. Mello and Pisu (2009) conducted a study to test for the existence of a bank lending channel in the transmission of monetary policy in Brazil using monthly aggregate data for the period 1995:12 to 2008:6. Mello and Pisu argued that using bank-level data to estimate the reduced form supply equations may not be informative about the strength of the bank lending channel for monetary transmission. Instead, they tested for exclusion/homogeneity restrictions on multiple cointegration vectors in the VECM to disentangle the loan supply and demand effects of monetary policy shocks. They documented the existence of a bank lending channel in Brazil and found that a comparatively low credit-to-GDP ratio does not preclude the transmission of monetary policy through a bank lending channel.

2.3.3 Overview of China’s Financial Institutions’ Development

The salient characteristic of the Chinese banking sector in the pre-reform era was a mono bank system. Between 1949 and the late 1970s, the PBC functioned both as the central bank and the only deposit-taking and lending institution. Hence, it was not similar to a commercial bank seeking profit to maximize shareholders’ wealth (Yu and Xie, 1999). In 1984, the PBC was transformed to the central bank of China. Its specialized banking functions were transferred to the Big Four state-owned specialized banks created in the 1970s, including the Industrial and Commercial Bank of China (ICBC, originally specialized in lending to the industrial sector), the Bank of China (BOC, traditionally responsible for foreign exchange activity and the financing of imports and exports), the Agricultural Bank of China (ABC, traditionally focused on agricultural lending and rural development) and the Construction Bank of China (CCB, traditionally focused on financing infrastructure development). The Big Four state-owned commercial banks dominate China’s banking system, accounting for more than half of the total bank assets. The objectives of the Big Four state owned banks differed according to the sector in which they were directed to specialize. Some
Bank loans were used by SOEs (state-owned enterprises) to meet their financial requirements. The SOEs regard bank debts as working capital; business losses and defaults were dealt with by additional borrowing (Dobson and Kashyap, 2006). The dominant state-ownership of commercial banks allowed the government to be involved in the decision making of these banks.

Since 1995, the government has introduced institutional and regulatory reforms to transform the Big Four into commercial banks. To relieve the Big Four of their state-directed lending roles, three policy banks were created in 1994. The Agriculture Development Bank of China took over the policy lending role from the ABC; the China Development Bank took over the policy lending role from the CCB and, to a certain extent, from the ICBC; and the Export-Import Bank of China took over the policy lending role from the BOC, particularly the trade financing function (Maswana, 2008).

In addition to the state banks’ domination, a few smaller commercial banks were established in the 1980s and 1990s, whose equity ownerships were distributed among state and private investors. These commercial banks are divided into two subgroups: (1) shareholding or joint-stock commercial banks, which are incorporated as joint-stock limited companies under the People’s Bank of China’s Company Law; and (2) urban commercial banks, based on the traditional urban credit cooperative, which became commercial banks with stock-holding features. Foreign-funded banks and branches of foreign banks also expanded rapidly in China. Currently, China’s financial system consists of China’s central bank, state-owned banks, policy banks, joint-stock commercial banks, foreign-funded banks and branches of foreign banks, trust and investment corporations, and rural and urban credit cooperatives (see Table 2.3).

The declining asset quality of state-owned banks forced the government to inject public funds to clean up the banks’ balance sheets. In addition, in late 2006, China began opening its banking sector to foreign competition, as mandated by the World Trade Organization (WTO). Furthermore, with regard to international competition, strategic investors (particularly, institutional investors) were ushered in to invest in state-owned banks that were transformed from a policy entity into a business entity
operating on a commercial basis. The ongoing commercialization process of China’s banking sector affects the behaviour of bank executives. For example, Chinese banks recently introduced incentive and discipline mechanisms to improve their credit analysis and risk evaluation. Moreover, local governments no longer have direct authority over local bank branches (Firth et al., 2009)

Table 2.3 Assets, Deposit, and Loans of Chinese Banking Institutions

<table>
<thead>
<tr>
<th>Type of institution</th>
<th>No. of Institution</th>
<th>Assets Percent of Total</th>
<th>Deposits Percent of Total</th>
<th>Loans Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Four commercial banks</td>
<td>4</td>
<td>48.4</td>
<td>53.5</td>
<td>45.58</td>
</tr>
<tr>
<td>Policy Banks</td>
<td>3</td>
<td>8.99</td>
<td>0.90</td>
<td>13.27</td>
</tr>
<tr>
<td>Joint Stock Commercial banks</td>
<td>12</td>
<td>18.4</td>
<td>18.0</td>
<td>20.04</td>
</tr>
<tr>
<td>Urban Commercial Banks</td>
<td>91</td>
<td>6.49</td>
<td>7.27</td>
<td>6.81</td>
</tr>
<tr>
<td>Foreign-investment Banks</td>
<td>267</td>
<td>2.14</td>
<td>1.188</td>
<td>2.146</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>12.86</td>
<td>11.06</td>
<td>12.33</td>
</tr>
</tbody>
</table>

Note: data as of December 31, 2008

2.3.4. The Credit Channel in China’s Monetary Policy Transmission

The studies of Wang and Wang (2000), Li (2001) and Zhou and Jiang (2002) pointed to the existence of the credit channel in China based on the cointegration method and Granger causality test. Sun (2004) examined the relationships among monetary aggregates \((M_1\) and \(M_2\)), credit aggregate, and GDP to identify China’s monetary transmission mechanism covering the period 1994:Q1 to 2003:Q1. Based on the cointegration relationships among the monetary aggregate, credit aggregate and GDP, Sun conducted the Granger-causality test and found that the credit aggregate did not ‘Granger cause’ the GDP and monetary aggregate, but the monetary aggregate ‘Granger cause’ credit aggregate and GDP. Therefore, Sun concluded that it is the money channel rather than the credit channel that is important in China’s monetary policy transmission.

Jiang, Liu and Zhao (2005) adopted a VAR model based on quarterly data for GDP, inflation rate, monetary aggregate and credit aggregate from 1992:Q1 to 2004:Q2 to
examine the effectiveness of the money and credit channels in monetary transmission in China. According to the impulse response function, Jiang, Liu and Zhao found that the credit aggregate had a more immediate and a stronger impact on inflation rate and GDP than the monetary aggregate $M_2$ in eight quarters. The magnitude of the impact reached its peak at four quarters lag and was significant even at 10 quarters lag but began to decline thereafter. The impact of credit on GDP was much stronger than the monetary aggregate in 10 quarters. The authors concluded that the credit channel plays an important role in China’s monetary policy transmission.

Sheng and Wu (2008) utilized a VAR model (a level VAR and a difference VAR) and monthly data for monetary aggregate $M_2$, CPI, industrial value-added, and credit aggregate to test whether the credit channel exists in China from 1998:1 to 2006:6. Based on the group Granger causality test, Sheng and Wu found that: (1) credit Granger causes $M_2$; and (2) $M_2$ and credit aggregate Granger causes industrial value-added. Sheng and Wu concluded that changes in the credit aggregate gave rise to changes in the monetary aggregate, not vice versa; and that the bank credit aggregate instead of the monetary aggregate was the actual intermediate target. Therefore, the money channel did not exist in China and the credit channel played an important role in monetary policy transmission. This result supported Wang’s (2003) findings.

Some questions still remain concerning the credit channel in China’s monetary policy transmission. First, previous researchers have tested the relationships among the bank loan aggregate, GDP (or industrial value), price level and monetary aggregate since the data on the bank loan aggregate not the data on bank loan demand or bank loan supply that are available. However, they did not identify which force, the bank loan supply or bank loan demand, drove the changes in the bank loan aggregate. Secondly, no researchers have examined whether the bank loan aggregate responds to changes in the stance of monetary policy of the PBC. According to Kashyap and Stein (1994), if the bank lending channel exists in China, changes in the required reserve ratio by the PBC should affect the supply of bank loans because it changes the quantity of reserves available to the banking system. Thirdly, the results based on the Granger causality tests have been ambiguous because it is difficult to draw clear conclusions unless the data can be described by a simple two-dimensional system (Bent, 2005). As
Sims (1977) described it, the conclusion of the Granger-causality test depends on the right choice of the conditioning set\(^4\). In reality, one can never be sure that the chosen conditioning was large enough. Another problem regarding this research method is that the approach to test the credit channel focuses on evaluating the forecast power of credit aggregates for real activity relative to the forecasting power of monetary aggregates. Bernanke and Gertler (1995) argued that such an approach to test the credit channel is invalid and suffered from an incorrect premise, which treats credit aggregates as an independent causal factor affecting the economy. In addition, credit is rarely a primitive driving force and the credit condition (measured by the external finance premium) is an endogenous factor that helps shape the dynamic response of the economy to shifts in monetary policy. Thus, the theory has no particular implications about the relative forecasting power of credit aggregates.

2.4 Reviews on McCallum Rule

2.4.1. Principles of the McCallum Rule

McCallum (1987, 1993, and 2006) advocated a policy rule for central banks to follow in setting monetary policy. The rule, developed outside the confines of a single model, would work well with different economic models since it is free from the model-specific problem. Since macroeconomists disagree about the forces that drive the economy, they are unlikely to come up with an optimal rule for the operation of the monetary policy (Stark, 1996). The McCallum Rule requires central banks to target the growth rate of nominal GDP using the monetary base as its instrument.

According to McCallum (1984, 1985, 1987), four principles should be followed in designing a monetary rule. First, the rule should dictate the behaviour of a variable that the monetary authority can control directly and/or accurately. Second, the rule should not rely on the presumed absence of regulatory changes and technical progress in the financial industries. Third, neither money stock nor (nominal) interest rate paths\(^5\) are important for their own sake; these variables are relevant only to the extent that they are useful in facilitating good performance in the magnitudes of inflation and

\(^4\) The central notion of Granger Causality is one of incremental predictability. If a series Y is better predicted by the complete universe of past information than by that universe less the series X, then X Granger-causes Y. According to the definition, the information set on which conditioning is defined includes all possibly relevant variables and is infinitely extended back into time. However, practical implementation must use data sets that are more limited: a finite number of lags and often only a pair of variables (Hoover, 2001).

\(^5\) In Macroeconomics, the word “path” describes the locus of a variable changes over time.
output or employment. Fourth, a well-designed rule should recognize the limits of macroeconomics knowledge. In particular, it should recognize that neither theory nor evidence points convincingly to any of the numerous competing models of the interaction of nominal and real variables.

Based on the four principles, McCallum (1987) specified a target path for nominal GDP using the monetary base as the operational mechanism, a variable that can be accurately set on a daily basis by the central bank with a floating exchange rate. Specifically, the rule “would adjust the base growth rate each month or quarter, increasing the rate if nominal GDP is below its target path and vice versa” (McCallum, 1984, p. 390). In 1993, McCallum revised the rule using the nominal GDP growth rate instead of the nominal GDP as the target, supported by Stark and Croushore (1996). In algebraic form, the McCallum Rule is given as follows:

\[ \Delta B_t = \Delta X_t^* - \Delta VB_t + \lambda(\Delta X_{t-4}^* - \Delta X_{t-4}) \]  

(2.1)

Where all the variables are in logarithms, \( B \) is the monetary base, \( \Delta VB \) is the average base velocity growth rate over the previous four years, \( \lambda \) is the monetary response factor, and \( X \) is the log of nominal GDP. The asterisk (*) denotes the target growth rate, which is the sum of the inflation rate and the long-run average real GDP growth rate.

The growth of the monetary base is determined by the three terms on the right-hand side of equation (2.1). The first term sets the monetary base growth rate equal to the desired rate of inflation plus the potential or desired real GDP growth rate. McCallum emphasized real, since outputs and employment levels over the long run will be independent of the average growth rate of the nominal variables (McCallum 1988, p.175). The second term on the right-hand side of equation (2.1) is the growth rate of monetary base velocity, which reflects the impact of technological and regulatory changes on the velocity of the monetary base. In this regard, the McCallum Rule forecasts the average growth rate of velocity over the future. This term helps to prevent the price level from drifting in response to a permanent shock to money demand. With the velocity growing at a steady-state rate and the nominal GDP growth
rate equal to its target, the rule forces the inflation rate to remain at a desired level, assuming that the monetary policy is neutral in the long run. The last term on the right-hand side of equation (2.1) is most important for stabilization of output and price level, which suggests the monetary policy authority to adjust monetary base growth whenever the nominal GDP growth rate differs from its target. When the nominal GDP growth rate is below its target, the monetary authority should temporarily increase monetary base growth and vice versa.

The first feature of the McCallum Rule is that the nominal GDP is preferred to monetary aggregates such as M1 or M2 as the monetary authority’s principal target variable. Monetary aggregates have become unreliable guides and the nominal GDP correlates with the real GDP and inflation. In addition, the nominal GDP, in principle, has two other features that make it a good guide for policy. First, under nominal GDP targeting, the monetary policy would adjust to offset disturbances to aggregate demand. A second attractive feature of nominal GDP targeting is that it would help the policy maker to balance the goals of stable output growth and inflation in response to aggregate supply disturbance (Clark, 1994). Furthermore, the nominal GDP is preferred to real GDP as the policy target because a central bank cannot control or predict with accuracy how the nominal GDP growth divides on a quarter-by-quarter basis between real growth and inflation (McCallum, 1988).

The second feature of the McCallum Rule is the specification of a constant growth target for nominal income, rather than a target rate that varies over the cycle. In this way, it would at least eliminate policy surprises as a source of undesirable fluctuations arising from the central bank’s pursuit of an optimal policy decision. The third feature of the McCallum Rule is to utilize the monetary base instead of interest rate as the monetary policy instrument. McCallum in his 1993 paper discussed in detail the reasons why he preferred monetary base to interest rate as a policy instrument. McCallum argued that if the nominal interest rate is use as an indicator of monetary policy stance, then tightening or easing the policy stance results in ambiguity. In this regard, the rule is desirably operational, since the central bank is capable of controlling the monetary base variable with accuracy.
A technical issue regarding the McCallum Rule is whether the behaviour of the base growth target specified by the rule is permissible for the base growth to be of use in practice. McCallum (2006) suggested using the average nominal GDP growth over the past 4 quarters instead of the most recent quarter for the rule’s final term (this is analogous to the Taylor Rule’s use of an average four-quarter inflation rate value). The McCallum Rule that uses the average nominal GDP growth over the past four quarters for the final term is refer as the improved (McCallum) rule in this study. We evaluate the original and improved McCallum Rule separately.

2.4.2 Previous Empirical Studies on McCallum Rule

Several studies have used the counterfactual or stochastic simulation method to test the robustness of McCallum’s rule. Based on seasonally adjusted U.S. quarterly data for 1954:Q1 – 1985:Q4, McCallum (1988) verified the rule using two single equation models, regressing nominal income growth rate on the current or one-period lagged monetary base growth rate, and one-period lagged nominal income growth rate. However, these two single equation models used to depict the nominal income determination are simple and likely to be policy invariant. McCallum further verified the robustness of his simple rule to an atheoretic VAR model and structural classical and Keynesian slant model. The simulation results showed that adherence to monetary base-growth rates specified in equation (2.1) would have yielded essentially the desired inflation, despite the financial and regulatory changes during the testing period, while reducing the extent of cyclical fluctuation in nominal income. In McCallum’s latter papers (1993, 1999, 2000), similar models were used to further verify the robustness of the rule based on data from different countries. In these papers, McCallum adopted a nominal target of the growth-rate type, rather than the growing-level type used in his prior research. The main disadvantage with a level-type target path is that the target variable reverts back to the preset path after any disturbance that has driven it away, even if the effect of the disturbance is of a permanent nature. Since such an action entails general macroeconomic stimulus or restraints, this type of targeting procedure would probably induce extra cyclical variability in demand conditions, which implies extra variability in real output if price level stickiness prevails (McCallum, 1999, p. 1498).
Hall (1990), Judd and Motley (1991, 1993), Dueker (1993), Stark and Croushore (1996), Philip (2000), and Razzak (2003) presented supportive evidence of the McCallum Rule based on data from different developed countries using simulation methods. In their study, Stark and Croushore (1996, p. 3) encouraged researchers to use models in which monetary policy has real effects. For this reason, they excluded the real business cycle and rational expectations models from their study because the real effects of monetary policy in these models tend to be nonexistent or very small. Stark and Croushore (1996) examined the effectiveness of the McCallum Rule using a Keynesian model, a reduced form model and a structural VAR model. They concluded that McCallum Rule is a potentially useful rule for setting monetary policy.

The historical analytical method developed by Stuart (1996) and Taylor (1999B) consists of contrasting actual settings of instrument variables during some historical time span with the values specified by particular rules in response to prevailing conditions. Discrepancies or agreements between rule-specified and the actual values can then be evaluated in light of ex-post judgments concerning the merit of the various rules. Stuart (1996) compared the McCallum Rule with the monetary policy decisions based on a thorough assessment of the prospect for inflation using UK data for the period 1985:Q1-1962:Q2. The author found that the simple rule provided information about inflation and economic activity that can be used with other relevant information in the formulation of monetary policy.

Taylor (1999B) examined the U.S. monetary history for two different periods: 1880-1914 versus 1955-1997, using the framework specified by the Taylor Rule. He concluded that the historical approach to monetary policy evaluation complements the model-based approach and that case studies were useful for judging how much discretion is appropriate when a policy rule is use as a guideline for central bank policy decisions. McCallum (2000) followed the Stuart-Taylor method on the U.S. and UK from the early 1960s to 1998 and for Japan from the 1970s to 1998. McCallum concluded that the Stuart–Taylor method can also be a useful approach to McCallum Rule evaluation in addition to simulations with structural models.

The McCallum Rule is currently less popular than the Taylor Rule in developed countries, but it has attracted the attention of some researchers who have a great
interest in China’s monetary policy. Some researchers have tried to test the McCallum Rule to identify a guideline for the PBC. For example, Burdekin and Siklos (2005) applied McCallum Rule to model Chinese monetary policy using the coefficient specified by McCallum and then allowed the data to determine the coefficient estimates. Based on the simulated values for the nominal GDP growth rate, the authors concluded that the PBC had appeared to respond to the gap between the target and the actual nominal GDP and China’s inflation and monetary policy outcomes could be satisfactorily modelled using standard empirical techniques instead of a figment of China-specific “structural” factors. However, Liu and Zhang (2007) compared the fit of the modified McCallum Rule using the monetary base or M2 as the dependent variable with the actual realized values for money supply. The authors concluded that a quantity of money rule in the spirit of McCallum could not adequately depict the PBC’s policy stance.

Following the estimation of the standard McCallum Rule and a modified McCallum Rule, Kong (2008) concluded that the two estimated McCallum rules reflected the trend of the actual base money growth rate. In this regard, it is practical to utilize the McCallum Rule as a guideline for China’s monetary policy. Koivu et al. (2008) analyzed China’s monetary policy after 1994 using a quantity-based McCallum Rule. By testing the excess money supply (deviation of the actual money supply growth from the value given by the McCallum Rule), the authors suggested that the McCallum Rule can be a useful tool for analyzing the monetary policy stance and for providing information about inflationary pressures in the Chinese economy.

Mehrotra and Sanchez-Fung (2010) modeled China’s monetary policy using a McCallum-Taylor type rule covering the period 1994Q1-2008Q1. Instead of using nominal GDP as policy target as in the original McCallum rule, the authors used a reaction function that allows feedback from the output and inflation gaps, together with an effective trade-weighted exchange rate. Mehrotra and Sanchez-Fung found that the Chinese monetary policy has been procyclical, reflecting an accommodative reaction to the inflation gap. However, the reaction to the output gap was countercyclical, whereas the money supply did not react significantly to the exchange rate development.
However, some unaddressed issues remain in previous studies. First, the Liu and Zhang (2007) and Koivu et al., (2009) studies adopted the McCallum’s specified coefficient value of 0.5 for the monetary response factor based on Japanese data for the period 1972-1992. In addition, a 4% long-term average annual growth rate of real output was used as the target growth rate in the rule when conducting the simulation to decide on the coefficient value (McCallum 1993). On the other hand, the McCallum Rule coefficient value of 0.25 is based on U.S. data for the period 1954:Q1-1985:Q4. A 3% long-term average annual growth rate of real output was used as the target growth rate in the rule when identifying the coefficient value (McCallum 1987, 1988). Therefore, to test the validity of the McCallum Rule using Chinese data, a researcher should take into account variations in the value for $\lambda$.

Second, Kong (2008) evaluated a modified McCallum Rule, with the inflation gap (the difference between inflation target and realized value) added into the rule as an independent variable. However, he neglected the fact that the feedback term defined in the McCallum Rule is the nominal GDP growth, which gives equal weight to changes in the real output gap and deviations of inflation from the target. Furthermore, Koivu et al. (2009) used $M_2$ as the dependent variable to test the effectiveness of the McCallum Rule in China. This ignores the fundamental principle of the McCallum Rule that the instrument variable should be under the central bank’s direct control.

The McCallum-Taylor type rule in Mehrotra and Sanchez-Fung’s study (2010) models China’s monetary policy constructively for its explicit consideration of real GDP, inflation and exchange rate variables. However, this type of rule does not consider the changes in money velocity that has significant influence on the monetary policy transmission, especially in developing countries such as China that has experienced markedly monetization process. This may influence the empirical results of their research. In addition, the specification of such rule essentially deviates from McCallum’s original thought about his policy rule.

2.5 Conclusion

In this chapter, we first reviewed previous researches of China’s monetary policy transmission mechanism. The effectiveness of the currently adopted monetary targeting regime is under question and the reform and development of China’s
financial system provide conditions for the possibility of adopting a new monetary policy regime, taking short-term interest rate as the PBC’s operating target. This is the motivation for our study to see if an effective interest rate channel currently exists in China. Section 2.3 first reviews the basic principles of the interest rate channel and credit channel then the previous empirical studies on credit channel in different countries including China. We found some problems remain to be solved after previous research on the credit channel in China, especially the force that drives the increases in bank credit aggregate was not identified clearly. These remaining problems led to this study on the credit channel in China. Finally, we summarize the principles of the McCallum Rule and the improvement of it. Some research in other countries showed the McCallum Rule can be used as a policy guideline. However, some mistakes exist in previous studies on the McCallum rule as a policy guideline in China. Because of this, we decided to re-evaluate the possibility of using McCallum Rule as China’s monetary policy guideline.
CHAPTER 3
VARIABLES SELECTION AND THE EXAMINATION
OF DATA PROPERTIES

3.1 Introduction

This chapter describes the variables and examines the properties of the data used in this study. Section 3.2 presents the Augmented Dickey-Fuller (ADF) test to examine the properties of the data and the Dickey-Fuller test with GLS detrending (DFGLS) method used to verify the results of the ADF test. Section 3.3 explains the selected variables used to test the impact of short-term interest rates on output and inflation and the results of the ADF and DFGLS tests on these variables. Section 3.4 describes the related variables for the identification of bank lending channel in China and the test results of their integration properties. The variables selected for the study of the McCallum Rule and tests of their integration properties are discussed in Section 3.5.

3.2 Integration Properties of Time Series Data

A time series variable is stationary when it has a finite mean, variance and autocovariance function that are all independent of time. Analogously, a non-stationary series variable has a time dependent mean or autocovariance function. A stochastic time series is said to be integrated of order \( d \) if the series requires difference of \( d \) times in order to achieve stationarity (Engle and Granger, 1987). Thus, the time series \( X_t \) is said to be integrated of order one, denoted \( X_t \sim I(1) \), if its level series \( X_t \) is non-stationary but its first difference series \( \Delta X_t \) is stationary, denoted as \( \Delta X_t \sim I(0) \).

Determining the order of integration of a time series variable involves testing for the number of autoregressive unit roots that the time series contains. For example, the first order autoregressive process is given as follows:

\[
X_t = \rho X_{t-1} + u_t \tag{3.1}
\]

Where \( X_0 \) is a fixed initial value, \( \rho \) is the autocorrelation coefficient and \( u_t \) is ‘white noise’. When \( |\rho| < 1 \), the series \( X_t \) is covariance stationary since it has a

---

6 The accuracy and transparency of Chinese statistics has been debated for a few years. Rawski (2001) and Holz (2008) reported that China’s GDP growth rate was over-estimated. However, Klein (2002) and Chow (2002) argued that China’s GDP growth performance was, to a large extend, reliable.
constant mean and variance that are independent of time. Algebraically, a covariance stationary \( X_t \) has these properties:

**Mean:** \( E(X_t) = \mu \) \hspace{1cm} (3.2)

**Variance** \( \text{var}(X_t) = E((X_t - \mu)^2) = \sigma^2 \) \hspace{1cm} (3.3)

**Covariance:** \( \gamma_k = E[(X_t - \mu)(X_{t+k} - \mu)] \) \hspace{1cm} (3.4)

Where \( \gamma_k \) is the covariance between the values of \( X_t \) and \( X_{t+k} \), that is, between the two \( X \) values \( k \) period apart.

In contrast, when \( \rho = 1 \), \( X_t \) is nonstationary both its mean and variance are time dependent. Algebraically, a nonstationary \( X_t \) has these properties:

**Mean:** \( E(X_t) = E(X_0 + \sum u_t) = X_0 \) \hspace{1cm} (3.5)

**Variance:** \( \text{var}(X_t) = t\sigma^2 \) \hspace{1cm} (3.6)

Let \( L \) be the lag operator where \( L'X_t = X_{t-1} \), then equation (3.1) can be written as a lag polynomial of degree one in the form of equation (3.7)

\[
(1 - \rho L)X_t = u_t
\]  \hspace{1cm} (3.7)

The root of the associated polynomial equation \( 1 - \rho z = 0 \) is \( 1/\rho \). If the root of the equation exceeds one in absolute value, then \( |\rho| < 1 \) and hence \( X_t \) is stationary. On the other hand, if the root of the equation equals one then \( \rho = 1 \), in which case \( X_t \) has a unit root and is nonstationary (Hayashi, 2000).

Suppose \( X_t \) is a nonstationary random walk process with zero drift that is \( X_t = X_{t-1} + u_t \). Then, the first difference series \( \Delta X_t = u_t \) is clearly stationary since it is a white noise process by definition. Thus, if a non-stationary series contains only a single unit root then it needs to be differenced only once in order to achieve stationarity. Recalling the definition of the order of integration of a time series, such a nonstationary series will be integrated of order one or \( I(1) \). This result extends to the more general case where a non-stationary time series \( X_t \) containing \( d \) unit roots is said to be \( I(d) \) since \( X_t \) needs to be differenced \( d \) times to become stationary.
Conventional least squares regression analysis necessitates that all variables are covariance stationary, namely, the underlying data generating the process possesses a finite mean and variance. Under this circumstance, ordinary least squares estimates are distributed asymptotically normal, and $t$ statistics are valid for inference. However, empirical evidence suggests that the levels of most macroeconomic variables are often characterized as integrated of order one, i.e., non-stationary. According to Enders (2004, pp 108), important variables in macroeconomic analysis, for example GDP, financial aggregates, interest rates and exchange rates, have a time-dependent mean and variance that typically increase over time. Traditional regression with nonstationary variables will result in what Granger and Newbold (1974) called spurious regression. A spurious regression has a high $R^2$ and $t$ statistics that appear to be significant, but the results are without any economic meaning. The regression outputs “looks good” because the least-squares estimate are not consistent and $t$ statistics do not possess asymptotic $t$ distribution, if the residuals of the regression equation are nonstationary. Thus, inferences based on conventional tests may not be correct. These findings suggest that the integration properties of data should be tested before performing regression analysis. We apply two kinds of unit roots test procedures to test the integration properties of our data: the Augmented Dickey-Fuller (ADF) test and Dickey-Fuller test with GLS detrending.

### 3.2.1 Augmented Dickey-Fuller Unit Root Tests

The Augmented Dickey-Fuller tests (1981) for an autoregressive unit root are based on the following ordinary least square regression equations:

$$
\Delta y_t = \gamma y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t
$$

(3.8)

$$
\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t
$$

(3.9)

$$
\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t
$$

(3.10)

The difference between the three regressions is the presence of the deterministic elements $\alpha_0$ and $\alpha_2 t$. The first is a pure random walk model, the second adds an
intercept or drift term, and the third includes both a drift and a linear time trend. The process of ADF tests is summarized in Table 3.1.

<table>
<thead>
<tr>
<th>Model</th>
<th>Hypothesis</th>
<th>Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_3 t + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t$</td>
<td>$\gamma = 0$</td>
<td>$\tau_o = 0$</td>
</tr>
<tr>
<td></td>
<td>$\alpha_0 = 0$ given $\gamma = 0$</td>
<td>$\tau_{ar}$</td>
</tr>
<tr>
<td></td>
<td>$\alpha_2 = 0$ given $\gamma = 0$</td>
<td>$\tau_{br}$</td>
</tr>
<tr>
<td></td>
<td>$\gamma = \alpha_2 = 0$</td>
<td>$\Phi_3$</td>
</tr>
<tr>
<td></td>
<td>$\alpha_0 = \gamma = \alpha_2 = 0$</td>
<td>$\Phi_1$</td>
</tr>
<tr>
<td>$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t$</td>
<td>$\gamma = 0$</td>
<td>$\tau_{\mu} = 0$</td>
</tr>
<tr>
<td></td>
<td>$\alpha_0 = 0$ given $\gamma = 0$</td>
<td>$\tau_{\mu\delta}$</td>
</tr>
<tr>
<td></td>
<td>$\alpha_0 = \gamma = 0$</td>
<td>$\Phi_2$</td>
</tr>
<tr>
<td>$\Delta y_t = \gamma y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + \varepsilon_t$</td>
<td>$\gamma = 0$</td>
<td>$\tau_r = 0$</td>
</tr>
</tbody>
</table>

Sources: Dickey and Fuller (1979, 1981)

$\tau$, $\tau_{\mu}$ and $\tau_r$ statistics are used to test the hypothesis $\gamma = 0$. Dickey and Fuller (1981) provided three additional F-statistics (called $\Phi_1$, $\Phi_2$ and $\Phi_3$) to test joint hypothesis of the coefficients. Note that these test statistics are the conventional least squares regression $t$ and $F$-statistics computed for testing the appropriate null hypothesis.

In all cases, the null hypothesis is to test the time series variable whether it contains a unit root. However, a question concerns whether it is most appropriate to estimate equations (3.8), (3.9) or (3.10), unless the researcher knows the actual data-generating process. It might seem reasonable to test the hypothesis using the most general form of the models, equation (3.10). Enders (2004, p 210) argued that one problem with this line of reasoning is that the presence of the additional estimated parameters reduces the degrees of freedom and the power of the test. Reduced power means that researchers will not be able to reject the null of a unit root when, in fact, no unit root is present. Moreover, the appropriate test statistics (i.e., $\tau$, $\tau_{\mu}$, $\tau_r$) for $\gamma = 0$ depends on which of the regressors are included in the model. Campbell and Perron (1991) reported that only when the drift or trend is absent do the nonstandard Dickey-Fuller
distributions dominate. If the data-generating process is known to contain a trend or drift, we test the null hypothesis using the standardized normal distribution.

From the above summary, we can see that too few or too many regressors may cause a failure of the test to reject the null of a unit root. Doldado and Sosvilla-Rivero (1990) suggested a strategy to test for a unit root when the data-generating process is completely unknown. Doldado and Sosvilla-Rivero’s modification to resolve this problem was documented by Enders (2004) as follows:

Step 1: Start with the least restrictive of the plausible models (which will generally include a trend and drift) and use the $\tau_\gamma$ statistic to test the null hypothesis $\gamma = 0$. Unit root tests have a low power to reject the null hypothesis; hence, if the null hypothesis of a unit root is rejected, we can conclude that the \{y_t\} sequence does not contain a unit root (see Table 3.2).

Step 2: If the null hypothesis is not rejected, it is necessary to determine whether too many deterministic regressors were included in step 1. The presence of these regressors may have reduced the power of the test. As such, one can test for the significant of the trend term by testing the hypothesis $\gamma = \alpha_2 = 0$ using the $\Phi_3$ statistic. If the trend is not significant, proceed to step 3. Otherwise, if the trend is significant, retest for the presence of a unit root using the standardized normal distribution. If the null of a unit root is rejected, we can conclude that the \{y_t\} sequence does not contain a unit root. Otherwise, the \{y_t\} sequence contains a unit root.

Step 3: Estimate the model without the trend. Test for the presence of a unit root using the $\tau_\mu$ statistic. If the null is rejected, we can conclude that the model does not contain a unit root. If the null hypothesis of a unit root is not rejected, we should test for the significance of the constant by testing the hypothesis $\alpha_0 = \gamma = 0$ using the $\Phi_1$ statistic. If the drift is not significant, we should estimate an equation in the form of (3.9) and proceed to step 4. If the drift is significant, we should test for the presence of a unit root using the standardized normal. If the null hypothesis of a unit root is
rejected, we can conclude that the \( \{ y_t \} \) sequence does not contain a unit root. Otherwise, the \( \{ y_t \} \) sequence contains a unit root.

Step 4: Estimate a model in the form of equation (3.8). Use \( \tau \) to test for the presence of a unit root. If the null hypothesis of a unit root is rejected, we can conclude that the \( \{ y_t \} \) sequence does not contain a unit root. Otherwise, the \( \{ y_t \} \) sequence contains a unit root.

### Table 3.2 Summary of the ADF Tests Procedure

<table>
<thead>
<tr>
<th>Model 1:</th>
<th>( \Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \epsilon_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 )</td>
<td>Test Stat</td>
</tr>
<tr>
<td>Step 1.1 ( \gamma = 0 )</td>
<td>( \tau_\gamma )</td>
</tr>
<tr>
<td>Step 1.2a ( a_2 = 0, \gamma = 0 )</td>
<td>( \Phi_3 )</td>
</tr>
<tr>
<td>Step 1.3 ( \gamma = 0 )</td>
<td>( N(0,1) )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 2:</th>
<th>( \Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \epsilon_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 )</td>
<td>Test Stat</td>
</tr>
<tr>
<td>Step 2.1 ( \gamma = 0 )</td>
<td>( \tau_\mu )</td>
</tr>
<tr>
<td>Step 2.2a ( a_0 = 0, \gamma = 0 )</td>
<td>( \Phi_1 )</td>
</tr>
<tr>
<td>Step 2.3 ( \gamma = 0 )</td>
<td>( N(0,1) )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 3:</th>
<th>( \Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \epsilon_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 )</td>
<td>Test Stat</td>
</tr>
<tr>
<td>Step 3.1 ( \gamma = 0 )</td>
<td>( \tau )</td>
</tr>
</tbody>
</table>

Gu: (2004)

Another important issue regarding the implementation of the ADF tests is the selection of \( k \) - that is, the number of lagged first-difference terms \( \Delta y_{t-k} \) needed to induce an appropriate white noise error structure in the estimated ADF test regression equations. As documented by Enders (2004), Dickey-Fuller tests are sensitive to the choice of \( k \), the number of lags in the estimated equation. Too few lags may adversely
affect the size of the test. In other words, selecting too few lags may cause one to over-reject a true null of a unit root at any chosen significance level. Second, too many lags may reduce the power of test because more parameters are estimated and the number of effective observations is reduced, given the need for additional initial conditions. That is, there is a high probability of falsely rejecting a true null of a unit root against a false stationary alternative when more lags are used. One approach to selecting the appropriate lag length is to start with a relatively long lag length and pare down by the usual $t$-test or $F$-tests. In addition, it is also possible to determine the lag length using an information criterion such as the AIC or SBC. For information criterion selection methods, we must specify an upper bound to the lag length. In this study, we use the Bartlett criteria $\text{int}(12(T/100)^{1/4})$ where int denotes the largest integer less than or equal to $12(T/100)^{1/4}$ and $T$ is sample size, and this criterion is adopted by default in Eviews 6 that was used to run our data analysis.

Since the ADF test takes the absence (presence) of a unit root as the alternative (null) hypothesis, we begin testing for the presence of a unit root in our first difference series $\Delta y_t$. In other words, we begin by testing whether our level series $y_t$ contains two unit roots. If the null of a single unit root is rejected for the first difference series $\Delta y_t$, implying that $\Delta y_t$ is stationary, and $y_t$ does not contain two unit roots, then we proceed to test for the presence of a single unit root in the level series $y_t$.

### 3.2.2 Dickey-Fuller Test with GLS Detrending (DFGLS)

As discussed earlier, we may include a constant, or a constant and a linear time trend in our ADF test regression. We are concerned about the appropriate form to use since we do not know the actual data-generating process. To overcome this problem, we used the alternative procedure proposed by Elliott et al. (1996), the DFGLS test. It is a modification of the ADF test. The basic idea of the DFGLS test is to detrend data before applying the ADF unit root tests. Since the data are already detrended, the constant or time trend variables will be taken out before running the ADF tests.
Elliott et al. (1996) defined a quasi-difference of $y_t$ as $d(y_t | \alpha)$ that depends on the value $\alpha$ representing the specific point alternative against which we wish to test the null:

$$d(y_t | \alpha) = \begin{cases} y_t & \text{if } t = 1 \\ y_t - \alpha y_{t-1} & \text{if } t > 1 \end{cases}$$

(3.11)

Next, consider an OLS regression of the quasi-differenced data $d(y_t | \alpha)$ on the quasi-differenced $d(x_t | \alpha)$:

$$d(y_t | \alpha) = d(x_t | \alpha)\delta(\alpha) + \eta_t$$

(3.12)

where $x_t$ contains either a constant, or a constant and trend, and let $\hat{\delta}(\alpha)$ be the OLS estimates from this regression.

All that we need now is a value for $\alpha$. Elliott et al. (1996) provided a recommendation regarding the specific value of $\alpha = \bar{\alpha}$, where:

$$\bar{\alpha} = \begin{cases} 1 - 7/T & \text{if } x_t = \{1\} \\ 1 - 13.5/T & \text{if } x_t = \{1,t\} \end{cases}$$

(3.13)

We now define the GLS detrended data, $y_t^d$ using the estimates associated with the $\bar{\alpha}$:

$$y_t^d = y_t - x_t^d\hat{\delta}(\bar{\alpha})$$

(3.14)

Finally, the DFGLS test estimates the standard ADF test equation. The only difference is that the DFGLS test substitutes the GLS detrended $y_t^d$ for the original $y_t$:

$$\Delta y_t^d = \alpha y_{t-1}^d + \beta_1 \Delta y_{t-1}^d + \cdots + \beta_p \Delta y_{t-p}^d + \nu_t$$

(3.15)

No constant or trend term is included in equation (3.15) since the $y_t^d$ are detrended. Like the ADF test, we consider the $t$ ratio for $\hat{\alpha}$ from tested equation (3.15).

3.3 Variables Selected for Testing Interest Rate Channel in China

This section describes the related variables and quarterly data from 1996:Q1 to 2008:Q1 used to examine the macroeconomic dynamics of the unified interbank
market operation in China and reports the results of ADF and DFGLS tests on these variables.

First, we consider the effects of short-term interest rates on GDP, general price level, monetary aggregate, and exchange rate. We assume the 7-day interbank money market rate (INTm), normally referred to as CHIBOR, and 7-day repo rate (INTr) which is benchmark rate in the interbank bond market as the PBC’s policy stance. Another policy-related variable in our study is the domestic monetary aggregate M2 (M), which is the intermediate target of the PBC. We use the nominal effective exchange rate (NEER) to examine effects of managed floating exchange regime on output and prices. The output measure is real GDP with the consumer price index (CPI) as the general price level. All data are expressed in natural logs and are seasonally adjusted using ARIMAX12, with the exception of short-term interest rates.

Figure 3.1 graphically displays China’s real GDP, CPI, aggregate M2, nominal effective exchange rate, INTm and INTr in level. This figure shows the two short-term interest rate variables do not move together with other macro-variables, namely interest rate variables and do not display a similar stochastic trend over time.

Figure 3.1. Level of Real GDP, CPI, M, NEER, TNTm, INTr
Table 3.3 Results of ADF Unit Root Tests for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>K</th>
<th>$\tau_r$</th>
<th>$\Phi_3$</th>
<th>$\tau_\mu$</th>
<th>$\Phi_1$</th>
<th>$\tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>1</td>
<td>-1.96</td>
<td>2.54</td>
<td>0.59</td>
<td>7.14</td>
<td>3.78</td>
</tr>
<tr>
<td>CPI</td>
<td>0</td>
<td>0.90</td>
<td>3.44</td>
<td>2.58</td>
<td>10.81***</td>
<td>3.74</td>
</tr>
<tr>
<td>M2</td>
<td>0</td>
<td>-2.82</td>
<td>4.21</td>
<td>-0.71</td>
<td>428.7***</td>
<td>28.28</td>
</tr>
<tr>
<td>INTm</td>
<td>0</td>
<td>-1.61</td>
<td>1.42</td>
<td>-0.80</td>
<td>0.32</td>
<td>0.54</td>
</tr>
<tr>
<td>INTr</td>
<td>0</td>
<td>-1.06</td>
<td>1.55</td>
<td>-0.20</td>
<td>0.06</td>
<td>0.20</td>
</tr>
<tr>
<td>NEER</td>
<td>10</td>
<td>1.39</td>
<td>4.14</td>
<td>0.61</td>
<td>0.77</td>
<td>-1.08</td>
</tr>
</tbody>
</table>

| Difference |   |          |          |             |          |        |
| GDP        | 0 | -11.37***| 64.71*** | -11.30***   | 63.95*** | -9.47***|
| CPI        | 0 | -6.78*** | 23.25*** | -5.77***    | 16.67*** | -5.01***|
| M2         | 3 | -4.25*** | 9.47***  | -4.31***    | 9.35***  | -0.73  |
| INTm       | 1 | -3.29*   | 5.50     | -2.78*      | 3.88     | -2.48* |
| INTr       | 1 | -4.26*** | 13.22*** | -4.98***    | 12.58*** | -5.00***|
| NEER       | 1 | 3.37*    | 5.68*    | -2.48       | 3.09     | -2.20**|

Notes: ***; **; * signify 1%, 5% and 10% significance level respectively

Table 3.3 reports the results of the ADF unit root tests for the time series. We first tested the first difference for all the time series for the possible presence of two unit roots. The $\tau_r$ statistics are all significant at the 10% level. Thus, the null hypothesis of a unit root is rejected. This suggests that the first differences of all time series are stationary. Following this, we tested all time series in level. The $\tau$ statistics are insignificant at the 5% level. Therefore, we fail to reject the null hypothesis of a unit root and hence they are non-stationary.

Table 3.4 Results of DFGLS Unit Root Tests for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>K</th>
<th>Constant</th>
<th>Constant and trend</th>
<th>k</th>
<th>Constant</th>
<th>Constant and trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>1</td>
<td>1.78</td>
<td>-1.59</td>
<td>0</td>
<td>-11.30***</td>
<td>-11.44***</td>
</tr>
<tr>
<td>CPI</td>
<td>0</td>
<td>3.62</td>
<td>-1.48</td>
<td>0</td>
<td>-3.57***</td>
<td>-4.80***</td>
</tr>
<tr>
<td>M2</td>
<td>6</td>
<td>0.77</td>
<td>-2.04</td>
<td>0</td>
<td>-3.70***</td>
<td>-5.60***</td>
</tr>
<tr>
<td>INTm</td>
<td>8</td>
<td>-0.21</td>
<td>-1.39</td>
<td>2</td>
<td>-2.13**</td>
<td>-4.00***</td>
</tr>
<tr>
<td>INTr</td>
<td>0</td>
<td>-0.92</td>
<td>-1.52</td>
<td>0</td>
<td>-1.92*</td>
<td>-3.17*</td>
</tr>
<tr>
<td>NEER</td>
<td>1</td>
<td>-1.12</td>
<td>-1.90</td>
<td>1</td>
<td>-2.43**</td>
<td>-3.34**</td>
</tr>
</tbody>
</table>

Notes: ***; **; * signify 1%, 5% and 10% significance level respectively
The DFGLS test results for the time series are listed in Table 3.4. Starting from the first differences of the time series, the null hypothesis of unit root is rejected. This suggests that the first differences of the time series are stationary. Following this, we tested the time series in level and failed to reject the null hypothesis of unit root, which implies that the level series are non-stationary.

3.4 Variables Selected for Identifying the Bank Lending Channel in China

Aguiar and Drumond (2006), Van den Heuvel (2007), and Gomez-Gonzalez and Grosz (2007) noted that bank capital influences the loan supply through changes in capital requirements. Furthermore, the interbank interest rate is used as the monetary policy instrument to influence bank loans (Gomez-Gonzalez and Grosz, 2007; Mello and Pisu, 2009) because it reflects the cost of a bank’s borrowing that further affects a bank’s lending. However, this study does not utilize these two variables for the following reasons. First, commercial banks in China have no strictly imposed capital adequacy regulations. Secondly, the interbank interest rate does not influence the commercial bank lending rates that are under the PBC’s regulation. Geiger’s (2006, 2008) research showed that changes in interbank interest rates do not have any effect on bank loans in China.

This research uses the total loans of financial institutions, official benchmark annualized one-year loan interest rate (RC) and required reserve ratio (RR) as the proxy for bank loan (BL) and the two policy instrument variables that influence loan demand and supply, respectively. The required reserves ratio is changed frequently by the PBC. Therefore, it is important to consider the effects of changes in the required reserve ratio on the variations of bank credit in China. Since the required reserves are levied solely on banks, the identification problem is much less acute for this policy variable. GDP is used as real activity variable that influences loan demand. The credit aggregate and GDP are deflated by the consumer price index (CPI) and defined in log terms. We also included seasonal dummy variables in the VECM, which consider the possibility of seasonal factors in the GDP and loan aggregate. Quarterly data from 1997:Q1 to 2008:Q4 were obtained from the PBC quarterly statistical bulletin. We conducted the ADF unit root test on all relevant time series and report the results in Table 3.5.
Table 3.5 Results of ADF Unit Roots Test for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>K</th>
<th>( \tau )</th>
<th>( \Phi_3 )</th>
<th>( \tau_\mu )</th>
<th>( \Phi_1 )</th>
<th>( \tau )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>1</td>
<td>-2.12</td>
<td>3.23</td>
<td>0.86</td>
<td>8.35***</td>
<td>4.05</td>
</tr>
<tr>
<td>BL</td>
<td>2</td>
<td>-0.81</td>
<td>4.39</td>
<td>2.66</td>
<td>17.74***</td>
<td>5.82</td>
</tr>
<tr>
<td>PI</td>
<td>6</td>
<td>-0.47</td>
<td>4.21</td>
<td>1.08</td>
<td>1.84</td>
<td>1.59</td>
</tr>
<tr>
<td>RR</td>
<td>1</td>
<td>-1.90</td>
<td>5.10</td>
<td>-1.15</td>
<td>0.67</td>
<td>-0.20</td>
</tr>
<tr>
<td>RC</td>
<td>1</td>
<td>-0.57</td>
<td>0.42</td>
<td>-0.69</td>
<td>1.00</td>
<td>-1.35</td>
</tr>
</tbody>
</table>

| Difference |    |           |        |        |       |     |
| GDP        | 0  | -11.60*** | 67.42*** | -11.43*** | 65.36*** | -9.26*** |
| BL         | 1  | -6.90***  | 23.82*** | -5.80***  | 16.87*** | -2.40**  |
| PI         | 5  | -4.13**   | 8.93**  | -2.78*   | 3.92    | -2.26**  |
| RR         | 0  | -5.98***  | 18.01*** | -5.16***  | 13.36*** | -5.22**  |
| RC         | 0  | -3.10     | 5.39    | -3.21**  | 5.40**  | -3.02*** |

Notes: ***; **; * signify 1%, 5% and 10% significance level respectively.

In difference, the \( \tau \) statistics are all significant at the 5% level. Thus, the null hypothesis of unit root is rejected. This suggests that the first differences of the time series are stationary. In level, the \( \tau \) statistics are insignificant at the 10% level for all time series. We failed to reject the unit root hypothesis and hence they are non-stationary. The DFGLS unit root test results are shown in Table 3.6. The results are consistent with the ADF test. In difference, the hypothesis of unit root is rejected for all variables that are stationary.

Table 3.6 Results of DFGLS Unit Root Tests for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>K</th>
<th>Constant</th>
<th>Constant and trend</th>
<th>k</th>
<th>Constant</th>
<th>Constant and trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>Difference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>1</td>
<td>2.02</td>
<td>-1.76</td>
<td>0</td>
<td>-10.13***</td>
<td>-11.30***</td>
</tr>
<tr>
<td>BL</td>
<td>0</td>
<td>0.70</td>
<td>-0.92</td>
<td>2</td>
<td>-2.70***</td>
<td>-3.89***</td>
</tr>
<tr>
<td>PI</td>
<td>4</td>
<td>-0.98</td>
<td>-2.06</td>
<td>4</td>
<td>-2.08**</td>
<td>-2.92*</td>
</tr>
<tr>
<td>RR</td>
<td>1</td>
<td>-0.98</td>
<td>-1.29</td>
<td>0</td>
<td>-5.18***</td>
<td>-5.67</td>
</tr>
<tr>
<td>RC</td>
<td>1</td>
<td>0.68</td>
<td>-2.01</td>
<td>0</td>
<td>-3.30***</td>
<td>-3.08*</td>
</tr>
</tbody>
</table>

Notes: ***; **; * signify 1%, 5% and 10% significance level respectively. K stands for the lag length that is determined by SIC. The results are obtained using Eviews 6. The sample period is 1997:Q1-2008:Q4.
3.5 Variables Selected for Evaluating the McCallum Rule

Our study uses the GDP target and real effective exchange rate from 1994:Q1 to 2009:Q1, and monetary base and nominal GDP from 1990:Q1 to 2009:Q1 to study the McCallum Rule. We chose 1994 as the starting point since the third phase of China’s economic reforms started then. During the third phase, the official and market exchange rates were unified and current account transactions were liberalized. In addition, the banking reform included the establishment of three policy (non-commercial) banks and separating policy finance from more commercially oriented activities. In the same year, the PBC started the monetary targeting regime using M2 as the intermediate target.

To construct the time series for $\Delta VB$ (average value of previous four years) starting from 1994:Q2 ($VB = \text{NGDP}/\text{MB}^7$), we used the monetary base and nominal GDP data from 1990:Q1. However, officially released quarterly data for the monetary base are available only from 1993:Q1 (The People’s Bank of China Quarterly Statistical Bulletin). Therefore, we utilized annual data for the monetary base and M1 from International Financial Statistics (IFS) to calculate the money multiplier for the period 1990-1992. Based on the calculated money multiplier and officially released quarterly data for M1 from 1990:Q1 to 1992:Q4, we obtained the quarterly data for the monetary base from 1990:Q1 to 1992:Q4.

Another important time series in the McCallum Rule is the nominal GDP target but it is unavailable for China since the Chinese government released only the annual real GDP target instead of the annual nominal GDP target. McCallum uses the sum of the average long-run real GDP growth rate and the target inflation rate as a proxy for the nominal GDP target. In China, the government announces a real GDP target and a RPI or CPI inflation target every year in the Report on the implementation of the plan for National Economic and Social Development and on the Protocol for National Economic and Social development. Although the RPI (retail price index) or CPI (consumer price index) inflation rate are not exactly equal to the GDP deflator inflation rate, we preferred the former to the latter, since the GDP deflator is a realized value not a target value. Furthermore, we do not know how the current

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7 NGDP and MB stand for nominal GDP and Monetary base in level.
changes in GDP are divided into the GDP deflator and real output growth. Before 1997, the Chinese government announced a RPI inflation rate target instead of the CPI inflation rate target, and announced a RPI and CPI inflation target rate simultaneously between 1998 and 2000. The annual CPI inflation target rate, which became available only from 2001, exceeded the annual RPI inflation target rate for the same period by 2%.

To construct a complete time series for the CPI inflation target, we added 2% to the RPI inflation target rate for 1994-1997 to approximate the CPI inflation target values for the same period. Following this, we added the CPI inflation target rate to the officially announced real GDP target growth rate to obtain a time series for the annual nominal GDP growth rate target. The annual values for the nominal GDP growth target rate are interpolated into quarterly values using the following formula:

$$Qr = (1 + ar)^{1/4} - 1$$  \hspace{1cm} (3.16)

Where $ar$ denotes annual growth rate and $Qr$ is the interpolated quarterly growth rate.

Data on the exchange rate (quarterly average real effective exchange rate) were obtained from the Bank for International settlement (BIS) monthly average real effective exchange rate using the simple average method with the year 2005 equal to 100.

The results of ADF and DFGLS tests on monetary base growth rate ($\Delta B$), monetary base velocity change rate ($\Delta VB$), nominal GDP growth rate ($\Delta X$), real effective exchange rate change rate ($\Delta S$) are reported in Table 3.7 and 3.8, respectively. The results of both ADF and DFGLS tests show all time series are stationary. The $\tau$ statistics from the ADF test are significant at 5% level for all time series. Therefore, we can reject the null hypothesis of unit root. When including the constant alone, DFGLS also reported all time series reject the null hypothesis of unit root at 5% level.
Table 3.7 Results of ADF Unit Root Tests for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>$K$</th>
<th>$\tau_\tau$</th>
<th>$\Phi_3$</th>
<th>$\tau_\mu$</th>
<th>$\Phi_1$</th>
<th>$\tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta B$</td>
<td>1</td>
<td>-3.91**</td>
<td>7.71**</td>
<td>-3.89***</td>
<td>7.65**</td>
<td>-2.28**</td>
</tr>
<tr>
<td>$\Delta VB$</td>
<td>1</td>
<td>-2.63</td>
<td>4.56</td>
<td>-2.95**</td>
<td>4.35*</td>
<td>-2.95**</td>
</tr>
<tr>
<td>$\Delta X$</td>
<td>0</td>
<td>-2.21</td>
<td>2.57</td>
<td>-2.23</td>
<td>6.74**</td>
<td>-2.10**</td>
</tr>
<tr>
<td>$\Delta S$</td>
<td>0</td>
<td>-5.22***</td>
<td>13.70***</td>
<td>-5.22***</td>
<td>13.65***</td>
<td>-4.96***</td>
</tr>
</tbody>
</table>

Notes: ***, **, * signify 1%, 5% and 10% significance level respectively

Table 3.8 Results of DFGLS Unit Root Tests for Time Series

<table>
<thead>
<tr>
<th>Series</th>
<th>$K$</th>
<th>Constant</th>
<th>Constant and Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta B$</td>
<td>2</td>
<td>-2.04**</td>
<td>-2.83*</td>
</tr>
<tr>
<td>$\Delta VB$</td>
<td>1</td>
<td>-2.09**</td>
<td>-2.81*</td>
</tr>
<tr>
<td>$\Delta X$</td>
<td>0</td>
<td>-12.39***</td>
<td>-12.29***</td>
</tr>
<tr>
<td>$\Delta S$</td>
<td>0</td>
<td>-4.46***</td>
<td>-5.16***</td>
</tr>
</tbody>
</table>

Notes: ***, **, * signify 1%, 5% and 10% significance level respectively

3.6 Conclusion

In this chapter, we selected the variables that will be used to test different monetary policy transmission channels based on theory. In the light of Enders (2004), macroeconomic variables, for example GDP, financial aggregates, interest rates and exchange rates, have time-dependent means and variances increasing over time. Therefore, after describing the concept of the data integration property, we used the ADF test and the Dickey-Fuller test with the detrending method to test the order of integration of our time series data. We found that all the time series data, except for short-term interest rates, were integrated of $I(1)$. For this reason, when testing whether an effective interest rate exists in China, we used the first different data to construct a difference VAR. A cointegration relationship existed among the related variables credit aggregate, price level, bank lending interest rate, GDP and required reserve ratio. Therefore, in next chapter, we can use a cointegration approach together with restrictions on the cointegrated relationship to test the bank lending channel. Moreover, the $I(0)$ properties of the monetary base growth rate ($\Delta B$), monetary base velocity change rate ($\Delta VB$), nominal GDP growth rate ($\Delta X$), real effective exchange
rate change rate (ΔS) ensure that OLS method can be used in estimating the coefficients in the macroeconomic condition model before we conduct the simulation.
CHAPTER 4
RESEARCH METHODOLOGY

4.1 Introduction

This chapter introduces the three different research methodologies used in the study. Section 4.2 presents the Vector Autoregressive (VAR) method used to test the effects of short-term interest rates on output and price level. Section 4.3 describes the cointegration method used to identify the bank lending channel in China. Section 4.4 discusses a counterfactual simulation method used to study the McCallum Rule.

4.2 Vector Autoregressive Method

Since Sims’s seminal paper in 1980, the VAR framework has been widely used in macroeconomics research because it allows the direct estimation of the joint stochastic processes describing the variables under consideration. If a researcher is unclear about which variable is endogenous and which is exogenous, the VAR method allows the researcher to treat all variables as jointly endogenous. Researchers using VAR to identify transmission of monetary policy in advanced economies include Christiano, Eichenbaum, and Evans (2000) for the United States, Kim and Nouriel, (2000) for the G-7 economies, and Peersman and Smets (2003) for the Euro area. Era and Holger (2007) and Cheng (2006) used the VAR framework to study the monetary policy transmission mechanism in developing countries Armenia and Kenya separately. The basic concepts underlying the VAR modelling process can be summarized as follows:

Let \( Y_t \) be a \( n \times 1 \) vector of variables, \( \epsilon_t \) a \( n \times 1 \) vector of mean zero structural innovations and \( B(L) = B_0 - B_1 L - B_2 L^2 - \ldots - B_p L^p \) a \( n \times n \) matrix polynomial in the lag operator. The \( p \)th order structural VAR model is written as:

\[
B(L)Y_t = \epsilon_t; \quad E\epsilon_t, \epsilon_t' = \Lambda; \quad E\epsilon_t, \epsilon_{t+s} = 0, \quad \forall s \neq 0
\]  

(4.1)

where \( \Lambda \) is a diagonal matrix. \( B_0 \) is a non-singular normalized matrix with ones on the diagonal. This matrix summarizes the contemporaneous relationships between the variables of the model. The coefficients are unknown and the variables have contemporaneous effects, so this VAR cannot be estimated directly because standard
estimation techniques require that the regressors be uncorrelated with the error term. We therefore transform equation (4.1) into a reduced form VAR:

\[ Y_t = A(L)Y_t + \mu_t; \quad E\mu_t\mu_t' = \Sigma; \quad E\mu_t\mu_{t+s} = 0, \forall \neq 0 \]  

(4.2)

where \( A(L) = B_0^{-1}B(L) = I - AL - A_2L^2 - \ldots - A_pL^p \) and \( \mu_t = B_0^{-1}\epsilon_t \).

The error terms \( \mu_t \) are composites of the underlying shocks \( \epsilon_t \). Equation (4.2) contains only predetermined variables and the errors terms are assumed to be serially uncorrelated with constant variance. Hence, each equation in the VAR system can be estimated using OLS. Furthermore, the OLS estimates are consistent and asymptotically efficient. The model must be exactly or over-identified in order to estimate the structural model. We adopt the identification method proposed by Sims (1980) based on the Choleski decomposition of the structural innovations to solve the identification problem. In order to recover the structural parameters from the reduced form model, so that the innovations in Choleski decomposition have a direct economic interpretation, there must be the same number of parameters in \( B_0 \) and \( \Lambda \) as there are in \( \Sigma \), the variance-covariance matrix of the reduced form.

Combining equations (4.1) and (4.2), the variance-covariance matrix, \( \Sigma \) can be expressed as follows:

\[ \Sigma = (B_0^{-1})\Lambda(B_0^{-1})' \]  

(4.3)

Consistent estimates of \( B_0 \) and \( \Lambda \) can be obtained through the sample estimation of \( \Sigma \) that can be estimated by OLS. The right hand side of equation (4.3) contains \( n \times (n+1) \) parameters to be estimated whereas the left-hand side contains only \( n \times (n+1)/2 \) parameters; we need \( n \times (n+1)/2 \) restrictions to achieve identification. If the \( n \) diagonal elements of \( \Lambda \) are set to one, all that is required is a further \( n \times (n-1)/2 \) restriction on \( B \). In the Choleski decomposition scheme, the identification of structural shocks depends on the ordering of the variables. It corresponds to a recursive economic structure with the most endogenous variable ordered last.
Following identification of the structural shocks of the interest rate, the standard practice in VAR analysis is to report results from Granger-causality tests, impulse responses, and forecast error variance decompositions (Stock and Watson, 2001). Because of the complicated dynamics in the VAR, these statistics are more informative than the estimated VAR regression coefficients or $R^2$ statistics, which typically go unreported (Stock and Watson, 2001).

One of the main uses of VAR model is forecasting and the structure of the VAR model provides information about a variable’s or a group of variables’ forecasting ability for other variables. According to Granger (1969), if a variable, or a group of variables $y_1$ is helpful for predicting another variable, or a group of variables $y_2$, then $y_1$ is said to Granger-cause $y_2$, otherwise it fails to Granger-cause $y_2$. Formally, $y_1$ fails to Granger-cause $y_2$ if for all $s > 0$ the MSE (mean square error) of a forecast of $y_{2,s+s}$ based on $(y_{2,s}, y_{2,s-1}, \ldots)$ is the same as the MSE of a forecast of $y_{2,s+s}$ based on $(y_{1,s}, y_{1,s-1}, \ldots)$ and $(y_{1,s+1}, y_{1,s-1}, \ldots)$. Clearly, the notion of Granger causality does not imply true causality. It implies only forecasting ability.

The impulse response function can be computed based on equations (4.2) and (4.1) as follows. First, we decompose the residual covariance matrix $\Sigma$ as $\Sigma = CDC^\top$; where $C$ is an invertible lower triangular matrix with ones along the diagonal and $D$ is a diagonal matrix with positive diagonal elements. Next, we define the structural errors as $\varepsilon_t = C^{-1}\mu_t$. These structural errors are orthogonal by construction since

$$\text{var}(\varepsilon_t) = C^{-1}\Sigma C^{\top} = C^{-1}CDC^\top = D$$

(4.4)

Any covariance stationary VAR($p$) process similar to equation (4.2) has a Wold representation of the form, where $\Psi_s$ is $(n \times n)$ moving average matrices

$$Y_t = \mu_t + \Psi_1 \mu_{t-1} + \Psi_2 \mu_{t-2} + \ldots$$

$$= CC^{-1}\mu_t + \Psi_1 \mu_{t-1} + \Psi_2 \mu_{t-2} + \ldots$$

$$= \Theta_0 \varepsilon_t + \Theta_1 \varepsilon_{t-1} + \Theta_2 \varepsilon_{t-2} + \ldots$$

(4.5)
where \( \Theta_j = \Psi_j A \), the matrices \( \Psi_s \) are determined by recursive substitution \( \Psi_s = \sum_{j=1}^{n-1} \Psi_{s-j} A_j \), with \( \Psi_0 = I_n \) and \( A_j = 0 \) for \( j > p \). The structural \( B \) matrix in equation (4.1) is equal to \( C^{-1} \).

The impulse responses to the orthogonal shocks \( \varepsilon_j \) are
\[
\frac{\partial y_{i,t+s}}{\partial \varepsilon_{i,j}} = \frac{\partial y_{i,j}}{\partial \varepsilon_{i,j-s}} = \theta_{ij} \quad i, j = 1, \ldots, n; s > 0
\]
(4.6)

Where \( \theta_{ij} \) is the \((i, j)\) element \( \Theta_s \). A plot of \( \theta_{ij} \) against \( s \) is called the orthogonal impulse response function of \( y_i \) with respect to \( \varepsilon_j \). With \( n \) variables, there are \( n^2 \) possible impulse response functions.

The forecast error variance decomposition (FEVD) answers the question: what portion of the variance of the forecast error in predicting \( y_{i,t+h} \) is due to the structural shock \( \varepsilon_j \)? Using the orthogonal shocks \( \varepsilon_i \) the \( h \)–step ahead forecast error vector, with a known VAR coefficient, may be expressed as:
\[
Y_{t+h} - Y_{t+h|t} = \sum_{s=0}^{h-1} \Theta_s \varepsilon_{t+h-s}
\]
(4.7)

For a particular variable \( y_{i,t+h} \), this forecast error has the form
\[
y_{i,t+h} - y_{i,t+h|t} = \sum_{s=0}^{h-1} \theta_{i1}^s \varepsilon_{1,t+h-s} + \cdots + \sum_{s=0}^{h-1} \theta_{in}^s \varepsilon_{n,t+h-s}
\]
(4.8)

Since the structural errors are orthogonal, the variance of the \( h \)–step forecast error is
\[
\text{var}(y_{i,t+h} - y_{i,t+h|t}) = \sigma^2_{\varepsilon_j} \sum_{s=0}^{h-1} (\theta_{i1}^s)^2 + \cdots + \sigma^2_{\varepsilon_n} \sum_{s=0}^{h-1} (\theta_{in}^s)^2
\]
(4.9)

where \( \sigma^2_{\varepsilon_j} = \text{var}(\varepsilon_j) \). The portion of \( \text{var}(y_{i,t+h} - y_{i,t+h|t}) \) due to shock \( \varepsilon_j \) is:
\[
\text{FEVD}_{i,j}(h) = \frac{\sigma^2_{\varepsilon_j} \sum_{s=0}^{h-1} (\theta_{i1}^s)^2}{\sigma^2_{\varepsilon_j} \sum_{s=0}^{h-1} (\theta_{i1}^s)^2 + \cdots + \sigma^2_{\varepsilon_n} \sum_{s=0}^{h-1} (\theta_{in}^s)^2}, \quad i, j = 1, \ldots, n
\]
(4.10)

In a VAR with \( n \) variables there will be \( n^2 \) \( \text{FEVD}_{i,j}(h) \) values. We must keep in mind that the FEVD in equation (4.10) depends on the recursive causal ordering used...
to identify the structural shocks \( \varepsilon_t \) and is not unique. Different causal ordering will produce different FEVD values (Zivot and Wang, 2003).

The variables in the model should be stationary for the model to be meaningful in modelling the relationships among the outputs, prices, and policy-related variables in a VAR. However, the unit root tests have shown nonstationarity for some time series used in our study. Sims (1980A) and Sims and Stock and Watson (1990) recommended against differencing when the related variables are cointegrated (the cointegration procedure will be discussed in next the section) even if the variables contain a unit root. They argued that the goal of a VAR analysis is to determine the interrelationships among the variables, not to determine the parameter estimates. Conducting the analysis in levels allows for implicit cointegration relationship in the data. However, if the related \( I(1) \) variables are not cointegrated, it is preferable to use the first difference. There are three consequences if the \( I(1) \) variables are not cointegrated and one estimates the VAR in level. The first consequence is the test loses its power because we estimate \( n^2 \) with more than one parameter. The second is the test for Granger causality on the \( I(1) \) variables, which do not have a standard \( F \) distribution for a VAR in levels. The last is when the VAR has \( I(1) \) variables, the impulse responses at long forecast horizons are inconsistent estimates of the true response.

Enders (2004) noted that the lag length test can be performed regardless of the variables in question are stationary or integrated. Eviews 6 selects the lag length of our VAR model using the VAR lag order selection criteria. All the information criteria select a lag order of one. The residual test suggests that we can reject autocorrelation and heteroskedasticity at the conventional 5% level of significance. Based on the selected lag length, we performed two cointegration tests; one for the same five variables in the level VAR, and exclude the short-term interest rates in the second test. The results show that when short-term interest rates are included in the VAR, we fail to reject the null hypothesis of no cointegration (see Table 4.1). In this study, we use the first order difference of the related variables to construct a VAR model.
The vector of endogenous variables in our benchmark model, equation (4.11), consists of real GDP (GDP), the consumer price index (CPI), monetary aggregate (M), interbank market borrowing rate (INTm) and nominal effective foreign exchange rate (NEER). We replaced the interbank market bond repurchase rate (INTr) with INTm in equation (4.12) to test the robustness of our results:

\[
Y_t = \left[\text{GDP}, \text{CPI}, \text{M}, \text{INTm}, \text{NEER}\right] \quad (4.11)
\]

\[
Y_t = \left[\text{GDP}, \text{CPI}, \text{M}, \text{INTr}, \text{NEER}\right] \quad (4.12)
\]

Equation (4.11) and (4.12) show the ordering of the variables. When using Choleski decomposition method to identify structural shocks, the ordering of variables is of crucial importance. According to Favero (2001), monetary variables should be ordered last, since they are expected to react faster to real economy than otherwise. Belke and Polleit (2010) strongly support Favero’s principle of ordering variables.

The Chinese government sets its real GDP growth rate and inflation rate every year, and they are real variables. Currently, money supply is still PBC’s policy operating target, and short-term interests are assumed to be endogenous. Under the managed floating foreign exchange rate regime, exchange rate is determined by domestic and international together, so it is assumed to be most endogenous variable. For these reason, we assumed that prices (CPI) have no immediate effects on output (GDP), money stock (M) has no immediate effect on prices, monetary policy shock (INTm) has no immediate effect on the money stock and the nominal effective exchange rate (NEER) has no immediate effect on the money policy. Technically, this means we first estimate the reduced form of the benchmark model equation (4.11) then compute

---

**Table 4.1 Result of Johansen Cointegration Test**

<table>
<thead>
<tr>
<th>Variables: GDP, CPI, M, INTm, NERR (p=1)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$ Trace 5% Critical Value Max-Eigen 5% Critical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value $r = 0$</td>
<td>76.72</td>
<td>88.03</td>
<td>27.07</td>
<td>38.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables: GDP, CPI, M, NEER (p=1)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$ Trace 5% Critical Value Max-Eigen 5% Critical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value $r = 0$</td>
<td>67.50</td>
<td>54.07</td>
<td>35.99</td>
<td>28.58</td>
</tr>
</tbody>
</table>

This table reports two Johansen cointegration test results, one for the five variables in the level VAR, and one excluding the short-term interest rate variable.

---
the Cholesky factorization of the reduced form VAR covariance matrix. In other words, the relations between the reduced form errors and the structural disturbances are given as follows:

$$
\begin{bmatrix}
\varepsilon_{t, GDP}^C \\
\varepsilon_{t, CPI}^M \\
\varepsilon_{t, M}^{INTm} \\
\varepsilon_{t, NEER}^5 \\
\end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
\end{bmatrix}
\begin{bmatrix}
\mu_{t, GDP}^C \\
\mu_{t, CPI}^M \\
\mu_{t, M}^{INTm} \\
\mu_{t, NEER}^5 \\
\end{bmatrix}
$$

(4.13)

4.3 Johansen Cointegration Tests and Vector Error Correction Model

In this section, we present the econometric framework and the procedures used to identify the bank lending channel. We model China’s bank lending activity using a vector error correction model (VECM). We then test for cointegration using the Johansen procedure.

Suppose $X_t$ represents a column vector of integrated order-$d$ variables. If some linear combination of these $I(d)$ variables, denoted $\beta X_t (\beta \neq 0)$ is integrated of order $d' < d$, then the variables $Y_t$ are said to be cointegrated of order $d-d'$ with cointegration vector $\beta$ (Engle and Granger, 1987). The most important case is where $d' = 0$, since this condition implies that the cointegration relation $\beta X_t$ is integrated of order zero, and hence is stationary. The stationarity condition allow us to interpret the stationary cointegrating relationship, $\beta X_t \sim I(0)$, among the series $X_t$ as a stable long-run “equilibrium” relationship since this specific set of variables obeys certain long-run equilibrium constraints. The intuition behind the concept of cointegration is that, even though the level variables are non-stationary, which is, dominated by their long-run components, certain linear combinations of these variables can be stationary. In these circumstances, the long-run components of the series cancel each other out to produce a stationary time series. Such variables are then said to be cointegrated, and the vectors of coefficients of the linear combinations are called the cointegrating vectors. The estimation methods for cointegration analysis fall into two categories: single equation method and system method. Phillips (1991)
demonstrated that the best approach to the estimation of a cointegarted system is the Johansen maximum likelihood procedure (Johansen, 1991). The Johansen maximum likelihood procedure ensures that the coefficient estimates obtained through this procedure are systematically distributed, median unbiased, and asymptotically efficient, and that hypothesis tests may be conducted using standard asymptotic Chi-square tests.

A principal feature of cointegrated variables is that their short-run dynamics must be influenced by the deviation from long-run equilibrium. The dynamic model implied by this feature is one of the error corrections. In an error-correction model, the short-run dynamics of the variables in the system are influenced by the deviation from equilibrium.

The Johansen (1991) multivariate cointegration procedure is based on the $k$th order vector autogression (VAR) model.

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_k Y_{t-k} + \mu + \Phi D_t + \epsilon_t$$

(4.14)

Where $Y_t = (Y_1, Y_2, \cdots, Y_p)'$ is a $p \times 1$ vector of jointly endogenous $I(1)$ variables. $A_i (i = 1, 2, \cdots, k)$ is a $p \times p$ matrix of parameters, $\mu$ is a $p \times 1$ vector of constant to represent deterministic trend, $D_t$ are centred seasonal dummy variables orthogonal to $\mu$, and $Y_{t-k}, \ldots, Y_{0}$ are fixed initial values. The $p \times 1$ random disturbance vector $\epsilon_t$ is assumed to be distributed independent and identically normal with zero mean and covariance matrix $\Omega$.

To highlight explicitly the distinction between the short-run dynamics and long-run static disequilibrium response the vector autoregressive model given in question is rewritten as a vector error-correction form as:

$$\Delta Y_t = B_1 Y_{t-1} + B_2 \Delta Y_{t-2} + \cdots + B_k \Delta Y_{t-k+1} + \mu + \Phi D_t + \epsilon_t$$

(4.15)
Where \( B_k = -I + \sum_{i=1}^{k} A_i \) and \( B_j = -\sum_{i=j}^{k} A_i \) for \( j = 2, \ldots, k \). In this reformulated model the matrices \( B_2, \ldots, B_k \) capture the short-run dynamic effects of the system since they are the coefficient matrices of the stationary lagged difference terms \( \Delta Y_{t-1}, \ldots, \Delta Y_{t-k+1} \). On the other hand, \( B_1 \) describes the long-run statistic equilibrium relationship that exists within the system since it contains the stationary linear combination of the integrated level variables \( Y_{t-1} \). As such, the coefficient matrix \( B_1 \) is called the long-run impact matrix.

Johansen (1991) showed that the number of distinct stationary cointegration relationships \( r \) among the variables \( Y_t \) is given the rank of \( B_1 \), where \( 0 < \text{rank}(B_1) = r \leq p - 1 \). This reduced rank condition permits the null hypothesis of at most \( r \) distinct stationary cointegrating vectors \( H_1(r) \), to be formulated as:

\[
H_1(r) : B_1 = \alpha \beta
\]  

(4.16)

Where \( \alpha \) and \( \beta \) are both \( p \times r \) matrices of full rank \( r \). The columns of \( \beta \) are interpreted as the \( r \) stationary cointegrating vectors of the systems \( Y_t \). That is, \( \beta \) has the property that the linear combinations \( \beta Y_t \) are stationary even though \( Y_t \) is itself non-stationary (Engle and Granger 1987). The \( i \)th row of \( \alpha \) measures the contribution of the vector error-correction model. More specifically, the individual values \( \alpha_{ir} \) indicate the force with which \( i \)th equation responds to disequilibrium in the \( r \)th cointegrating relations. The larger the absolute value of \( \alpha_{ir} \), the faster is the force of adjustment. As such, the matrix \( \alpha \) is often interpreted as a matrix of error-correction or adjustment parameters.

Since the Johansen procedure focuses on \( \alpha \) and \( \beta \), it first eliminates \( B_2, \ldots, B_k \). This estimation procedure proceeds by first adjusting the differenced and level series \( \Delta Y_t \) and \( Y_{t-1} \) for all short-run dynamic effects in the model. This is achieved by regressing \( \Delta Y_t \) and \( Y_{t-1} \) individually on \( \Delta Y_{t-1}, \ldots, \Delta Y_{t-k+1} \) and a constant and obtaining the two
$p \times 1$ least squares residual vectors $R_{0t}$ and $R_{tt}$, respectively. $R_{0t}$ and $R_{tt}$ are interpreted as the differenced and level series adjusted for short-run dynamics. These residual vectors are then used to reformulate the model as:

$$R_{ot} = a \beta' R_{tt} + \text{error}$$  \hspace{1cm} (4.17)

which is a standard reduced rank regression model only in the unknown parameters $\alpha$ and $\beta$.

The Johansen procedure maximizes the likelihood function with respect to $\alpha$ and $\beta$ and shows that the maximum of the likelihood function is obtained by solving the eigenvalue problem

$$\left| \lambda S_{11} - S_{10} S_{00}^{-1} S_{01} \right| = 0$$  \hspace{1cm} (4.18)

The matrices $S_{ij} = T^{-1} \sum_{t=1}^{T} R_{u_t} R_{u_t}$ ($i, j = 0, 1$) are the corresponding $p \times p$ residual product moment matrices of $R_{0t}$ and $R_{tt}$. Let $\lambda = (\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots > \hat{\lambda}_r > \ldots > \hat{\lambda}_p)$ be the corresponding estimated eigenvalues of equation (4.15) and let $\nu = (\hat{\nu}_1, \ldots, \hat{\nu}_r, \ldots, \hat{\nu}_p)$ be the corresponding estimated eigenvectors normalized such that $\nu' S_{11} \nu = I$.

The roots of equation (4.18), $\lambda = (\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots > \hat{\lambda}_r > \ldots > \hat{\lambda}_p)$, represent the $r$ squared canonical correlations between $R_{0t}$ and $R_{tt}$. The corresponding eigenvectors $\nu_i$ define the directions in which the linear combinations $\hat{\nu}_i Y_t$ are correlated with the stationary process, $R_{tt}$. Thus, $\hat{\lambda}_i$ measures how strongly the linear combination $Y_{t-1}$ is correlated with the stationary part of the system $\Delta Y_t$ after correcting for short-run dynamics.

The number of cointegrating vectors is generally unknown and all estimated eigenvalues $\hat{\lambda}_i$ are nonzero. To determine the number of stationary cointegrating
relationships one must therefore statistically discriminate between nonzero and zero eigen-values. Johansen (1988, 1991) proposed two likelihood ratio test statistics for testing the hypothesis of $r$ cointegrating vectors. They are called the trace statistic and the $\lambda_{\text{max}}$, or maximal eigen-value, statistic. The trace statistic tests the null hypothesis $r \leq r_0$ against the alternative $r > r_0$ for $r_0 = (0,1,\ldots,p)$ and is defined as

$$Q_{\text{Trace}}(H_1(r \leq r_0) \mid H_1(p)) = -T \sum_{i=r_0+1}^{p} \ln(1 - \hat{\lambda}_i)$$  \hspace{1cm} (4.19)$$

Where $\hat{\lambda}_{r_0+1} > \hat{\lambda}_{r_0+2} > \ldots > \hat{\lambda}_p$ are the $p - r_0$ smallest estimated eigen-values of equation (4.19). In contrast, the maximal eigen-value statistic tests the null hypothesis $r = r_0$ against the alternative $r = r_0 + 1$ and is defined as

$$Q_{\text{Max}}(H_1(r = r_0) \mid H_1(r = r_0 + 1)) = -T \ln(1 - \hat{\lambda}_{r_0+1})$$  \hspace{1cm} (4.20)$$

The main difference between these two statistics is that the maximal eigen-value statistic tests the null against a specific alternative, whereas the trace statistic tests against a general alternative. The intuition behind these test statistics is straightforward. Since the cointegrating relationships are associated with non-zero eigen-values testing the null of $r$ cointegrating vectors is equivalent to testing how many of the largest order eigen-values are significantly different from zero or equivalently, how many of the smallest ordered eigen-values are not significantly different from zero.

In the case of the trace statistic, if the null hypothesis of at most $r_0$ cointegrating vectors is true, then there must be $p - r_0$ estimated eigen-values that are not statistically different from zero, or equivalently, if the calculated trace statistic $Q_{\text{Trace}}$ is large. Analogously, for the maximal eigen-value statistic, if the null hypothesis of exactly $r_0$ cointegrating vectors is true, then we would expect the estimated $r_0 + 1$ ordered eigen-value $\hat{\lambda}_{r_0+1}$ to be not statistically different from zero. Thus, we would reject this null if $\hat{\lambda}_{r_0+1}$ is small, or equivalently, if the calculated value of the
maximaleigen-value statistic $Q_{Mac}$ is large. In both cases, the testing procedure is sequential commencing with the null hypothesis $H_1: R = 0$ and ending when one first fails to reject the null hypothesis under test. In either case, the null hypothesis is rejected if the calculated test statistic exceeds its corresponding critical value.

In general, the trace statistic tends to have greater power than the maximal eigen-value statistic when $\hat{\lambda}_i$'s are evenly distributed. The reason is that the trace statistic takes into consideration all $p-r_0$ smallest eigen-values. In contrast, the maximal eigen-value statistic has greater power when the $\hat{\lambda}_i$'s are either too large or small.

Under the null hypothesis of $r = r_0$ cointegrating vectors, the asymptotic distribution of both the trace and the maximal eigen-value statistics are non-standard. However, the critical values for these test statistics are tabulated by simulation in Johansen and Juselius (1990) and Osterwald-Lenum (1992).

The Johansen technique determines how many independent cointegrating relationships exist among the set of variables considered. However, the estimated parameter values in the $r$ cointegrating relations are not unique. In addition, when $r > 1$, we need other conditions to identify the parameters of the structural equations of the system in question. Therefore, we need to test the restrictions on the elements of the $\alpha$ and $\beta$ parameters matrices. The test of $\alpha$ allows us to identify which of the equations in the system the cointegrating vectors enter and at what magnitude. The test of $\beta$ is concerned with restrictions on the parameters within the long run relationships themselves. The test of $\beta$ is particularly important since the objective is to extract estimates of the structural equations that underline the reduced form. The parameter estimates obtained after having specified how many cointegrating relationships exist are the unrestricted reduced form parameter estimates.

When $r = 1$, the parameter estimates of the single cointegration relationship can be read directly from the estimated $\beta$ vector. There is no difference between the reduced form and structural model in this case. The estimated parameter values can be
obtained by following a conventional normalization, in which the variable is regarded as the dependent variable in the relationship and is given a coefficient of -1.

When \( r > 1 \), it is not rational to take the unrestricted estimates of the vectors in \( \beta \) directly as economically meaningful long run parameter estimates. In addition to the normalization problem, it is necessary to impose and test restrictions on the elements of \( \beta \) to identify the long-run structural relationships between the variables. An important part of this exercise is to conduct the long-run exclusion tests (i.e. the parameters associated with particular variables have zero coefficients). Johansen (1995) and Juselius (2006) discussed the formal description of this procedure as follows:

Let \( R_i \) denote a \( p \times m \) restriction matrix and \( H_i = R_i^\perp \), a \( p \times s \) design matrix \((m_i + s_i = p1)\) so that \( R_iH_i = 0 \). Thus, there are \( m_i \) restrictions and consequently \( s_i \) parameters to be estimated in the \( i \)th relation. The cointegrating relations are assumed to satisfy the restriction \( R_i\beta_i = 0 \), or equivalently \( \beta_i = H_i\phi_i \) for some \( s_i \)-vector \( \phi_i \), that is

\[
\beta = (H_1\phi_1, \ldots, H_r\phi_r) \tag{4.21}
\]

where the matrices \( H_1, \ldots, H_r \) express the linear hypothesis on \( \beta \) to be tested. Note that the linear restrictions \( H_i \) do not specify any normalization of the vectors \( \beta_i \).

Here, we discuss some principles for choosing \( H_i \) so that (4.21) identifies the cointegrating relations. The rank condition for identification requires that the first cointegration relations, for example, is identified if

\[
\text{rank}(R_1\beta_1, \ldots, R_r\beta_r) = \text{rank}(R_1H_1\phi_1, \ldots, R_rH_r\phi_r) = r - 1 \tag{4.22}
\]

This implies that no linear combination of \( \beta_2, \ldots, \beta_r \) can produce a vector that looks like the first relation, i.e. satisfies the restrictions defining the first relation. However, in order to check the rank condition (4.22) we need to know the coefficients \( \phi_i \) \((i = 1, \ldots, r)\) but, in order to estimate the coefficients we need to know whether the
restrictions are identifying. One can check the rank condition before estimation by first giving the coefficient $\varphi$ some arbitrary numbers. If the rank condition is satisfied, estimation can proceed. To avoid the arbitrary coefficients and explicitly check the rank condition based on the known matrices $R_i$ and $H_i$, Johansen (1995) gave the following condition for a set of restrictions to be identifying.

The set of restrictions is formally identified if for all $i$ and $g = 1, \ldots, r - 1$ and any set of indices $1 \leq i_1 < \ldots < i_g \leq r$ not containing $i$, it holds that:

$$
\text{rank}(R_i H_{i_1}, \ldots, R_i H_{i_g}) \geq g
$$

(4.23)

where, $i_1, \ldots, i_g$ indicates the number of columns in the matrix $(R_i H_{i_1}, \ldots, R_i H_{i_g})$.

The matrix $(R_i H_{i_1}, \ldots, R_i H_{i_g})$ contains at least $g$ linearly independent columns.

To identify the restrictions, the rank condition (4.23) holds for all $R_i$ ($i = 1, \ldots, r$). The structure is over-identified if it is identified and the inequality ($>$) holds for at least one $i$. The structure is just-identified if equality holds for all $i$ and there are zero restrictions. If other than zero restrictions are imposed, such as $(1, 1)$, the inequality ($>$) in equation (4.23) can in some cases be found in a just-identified model. The structure is under-identified if the rank condition (equation 4.23) is violated for at least one $i$.

In an identified model, the parameters can be estimated subject to the restrictions by the iterative procedure reported below.

We consider the equilibrium error correction term in equation (4.15) and write it as follows:

$$
\alpha \beta Y_{t-1} = \alpha_1 \beta_1 Y_{t-1} + \ldots + \alpha_r \beta_r = \alpha_1 \varphi_1 H_i Y_{t-1} + \ldots + \alpha_r \varphi_r H_i Y_{t-1}
$$

(4.24)

The hypothesis on $\beta$ is expressed as $\beta = (\beta_1, \ldots, \beta_r) = (H_i \varphi_1, \ldots, H_i \varphi_r)$.
where $H_i(i = 1, \ldots, r)$ are known design matrices of dimension $p_1 \times s_i$, and $\varphi_i$ are $s_i \times 1$
matrices of unrestricted coefficients. We again partition $\alpha$ so that it corresponds to
the partitioning of $\beta$: $\alpha = (\alpha_1, \ldots, \alpha_r)$.

The concentrated model can be written as follows:

$$R_{it} = \alpha_1\varphi_1 H_i R_{it} + \cdots + \alpha_r\varphi_r H_i R_{it} + \varepsilon_i$$  \hspace{1cm} (4.25)

The estimation procedure can be summarized as follows: for fixed values of $\varphi_2, \ldots, \varphi_r$, or $\beta_2, \ldots, \beta_r$, we can find the ML estimate of $\beta_i$ by performing a reduced rank
regression of $\Delta Y_i$ on $H_i Y_{t-1}$ correct for all the stationary and deterministic terms, that
is, $\beta_2 Y_{t-1}, \ldots, \beta_r Y_{t-1}, \Delta Y_{t-1}$ and $D_i$. This determines the estimate of $\varphi_1$ and
hence $\beta_1 = H_i \varphi_1$. In the next step, we keep the values $\beta_1, \beta_2, \ldots, \beta_r$ fixed and perform a
reduced rank regression of $\Delta Y_i$ on $H_2 Y_{t-1}$ corrected for all stationary and
deterministic terms. This determines $\beta_2$. By applying the algorithm until the
likelihood function has converged to its maximum, we can find the maximum
likelihood estimates of $\beta$ subject to the identifying restrictions.

The speed of convergence of the switching algorithm depends very much on how we
choose the initial values of $\beta$. For example, the unrestricted estimates of $\beta$ are not in
general the best choice because the unrestricted eigenvectors need not correspond to
the ordering given by $H_1, \ldots, H_r$, and thus can be very undesirable initial values.
Instead, the linear combination of the unrestricted estimates which is as close as
possible to $sp(H_i)$ ($i = 1, \ldots, r$) is clearly preferable as a starting value for $\beta_i$. These
can be found by solving the eigen-value problem:

$$\left| \rho \hat{\beta} - \hat{\beta} H_i (H_i H_i)^{-1} H_i \hat{\beta} \right|$$  \hspace{1cm} (4.26)

For the $r$ eigenvalue $\rho_1 > \ldots > \rho_r$, and $\nu_1, \ldots, \nu_r$, and choose the eigenvector defined by
$H_i \hat{\beta}_i = \hat{\beta} \nu_i$ as initial value for $\beta_i$. This choice of initial values has the extra advantage
that for exactly identified equations no iterations are needed.
The test restrictions on the elements of the matrix $\alpha$, also known as the loading matrix, address the weak exogeneity issue. Let the parameters of interest be $a_{ij}$, and the parameters of the $r$ the cointegrating vectors. If $a_{i1} = a_{i2} = \cdots = a_{ir} = 0$, the $i$–th endogenous variable, $x_i$, is weakly exogenous for the system as a whole, it would be valid to model a reduced system of $n-1$ equations condition on $x_i$ (Johansen, 1992). If the individual elements of $\alpha$ are zero, this implies the absence of a particular cointegrating relationship in the equations in the ECM system. This may also have implications for weak exogeneity of the variables with respect to the parameters of interest. For example, $a_{ij} = 0$ implies that the $j$–th cointegrating vector does not enter the $i$–th equation in the VAR (Viegi, 2005).

4.4 Counterfactual Simulation Method

Following the McCallum framework (1987, 2002A), we used the counterfactual simulation method to evaluate the possibility of the McCallum Rule to achieve a nominal GDP growth rate target for China. If the application of the rule in place of actual historical policy yields smoother nominal GDP paths than those actually experienced, we can conclude the rule performs well. In order to calculate the performance of the McCallum Rule in minimizing deviations around a given target path for nominal GDP, we need to specify the macroeconomic conditions in which the policy rule will work. Before presenting the simulation technique, we first discuss the macroeconomic condition used in this study. McCallum (1988, 1993) and Stark and Croushore (1996) documented the robustness of the rule by testing it across different models. The simple reduced-form type models used by McCallum (1988, 1993, 2002A) provided results that are comparable to those produced with small but somewhat more complex structure models used in his studies. Additionally, Hall (1990), Hafer et al. (1991, 1996) and Philip (2000) used single equation models to evaluate the McCallum Rule.

Recently, DSGE models have been widely used in monetary policy research for developed economies and some developing economies. However, this study does not use the DSGE model to construct a macroeconomic environment to simulate the
money supply growth path and nominal GDP growth path for a few reasons. First, most DSGE models available in the literature have a basic structure that incorporates elements of the New Keynesian paradigm and the real business cycle approach. The benchmark of the DSGE model is a fully micro-founded model with real and nominal rigidity (see, Christiano et al., 2005; Smets and Wouters, 2003).

In a benchmark DSGE model, households decide how much to invest and are monopolistic suppliers of different types of labour, which allows them to set the wages. However, it is widely known that China’s economic development depends more on government-led investments and export instead of consumption. In addition, China confronts a high unemployment problem. Households are nearly complete wage-takers and have no ability to affect aggregate investment and labour supplies. Therefore, the use of the DSGE model in China lacks a micro-foundation. Secondly, modelling and capturing the dynamics of emerging market economies is not easy. This is partly related to the idiosyncratic structural features exhibited by emerging economies as well as the historical vulnerabilities to external factors and resulting periods of high macroeconomic instabilities (Tovar, 2009). Thirdly, DSGE models are not likely to outperform other traditional models available at central banks, at least for now (Tovar, 2009).

Previous research showed that single equations could provide sufficient economic conditions to evaluate the McCallum Rule and that the DSGE model is not appropriate to evaluate China’s monetary policy. In this study, we first replicated a single equation macroeconomic model used by McCallum (2002A) that specified the relationship between the nominal GDP growth and monetary base growth. This model provided a basic macroeconomic condition to evaluate the possible effectiveness of the McCallum Rule using China’s data. The model is as follows:

\[ \Delta X_t = \beta_0 + \beta_1 \Delta X_{t-1} + \beta_2 \Delta X_{t-2} + \beta_3 \Delta B_{t-1} + \epsilon_{1t} \]  

(4.27)

where \( X_t \) and \( B_t \) denote logarithms of the nominal GDP and the monetary base, respectively. \( \Delta X_t \) and \( \Delta B_t \) are quarterly growth rates. \( \epsilon_{1t} \) is disturbance term.
To avoid the reverse-causation problem, equation (4.27) excluded the $\Delta B_t$ term (Sims, 1980B; King and Plosser, 1982). This method avoids the real sector that drives the monetary sector, in contrast to the traditional view of monetary movements as a business cycle impulse. Furthermore, it is common that monetary policy operates with variable lags on the economy (Blinder, 1998, p.13). Equation (4.27) introduces a full two-quarter lag between the target departures $\Delta X^*_t - \Delta X_{t-1}$ and corrective effects, which reflects the causal direction. Before conducting the simulation, we estimated the parameters and residuals of equation (4.27) over the study period, with the residuals capturing shocks to the economy. Then, using the McCallum Rule given by equation (2.1) and the initial actual values of GDP growth and monetary base growth, we determined a simulated value for monetary base growth. With a simulated monetary base growth, we can then use equation (4.27) to obtain a simulated value for nominal GDP, which feed into the equation. The root–mean–squared-error (RMSE) is used to measure the deviations of the simulated and actual values of the nominal GDP from the targets. The RMSE is given as follows:

$$
RMSE = \sqrt{\sum (\Delta X^*_t - \Delta X_t)^2 / n}
$$

(4.28)

In McCallum’s view, a floating exchange rate regime is necessary for the monetary policy rule to work effectively (1987, p. 13). Given China’s managed floating exchange rate regime, we extend equation (4.27) by adding an exchange rate variable to test the rule’s robustness, namely:

$$
\Delta X_t = \beta_0 + \beta_1 \Delta X_{t-1} + \beta_2 \Delta X_{t-2} + \beta_3 \Delta B_{t-1} + \beta_4 \Delta S_{t-1} + \epsilon_{2t}
$$

(4.29)

where $S_t$ denotes the log of the real effective exchange rate, with an increase in $S_t$ implying a devaluation of the Chinese currency.

In the following paragraphs, we discuss the technical characteristics of the counterfactual simulation technique. Currently, three main methods are used by economists to explore their interesting economic problems. The first is the regression method, asking how in fact results varied with initial or exogenous conditions. The second is the counterfactual simulation method, which asks how the results would
vary. Counterfactual simulation is what alternatives to actual history there are. It imagines what would have happened to an economy if, contrary to fact, some present condition were changed. When performing a counterfactual simulation, the usual method is to construct an explicit model $M$, with parameters, $P$, and initial conditions (or exogenous variables), $I$, and the simulation results obtained by way of endogenous variables, $R$. The counterfactual simulation process is to vary some element of the setup, the simplest being a variation in $I$, and then compare the different results (McCloskey, 1987). The third one is the computational experiment method (Kydland and Prescott 1996). It was not used in this research.

A model could be simulated deterministically or stochastically. In a deterministic simulation, all equations in the model are solved so that they hold without error during the simulation period (namely, all the error terms in the behaviour equations have been set at zero), all coefficients are held fixed at their point estimates and all exogenous variables are held constant. In a stochastic simulation, the equations of the model are solved so that they have residuals, which match to randomly drawn error and, optionally, the coefficients of exogenous variables of the model also varied randomly. Formally, we report Kolsrud’s (2004) review on stochastic simulation as below.

A macroeconomic model is a nonlinear dynamic simultaneous equation system. Without forward-looking behaviour its structural equations can be written as follows:

$$f(y_t, y_{t-1}, x_t, \beta) = \varepsilon_t \sim iid(0, \Sigma) \quad (4.30)$$

Where $f$ denotes a vector function. The $y_t, y_{t-1}, x_t,$ and $\beta$ are vectors of current and lagged endogenous variables, exogenous variables and parameter respectively. $\varepsilon_t$ is a vector of errors or shocks, assumed to be intertemporally independent and identically distributed $(iid)$, with zero means and a contemporaneous covariance matrix $\Sigma$. The dynamic structure of the model is made explicit by the inclusion of a single lag $y_{t-1}$. Lags in the exogenous variables are irrelevant for the discussion and are dropped to
simplify notation. Definitional equations are embodied in \( f \). They do not contribute to the simulation properties of the model, and are therefore ignored.

The parameters are estimated by suitable methods. The estimated model is given as follows:

\[
f(y_t, y_{t-1}, x_t, b) = e_t - id(0, S)
\]  

(4.31)

\( b \) denotes estimates of parameters. The vectors of the empirical residuals \( e_t \) are dependent, but approximately identically distributed (\( id \)).

Generally, the nonlinear system equation (4.30) has no closed form solution for \( y_t \). However, the system implicitly defines a presumably unique solution \( y_t = g(y_{t-1}, x_t, \varepsilon_t, \beta) \). A numerical approximation to this solution is a deterministic dynamic simulation of equation (4.31):

\[
\tilde{y}_t = g(\tilde{y}_{t-1}, x_t, \tilde{\varepsilon}_t, b), \quad \tilde{y}_0 = y_0, \quad t = 1, \ldots, T
\]  

(4.32)

where the tildes denote simulated values. It is common to set \( \tilde{\varepsilon}_t = E(\varepsilon_t) = 0 \).

If the model is linear, equation (4.31) can be written as \( G y_t - D y_{t-1} - P x_t = e_t \). \( G, D \) and \( P \) denote matrices of parameter estimates. With an invertible \( G \), the linear version of equation (4.32) is given as:

\[
\tilde{y}_t = G^{-1} D \tilde{y}_{t-1} + G^{-1} P x_t
\]  

(4.33)

which maps \( E(\varepsilon_t) = 0 \) onto \( E(y_t \mid G, D, P) \). This is called certainty-equivalence. In a nonlinear model, it does not hold. The procedure implicitly follows the statistical practice of plugging in the best estimates of unknown parameters, and treating only the \( \tilde{y} \) as stochastic. If we alter this practice by treating the parameter estimates as stochastic, then certainty-equivalence becomes untenable.
From the specification and estimation of the model, it follows that the shocks $\varepsilon_t$ in equation (4.30) and the estimates $b = \hat{\beta}$ in equation (4.31) are stochastic. The unknown parameters $\beta$ are constants. Therefore, the exogenous variables $x$ are the only deterministic input.

The mapping of variables implies a mapping of probability distributions of input variables onto a probability distribution of output variables. Classical econometrics lets us assume that the input vectors are independent. The two mappings can be schematized as:

$$y_{t-1}, x_t, \varepsilon_t, b \rightarrow \text{model} \rightarrow y_t$$

$$\downarrow$$

$$F_{y,t-1}(y_{t-1}), x_t, F_\varepsilon(\varepsilon_t), F_\beta(\beta) \rightarrow \text{model} \rightarrow F_{y,t}(y_t)$$

(4.34)

where $F$ denotes a joint distribution. A time subscript on $F_{y,t}$ accommodates non-stationarity. Since the mapping of the input variables is known implicitly through the structural model equation (4.31), the resulting mapping of the variables’ distributions is unknown. But $F_{y,t}(y_t)$ ($t = 1, \ldots, T$) can be estimated by dynamic stochastic simulation.

Stochastic simulation is synonymous with sampling the distributions of the stochastic variables in the estimated model. This involves first sampling the stochastic input variables and then it approximates the implicit reduced form solution numerically. The two tasks can be seen as first sampling on the input side of the model directly and then on the output side of the model indirectly. The sampling is carried out by replicating a single (deterministic) simulation $N$ times. Each $n$ replication is simulated with new values of the stochastic input variables randomly drawn from their respective postulated and estimated distributions. A simple way to do this is to assume a certain parametric distribution, typically normal, for the shocks and the simulation parameters, and to centre the distributions on the expected zero shock vector and on the estimated parameter vector.
The algorithm for stochastic dynamic simulation of a backward-looking model is:

\[
\text{For } n = 1, 2, \ldots, N \text{ replications of a single dynamic simulation}
\]

\[
\text{Generate } \beta_n \sim i_n \text{iN}(b, B), \text{ and let } y_{n,0} = y_0
\]

\[
\text{For } t = 1, 2, \ldots, T \text{ periods within a single dynamic simulation}
\]

\[
\text{Generate } \epsilon_{n,t} \sim i_n \text{iN}(0, S), \text{ and simulate } y_{n,t} = g(y_{n,t-1}, x_t, \epsilon_{n,t}, \beta_n)
\]

\[
\text{End for } t \text{ loop (returns a solution path } Y_{n,t} = (y_{n,t})_{t=1}^N \text{ for replication } n \text{)}
\]

\[
\text{End for } n \text{ loop (returns a bundle of } N \text{ solution paths } Y_{n,t} = \{(y_{n,t})_{t=1}^N\}_{n=1}^N \text{)}
\]

\[\beta_n\] is independent over replications \((i_n)\), and identically distributed normal \((iN)\), centred on the estimates \(b\) with empirical covariance matrix \(B\). Its value changes only with each \(n\) replication and remains constant through the \(T\) simulation periods. \(\epsilon_{n,t}\) is independent over both replications and time \((i_n)\) and is identically normally distributed. A new value is drawn for every simulation period \(t\) in every \(n\) replication.

In this study, we undertook stochastic simulation rather than deterministic simulation to find whether adopting the McCallum Rule would help stabilize China’s output and price level (see Copper and Fisher, 1972). First, the incorporation of random disturbances into a stable economic system can produce cyclical behaviour. In addition, nonstochastic simulations of nonlinear models can lead to results inconsistent with the true properties of the stochastic model. It is particularly important in the study of rules to decide on the use of the deterministic or stochastic forms of models because use of the deterministic forms of models would be likely to lead to recommending some sort of constant growth rate rules when exogenous variables follow steady time paths. Following these rules, policy variables will keep target variables constant or grow at a constant rate, since econometric models are usually systems of difference equations. In practice, economic relations do not hold exactly and it is not possible to keep variables exactly at their target levels. There will be discrepancies between the target and actual values of variables whatever policies are used; the question at issue is whether attempting to adjust these discrepancies by means of rules that depend on observations of the economy will be destabilizing. The technique of stochastic simulation ensures the existence of differences between actual and target values of variables under all policy regimes.
4.5 Conclusion

Three different research methodologies were described in this chapter. The advantage of the standard VAR method is that it allows researchers to treat all variables as jointly endogenous. In testing whether an effective interest rate channel exists, we are not sure which of the relationships, changes in macro-variables driving the changes in short-term interest rate or changes in short-term interest rates driving the changes in macro-variables, holds. Therefore, it is an appropriate method for us.

We then reproduced the Johansen cointegration procedure (1991). This procedure allows us to find out how many cointegration relationships exist. If more than one cointegration relationship exists, we can identify the loan supply and loan demand relationships simultaneously by imposing some restrictions on these cointegration relationships based on China’s economic condition. The method of imposing restrictions on cointegration relationships (Johansen, 1995) helps us to disentangle the bank loan demand and supply forces so that we can make sure whether the PBC could effectively control the credit supply using its policy instruments. The VECM model allows us to test the short-run dynamic relationships among the related variables without losing the long-run relationship.

Finally, we describe the simulation method. This method is widely used when evaluating different policy rules. To simulate the McCallum Rule, we need a model to characterize the properties of a given economy. For this purpose, we use equations (4.27) and (4.29) to characterize China’s macroeconomic circumstances.
CHAPTER 5
EMPIRICAL RESULTS

5.1 Introduction

This chapter reports the empirical results about the three aspects of China’s monetary policy transmission mechanism. Section 5.1 documents the results of the block causality test, the impulse response functions and forecasting error variance decompositions regarding the impacts of changes in short-term interest rate on output and price level. The next section reports the cointegration test results and the imposition of joint exclusion and exogeneity restrictions in identifying the bank lending channel in China. The simulation results of the McCallum Rule in a simple macroeconomic model are presented in Section 5.3.

5.2 Impacts of Changes in the Short-term Interest Rate on Real Variables

This section reports the block Granger Causality test, the response to system shocks by analysing impulse and forecasting error variance decomposition. Table 5.1 summarizes the Granger Causality test results for the five-variable VAR and the P-values associated with the F-statistics to test whether the relevant sets of coefficients are zero.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>∆GDP</th>
<th>∆CPI</th>
<th>∆M2</th>
<th>∆INTm</th>
<th>∆NEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆GDP</td>
<td>0.56</td>
<td>0.74</td>
<td>0.20</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>∆CPI</td>
<td>0.45</td>
<td>0.51</td>
<td>0.29</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>∆M</td>
<td>0.21</td>
<td>0.95</td>
<td>0.07*</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>∆INTm</td>
<td>0.61</td>
<td>0.06*</td>
<td>0.90</td>
<td></td>
<td>0.49</td>
</tr>
<tr>
<td>∆NEER</td>
<td>0.84</td>
<td>0.01**</td>
<td>0.86</td>
<td>0.71</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1 VAR Granger-Causality/Block Exogeneity Wald Tests

This table summarizes the Granger Causality results for the five-variable VAR.

* and ** indicates significance level of 10 and 1% levels respectively.

The results show increases in the INTm\textsuperscript{8} and NEER significantly predict the CPI growth at 10% and 1% significance levels respectively, but did not Granger cause

\textsuperscript{8} Note: now that the first difference of all variables, namely INTm, NEER, GDP, CPI, M and Repo, was used in this section, and NEER, GDP, CPI and M are in logarithmic form, so the changes in a variable refer to the changes in its growth rate.
GDP. An increase in the monetary aggregate Granger causes the growth of INTm at the 10% significance level, but not vice versa.

Impulse responses trace the response of current and future values for each of the variables to a one-unit increase in the current value of one of the VAR errors. This assumes that errors return to zero in subsequent periods and that all other errors are equal to zero (Stock and Watson, 2001). In other words, the interpretation of the impulse response requires that the innovations be contemporaneously uncorrelated across equations. However, the innovations in a VAR are correlated and may be viewed as having a common component that cannot be associated with a specific variable (Eviews 6). Thus, we use the inverse of the Choleski factor of the residual covariance matrix to orthogonalize the impulses.

Figure 5.1 presents the impulse response functions that document the impact of a one-off rise in the INTm on output, prices, monetary aggregate and exchange rate. The dotted lines show the impact of a unit rise in the monetary aggregate on other variables at 95% confidence levels. Output changed by about 0.4%, peaking in the second quarter and vanishing completely by the seventh quarter following monetary contraction. The CPI changed by about 0.2% peaking in the second quarter and decreased to below 0.1% by the fifth quarter after monetary contraction. The response of the monetary aggregate to the interest rate shock appeared to be insignificant. However, an inspection of these impulse response functions shows that the response functions of GDP and CPI are inconsistent with what we expected to be the effects of monetary policy contraction. Only the impulse response function of the nominal effective exchange rate appeared to be consistent with the theoretical prediction that an increase in the interest rate leads to an appreciation of the nominal exchange rate, but is statistically insignificant.
Figure 5.1 Impulse Responses in the Recursive VAR (INTm)
This study also examined the impacts of the shocks of monetary aggregate on the other variables. A rise in a one-unit monetary aggregate resulted in a 1% decline in the GDP, reaching a trough in the second quarter and reverting to 0.5% at the peak of the third quarter. An increase in monetary aggregate led to a decline in real GDP within two quarters and then promoted economic growth with four to six quarters’ lag. There is an insignificant impact on both the CPI and NEER. However, the impact on the short-term interest rate is significant at the 10% level after one quarter (see Figure 5.1).

The forecast error decomposition is the percentage of the variance of the error made in forecasting a variable due to a specific shock at a given horizon (Stock and Watson, 2001). The relative importance of monetary policy fluctuations in the other variables can be measured through the variance decomposition. Table 5.2 reports the variance decomposition of the five VAR variables covering 1 to 12 quarters. The second column in each sub-table shows the forecast errors of the variable for each forecast horizon. The remaining columns present the percentage of the variance due to the shock of the variable appearing as heading, with each row adding up to 100. The results show that innovations in INTm account for about 0.34% of the forecast error variance in the output and about 9% in the price level in a year. Innovations in the monetary aggregate explain about 3.24% of the output forecast error, and only about 0.1% in the price level. The innovations of money supply and interest explain each other, at about 4.7% and 0.1% respectively. Our results confirm the insignificant influence of changes in the short-run interbank bank borrowing interest rate on GDP growth rate and the statistically significantly influence on the price level, but in the “wrong” direction. Another interesting result is that shocks to the monetary aggregate significantly influence the INTm rather than the reverse.
Figure 5.2 displays the impulse responses to monetary policy shocks defined as temporary, unexpected and exogenous rises in the Repo with the variance decomposition of the forecast errors shown in Table 5.3. The results are similar to those derived from Figure 5.1 and Table 5.2. For a one-unit rise in the Repo, the GDP rose by about 0.4% at the peak of the second quarter and decreased to 0.08% in the fourth quarter; the CPI rose to a peak by 0.2% in the second quarter. The directions of the changes were similar to those in the benchmark VAR. Within one year, the innovations in the Repo explained about 0.35% of the GDP forecast error and about
7.7% for the price level forecast error. However, the impact of the Repo and monetary aggregate on GDP is statistically insignificant.

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ΔGDP</th>
<th>ΔCPI</th>
<th>ΔM2</th>
<th>ΔINTR</th>
<th>ΔNEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.071468</td>
<td>100.0000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>4</td>
<td>0.082012</td>
<td>94.62480</td>
<td>1.382626</td>
<td>3.42394</td>
<td>0.35899</td>
<td>0.212286</td>
</tr>
<tr>
<td>8</td>
<td>0.082096</td>
<td>94.59207</td>
<td>1.390798</td>
<td>3.435846</td>
<td>0.359099</td>
<td>0.222188</td>
</tr>
<tr>
<td>12</td>
<td>0.082097</td>
<td>94.58933</td>
<td>1.391206</td>
<td>3.435795</td>
<td>0.359456</td>
<td>0.224209</td>
</tr>
</tbody>
</table>

Variance Decomposition of ΔCPI:

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ΔGDP</th>
<th>ΔCPI</th>
<th>ΔM2</th>
<th>ΔINTR</th>
<th>ΔNEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.009595</td>
<td>1.302966</td>
<td>98.69703</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>4</td>
<td>0.010676</td>
<td>1.775495</td>
<td>81.55952</td>
<td>1.970865</td>
<td>7.730516</td>
<td>6.963607</td>
</tr>
<tr>
<td>8</td>
<td>0.010884</td>
<td>1.730996</td>
<td>79.14847</td>
<td>1.915285</td>
<td>8.505136</td>
<td>8.700115</td>
</tr>
<tr>
<td>12</td>
<td>0.010921</td>
<td>1.723015</td>
<td>78.72026</td>
<td>1.905542</td>
<td>8.610425</td>
<td>9.040754</td>
</tr>
</tbody>
</table>

Variance Decomposition of ΔM2:

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ΔGDP</th>
<th>ΔCPI</th>
<th>ΔM2</th>
<th>ΔINTR</th>
<th>ΔNEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.008841</td>
<td>0.701716</td>
<td>0.345849</td>
<td>98.95243</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>4</td>
<td>0.008876</td>
<td>0.762420</td>
<td>0.413269</td>
<td>98.41496</td>
<td>0.037637</td>
<td>0.371711</td>
</tr>
<tr>
<td>8</td>
<td>0.008882</td>
<td>0.762074</td>
<td>0.425920</td>
<td>98.30062</td>
<td>0.048837</td>
<td>0.462552</td>
</tr>
<tr>
<td>12</td>
<td>0.008883</td>
<td>0.761997</td>
<td>0.429913</td>
<td>98.27425</td>
<td>0.054278</td>
<td>0.479562</td>
</tr>
</tbody>
</table>

Variance Decomposition of ΔNEER:

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>ΔGDP</th>
<th>ΔCPI</th>
<th>ΔM2</th>
<th>ΔINTR</th>
<th>ΔNEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.004997</td>
<td>0.453490</td>
<td>6.613098</td>
<td>0.393814</td>
<td>17.40211</td>
<td>75.13749</td>
</tr>
<tr>
<td>4</td>
<td>0.007863</td>
<td>0.405743</td>
<td>11.70457</td>
<td>0.392003</td>
<td>17.68611</td>
<td>69.81157</td>
</tr>
<tr>
<td>8</td>
<td>0.008662</td>
<td>0.421778</td>
<td>12.40114</td>
<td>0.407970</td>
<td>18.38188</td>
<td>68.38723</td>
</tr>
<tr>
<td>12</td>
<td>0.008814</td>
<td>0.425498</td>
<td>12.52219</td>
<td>0.410484</td>
<td>18.52898</td>
<td>68.11285</td>
</tr>
</tbody>
</table>

Table 5.3: Variance Decomposition of VAR (Repo)
Figure 5.2 Impulse Responses in the Recursive VAR (Repo)
5.3 Empirical Testing for the Bank Lending Channel in China

We first discuss the model we used to identify the bank-lending channel in the monetary transmission mechanism and then report the empirical testing results. We consider a simple aggregate model of loan supply \( (L') \) and demand \( (L^D) \). In light of economic theory, the loan supply depends on a required reserve ratio \( (RR) \), bank lending rate \( (RC) \) and inflation rate \( (\pi) \), which affects the real rate of return on bank credits. Loan demand depends on the macroeconomic conditions, a proxy for economic activity \( (GDP) \), and the general price level \( (CPI) \) and the bank lending rate, which affects the bank credit profits. The data on bank loan aggregate from the PBC quarterly statistics were used as the data on bank loan demand and on bank loan supply simultaneously. This simple model allows the identification of the loan supply and demand thus avoiding the identification problem (see Section 2.3.4) that arises in the estimation of reduced-form credit supply equations. The model can be written as:

\[
L^D = \lambda_0 + \lambda_1 GDP + \lambda_2 RC + \lambda_3 CPI + \varepsilon_2
\]

\[
L' = \gamma_0 + \gamma_1 RR + \gamma_2 RC + \gamma_3 CPI + \varepsilon_1
\]

If the presence of two cointegration relationships cannot be rejected, the identification of the supply and demand functions depends on the estimated sign of the lending rate, which is negative in the demand and supply equations. This is inconsistent with classical economic theory. In the classical economic theory, the bank lending rate is regarded as the bank loan return rate and is positively correlated with loan supply. However, during 1994-2006, Ginger (2008) found that China’s domestic credits increased with the declining official one-year lending interest rate. In addition, identification depends on testing for two exclusion restrictions: the required reserve ratio should not enter the demand function (while negatively correlated to loan supply) and GDP should not enter the loan supply function (while positively correlated to loan demand).

The test for cointegrating relationships in a VAR system is sensitive to the lag length of the variables in the system. In choosing the lag length, one must weigh two opposing considerations: the curse of dimensionality and the correct specification of the model (Canova, 1995). The optimal lag length in this study is based on Schwarz...
(SC) and Akaike (AIC) criteria, together with misspecification tests for the error terms. The results of the lag length criteria from Eviews 6 are reported in Table 5.4.

### Table 5.4 VAR Lag Order Selection Criteria

<table>
<thead>
<tr>
<th>Lag</th>
<th>Logl</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>44.959</td>
<td>NA</td>
<td>2.22e-07</td>
<td>-1.134</td>
<td>-0.323</td>
<td>-0.833</td>
</tr>
<tr>
<td>1</td>
<td>314.2</td>
<td>428.42*</td>
<td>3.34e-12*</td>
<td>-12.238*</td>
<td>-10.414*</td>
<td>-11.56*</td>
</tr>
<tr>
<td>2</td>
<td>318.40</td>
<td>30.170</td>
<td>3.48e-12</td>
<td>-12.251</td>
<td>-9.998</td>
<td>-11.42</td>
</tr>
<tr>
<td>3</td>
<td>346.12</td>
<td>34.81</td>
<td>3.49e-12</td>
<td>-12.377</td>
<td>-9.101</td>
<td>-11.16</td>
</tr>
<tr>
<td>4</td>
<td>374.15</td>
<td>28.67</td>
<td>3.97e-12</td>
<td>-12.518</td>
<td>-8.218</td>
<td>-10.93</td>
</tr>
<tr>
<td>5</td>
<td>416.56</td>
<td>33.53</td>
<td>2.92e-12</td>
<td>-13.328</td>
<td>-8.004</td>
<td>-11.36</td>
</tr>
</tbody>
</table>

* indicates the identified lag number by different criteria

Both the SC and AIC criteria suggest the inclusion of one lag. Applying the no-residual-correlation criterion, we found that the VAR also supported the choice of one lag (LM-statistic = 19.48, and P-value = 0.77).

Table 5.5 reports the results of the Johansen cointegration tests (with no trend included in the cointegration equation and VAR). The trace test suggests two cointegration relationships. In addition, all characteristic roots lie inside the unit circle and, as a result, the system is stable and converges to its long-run equilibrium.

### Table 5.5 Results of Johansen Cointegration Tests

<table>
<thead>
<tr>
<th>$H_0$</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>5% Critical Value</th>
<th>5% $p-value$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0$</td>
<td>0.666</td>
<td>94.553</td>
<td>69.818</td>
<td>0.002**</td>
</tr>
<tr>
<td>$r \leq 1$</td>
<td>0.428</td>
<td>52.196</td>
<td>47.856</td>
<td>0.018**</td>
</tr>
<tr>
<td>$r \leq 2$</td>
<td>0.344</td>
<td>26.466</td>
<td>29.797</td>
<td>0.115</td>
</tr>
</tbody>
</table>

** indicates significant at 5% level. Mackinnon-Haug-Michelis (1999) p-values

The estimated unrestricted cointegrating vectors are reported in the top panel of Table 5.6. Based on the signs of the relevant parameters, the vectors $\beta_1$ and $\beta_2$ could be interpreted as demand and supply relationships, respectively. The bottom panel of the Table 5.6 reports the hypothesis tests conditional on the selected rank. The long run exclusion tests suggested that none of the variables included in the VECM can be omitted from the long-run relationships at the 5% level of significance. The hypothesis of weak exogeneity cannot be rejected for the required reserve ratio.
Table 5.6 Unrestricted Cointegration Vectors and Restriction Tests

<table>
<thead>
<tr>
<th></th>
<th>Loan</th>
<th>GDP</th>
<th>RR</th>
<th>RC</th>
<th>CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unrestricted Vector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>16.449</td>
<td>-17.636</td>
<td>-0.285</td>
<td>1.365</td>
<td>46.181</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>-3.865</td>
<td>-8.154</td>
<td>-0.838</td>
<td>-0.374</td>
<td>106.97</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Long run exclusion</th>
<th>Weak exogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$ value</td>
<td>[0.000] [0.000]</td>
<td>[0.051] [0.052]</td>
</tr>
</tbody>
</table>

To identify the supply and demand equations, the following joint exclusion and exogeneity restrictions are imposed on the cointegration parameters.

$$\beta_{1RR} = \beta_{2GDP} = \alpha_{RR1} = \alpha_{RR2} = 0$$

If the null hypothesis is not rejected, the loan demand is unaffected by the required reserve ratios, the loan supply is unaffected by GDP and the required reserve ratios are weakly exogenous. The null hypothesis could not be rejected at the 5% level of significance based on the LR test ($\chi^2(2) = 743$, p-value=$0.689$). As a result, the parameters in the loan demand ($L^D$) and supply ($L^S$) equations normalized in bank loan (L) are given as follow (the absolute values of t-statistics in parentheses):

$$L^D = 0.811GDP - 0.085RC - 0.359CPI$$

(10.79) (-7.08) (-0.61)

$$L^S = -0.0471RR - 0.098RC + 7.059CPI$$

(-2.88) (-3.629) (9.617)

The estimated parameters show that GDP is a strong determinant of the demand for bank loans. However, the estimated value of the income elasticity of bank loan
demand for China is relatively low compared with other studies, such as Mello and Pisu (2009) for Brazil, Calza et al. (2006) for the Euro area and Kakes (2000) for the Netherlands. Moreover, the demand for loans appears to be negatively related to the lending rate and the coefficient is statistically significant.

There are negative relations between bank loans and required reserve ratios as well as the bank lending rate in the loan supply in equation (5.4). The estimated RR and RC coefficients are statistically significant. This finding points to the existence of a bank lending channel in China, since monetary policy movement affects the supply of loans. In addition, the inflation rate is positively related to loan supply and statistically significant. The negative relationship between the loan supply and lending interest rate implies that China’s economy is neither completely market-based nor entirely planned. A market-based indirect monetary policy approach (mainly through open-market operations) has been adopted, together with quantity-based monetary measures, to achieve the monetary policy targets in China. Under such a situation, if the PBC increases interest rate to fight inflation and uses quantity-based instruments simultaneously to supply a given amount of money without considering prices, the higher interest rate on the given amount of funds would lead to overall higher interest rate. This leads to a negative relationship between the loan supply and lending interest rate (Ginger 2006). The positive inflation rate is similar to Mello and Pisu’s (2009) findings.

We tested the short-term dynamic adjustment process to confirm these relationships. The short term dynamic loan supply and demand can be assessed using the loading matrix (α) in conjunction with the normalized restricted cointegrating vectors reported in equation (5.3) and (5.4). According to Juselius (2006), if αj and βj have the same signs, the jth variable adjusts towards the equilibrium defined by the cointegrating relationship. If they have opposite signs, the i th variable does not converge to the equilibrium; in this case, convergence is achieved through the other variables included in the VECM (Mello and Pisu, 2009).

Based on the loading matrix presented in Table 5.7, the demand in equation (5.1) is equilibrium-correcting with regard to the loan volume, but this is not true for the
supply equation ($\alpha_{ij}$ is not statistically significant). As a result, all other things being equal, short-term disequilibria in the demand for loans are self-correcting. Although GDP and RC are statistically significant, the $\alpha_{GDP}$ and $\alpha_{RC}$ signs are opposite to the $\beta_{GDP}$ and $\beta_{RC}$ signs in the long-run demand equation in (5.3), so convergence is not achieved through their movements. On the other hand, the short-run disequilibria in the long-run supply equation in (5.4) are corrected through changes only in the lending rate. The inflation rate ($\alpha_{x2}$) is statistically significant but has an opposite sign to the $\beta_{x2}$. In summary, monetary policy plays an important role in restoring equilibrium in the credit market where excess supply of loans affect the commercial banks’ lending rates regulated by China’s central bank.

\textbf{Table 5.7 Loading Matrix}

<table>
<thead>
<tr>
<th></th>
<th>Demand ($\alpha_i$)</th>
<th>Supply ($\alpha_j$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta L$</td>
<td>-0.129 (2.186)</td>
<td>0.053 (1.403)</td>
</tr>
<tr>
<td>$\Delta GDP$</td>
<td>-0.630 (2.560)</td>
<td>0.247 (1.563)</td>
</tr>
<tr>
<td>$\Delta RR$</td>
<td>0.000 (-)</td>
<td>0.000 (-)</td>
</tr>
<tr>
<td>$\Delta RC$</td>
<td>5.253 (4.694)</td>
<td>-2.807 (3.909)</td>
</tr>
<tr>
<td>$\Delta \pi$</td>
<td>0.041 (1.863)</td>
<td>-0.061 (4.357)</td>
</tr>
</tbody>
</table>

Note: Absolute values of t-statistics in parentheses

\textbf{5.4 Simulation Results and Historical Analysis of McCallum Rule in China}

This section documents the results of counterfactual simulation using the McCallum Rule in an estimated simple macroeconomic model. Before conducting the simulation, we first estimate equations (4.27) and (4.29). The estimated result of equation (4.27) is:

$$\Delta X_t = 0.0474 - 0.552\Delta X_{t-1} - 0.226\Delta X_{t-2} + 0.431\Delta B_{t-1} + \hat{\epsilon}_t$$

\begin{align*}
\text{t-val} & \quad (2.506) \quad (-4.234) \quad (-1.717) \quad (1.186) \\
R^2 & = 0.251 \quad \hat{\sigma} = 0.091 \quad \text{Breusch–Godfrey (BG) test} = 0.737(P-value, 0.539)
\end{align*}
where $\varepsilon_{3t}$ is the residual, i.e. the estimated disturbance for period $t$. The simulated values for $\Delta B_t$ and $\Delta X_t$ were calculated for 60 periods using equations (2.1) and (5.5), with the initial conditions equal to the 1994:Q2 values and with $\varepsilon_{3t}$ values fed in as the shock estimates for each period. Table 5.8 lists the results of this simulation exercise with different $\lambda$ values. The study used RMSE to choose the $\lambda$ value to verify if McCallum Rule can be a guideline for Chinese monetary policy.

Table 5.8 Simulation Results (using Equation (5.5))

<table>
<thead>
<tr>
<th>Policy</th>
<th>$RMSE(\Delta X^* - \Delta X)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Historical</td>
<td>0.1016</td>
</tr>
<tr>
<td>Rule (1)</td>
<td>$\lambda = 0$, $\lambda = 0.1$, $\lambda = 0.2$, $\lambda = 0.3$, $\lambda = 0.5$, $\lambda = 0.7$, $\lambda = 1$</td>
</tr>
<tr>
<td></td>
<td>0.02102, 0.02104, 0.02114, 0.0213, 0.0219, 0.0229, 0.0256</td>
</tr>
<tr>
<td>Rule (2)</td>
<td>0.02100, 0.02107, 0.0212, 0.0217, 0.0225, 0.0242</td>
</tr>
</tbody>
</table>

Rule (1) refers to the rule using the lag-one nominal GDP value in the final term. Rule (2) uses the average nominal GDP growth rate over the past four quarters.

Since a smaller RMSE means a better performance, the RMSE values in Table 5.8 suggest that adopting the McCallum Rule (1) or rule (2) would have dramatically improved the macroeconomic performance compared with the actual performance when not following a rule. Furthermore, using the nominal GDP growth rate of the most recent quarter in the rule’s final term, $RMSE(\Delta X^* - \Delta X)$ increases when $\lambda$ increases. We obtained similar results when the average nominal GDP growth rate over the past four quarters is in place of that of the most recent quarter in the rule’s final term. Rule (2) is slightly superior to Rule (1).

Next, we checked the performance of the McCallum Rule under the macroeconomic condition specified in equation (5.6) - the regression result of equation (4.29), so that we can robustly identify which rule is better and what value to assign to $\lambda$.

\[
\Delta X_t = 0.0470 - 0.5689\Delta X_{t-1} - 0.2635\Delta X_{t-2} + 0.4863\Delta B_{t-1} + 0.3455 S_{t-1} + \hat{\varepsilon}_t,
\]

(5.6)

$R^2 = 0.27$ \quad $\hat{\sigma} = 0.091$ \quad BG test = 0.401($P-value$ = 0.529)
The simulated values for $\Delta B_t$ and $\Delta X_t$ were calculated using equations (2.1) and (5.6) for 60 periods, with the actual 1994:Q2 values as the initial conditions and with the $\varepsilon_{\Delta_t}$ values fed in as the shock estimates for each period. Table 5.9 presents the simulation results.

Table 5.9 Simulation Results (using Equation (5.6))

<table>
<thead>
<tr>
<th>Policy</th>
<th>$\text{RMSE}(\Delta X^* - \Delta X)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Historical</td>
<td>0.1016</td>
</tr>
<tr>
<td>Rule (1)</td>
<td></td>
</tr>
<tr>
<td>$\lambda = 0$</td>
<td>0.0225</td>
</tr>
<tr>
<td>$\lambda = 0.2$</td>
<td>0.0228</td>
</tr>
<tr>
<td>$\lambda = 0.5$</td>
<td>0.0240</td>
</tr>
<tr>
<td>$\lambda = 0.7$</td>
<td>0.0255</td>
</tr>
<tr>
<td>$\lambda = 1$</td>
<td>0.0301</td>
</tr>
<tr>
<td>Rule (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0228</td>
</tr>
<tr>
<td></td>
<td>0.0238</td>
</tr>
<tr>
<td></td>
<td>0.0250</td>
</tr>
<tr>
<td></td>
<td>0.0272</td>
</tr>
</tbody>
</table>

Rule (1) refers to the rule using the lag-one nominal GDP value in the final term. Rule (2) uses the average nominal GDP growth rate over the past four quarters.

Comparing the $\text{RMSE}(\Delta X^* - \Delta X)$ value in Table 5.9, we found that the macroeconomic performance improved greatly by adopting a policy rule. In addition, the value for $\text{RMSE}(\Delta X^* - \Delta X)$ ascends when $\lambda$ increases, regardless of Rule (1) or Rule (2) being adopted; and Rule (2) is slightly superior to Rule (1) when $\lambda$ is bigger than 0.2.

The simulated results in Table 5.8 and 5.9 clearly show that adopting the McCallum Rule could significantly improve Chinese monetary policy performance. To identify the stability property of the rule with different values for $\lambda$, we depicted the target GDP growth rate together with simulated GDP growth rates in Figures 5.3 to 5.6. Explosive oscillation does not appear, but the band of oscillation gets wider with an increase in the value of $\lambda$ as shown in the four figures. The improved base rule is slightly better than the original base rule as a monetary policy guideline. Thus, for the stability of nominal economic growth, we selected Rule (2) as China’s monetary policy guideline with $\lambda = 0.2$, which is similar to McCallum results based on US data (1987, 1988, and 1993). When $\lambda = 0.2$, the original and improved rules produce equal $\text{RMSE}(\Delta X^* - \Delta X)$ under the macroeconomic condition specified by equation (5.5),

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9 The GDP growth rate is expressed in term of percentage, the difference between the value of simulated GDP growth rate and target GDP growth rate are in percentage. The difference between the simulated values shows directly the merits of McCallum rule when different coefficient values are assigned to the McCallum rule. Therefore, we follow McCallum method to compare the simulated values with target GDP value, not their ratios.
and produce approximately equal $RMSE(\Delta X^* - \Delta X)$ under the macroeconomic condition specified by equation (5.6).

**Figure 5.3 Simulation results with $\lambda$ set at alternative values in a model consisting of Rule (1) and equation (5.5)**

![Graph showing simulation results with $\lambda$ set at alternative values in a model consisting of Rule (1) and equation (5.5)](image1)

**Figure 5.4 Simulation results with $\lambda$ set at alternative values in a model consisting of Rule (2) and equation (5.5)**

![Graph showing simulation results with $\lambda$ set at alternative values in a model consisting of Rule (2) and equation (5.5)](image2)
Figure 5.5 Simulation results with $\lambda$ set at alternative values in a model consisting of Rule (1) and equation (5.6)

![Graph](image)

Figure 5.6 Simulation results with $\lambda$ set at alternative values in a model consisting of Rule (1) and equation (5.6)

![Graph](image)
This study has demonstrated how the McCallum Rule could describe China’s monetary policy using a counterfactual simulation method. Next, we followed Stuart (1996) and Taylor’s (1999B) historical analysis method to further assess whether the McCallum Rule would have provided useful information about the policy stance in specific economic situations. We tested whether past policy errors can be identified by observing the divergence of actual policy from the paths implied by the rule based on historical data (rather than simulation). This method looks at the trend in actual policy rather than comparing point estimates. Figure 5.7 shows the path for actual historical monetary base quarterly growth rate and the path for the rule-specified (Rule (2) where $\lambda = 0.2$ ) is the monetary base quarterly growth rate between 1994:Q2 and 2009:Q1.

![Figure 5.7 McCallum Rule for Monetary Base](image)

The actual monetary base growth rate showed an upward trend between 1995:Q1 and 1996:Q4, but the rule-specified base growth rate displayed a downward trend (see Figure 5.7). During this period, China experienced high annual inflation rates, 16.9 and 8.3% in 1995 and 1996, respectively. Between 1997:Q1 and 2001:Q4, the actual base growth rate in most cases is below the rule generated base growth rate and, on
many occasions, the actual momentary base growth rate is negative. During this period, China experienced deflation with annual inflation rates of -0.8, -1.4, 0.3, and 0.5% in the four years. During 2003 to 2008, the actual base growth rate is above the rule-specified base growth rate in most cases. The inflation rate climbed to 5.9% in 2008. The actual monetary base growth rate oscillated around the rule-specified growth rate during the study period. Using the McCallum Rule as a benchmark, when China’s monetary policy is too restrictive, the Chinese economy experienced deflation; when the actual policy is too expansionary, the Chinese economy ran into an inflation cycle.

The peaks and troughs of the actual monetary base growth rates shown in Figure 5.7 result from the policy adjustment shocks. The Chinese government implemented a tight monetary policy to reduce high inflation from the second half of 1993. Following successful control of price levels and the local government investment impulse in the first half of 1996, a relatively expansionary policy was adopted by lowering the benchmark interest rate in May 1996. The first peak appeared in 1996:Q3, which is regarded as the rebound of the money supply. The second peak in 1998:Q1 is the result of a series of policy actions to stimulate the economy, such as removal of the imposition on credit rationing in state-owned commercial banks, and undertaking more open market operations to increase the money supply.

The transitory effect followed by a trough in 1998:Q2 results from a dramatic decrease in China’s export demand and therefore the aggregate demand. After four years of deflation, an increase in government investment in infrastructure and real estate as well as the increase in the official wages led to the third peak at the beginning of 2002. Another trough appears in 2002:Q2 because of the call-back adjustment and the rise in the interest rate on reserve requirement in June 2002. From then on, the Chinese economy recovered and started a gradual increase in price level. The big gap between the actual monetary base growth rate and the rule-generated monetary base growth rate during the 2006:Q2 – 2008:Q3 is the result of expansionary monetary policy (the negative real deposit interest rates) and the increasing funds outstanding for foreign exchange. Chinese foreign exchange reserves increased from US$ 9,411.15 billion to US$ 19,055.85 billion during the 2006:Q2 to 2008:Q3.
5.5 Conclusion

In this chapter, we reported the empirical results of the three research objectives. Section 5.2 documented the impacts of changes in short-term interest rates on general price level, real GDP, exchange rate and monetary aggregate. The impulse response functions and variance decompositions have shown us that shocks of short-term interest rates on general price level and real GDP were not consistent with what should happen when an effective interest rate channel plays a role in monetary policy transmission. Furthermore, shocks to the monetary aggregate growth rate significantly influenced the short-term interest rates change but not vice versa. This is evidence that it is the monetary aggregate not the short-term interest rates that is more appropriate to serve as the policy variable. Therefore, we conclude that an effective interest rate channel has not come into existence over the study period.

In Section 5.3, the empirical test results assure us of the existence of a bank lending channel in China. By imposing joint exclusion and exogeneity restrictions on the cointegration parameters in a VECM model, we found negative relationships between bank loans and required reserve ratios as well as the bank lending rate in the loan supply in equation (5.4). RR and RC affect the loan supply significantly. Further, we tested the short-term dynamic adjustment process to confirm these relationships. Based on the loading matrix presented in Table 5.7, the short-run disequilibria in the long-run supply equation in (5.4) are corrected only through changes in the lending rate. This means monetary policy plays an important role in restoring equilibrium in the credit market by changing the commercial banks’ lending rates.

In Section 5.4, our counterfactual simulation results of nominal GDP growth path showed that the McCallum Rule could have been a policy guideline for the PBC during the evaluated period. In the economic circumstance provided by equations (5.5) or (5.6), simulated nominal GDP growth rate produces $RMSE(\Delta X^* - \Delta X)$ much less than that produced by actual nominal GDP growth rate. Historical analysis confirms our results based on simulation. When actual values of the monetary base growth significantly deviate from the McCallum Rule specified values, the economy ran into problem of inflation or deflation.
CHAPTER 6
CONCLUSIONS AND POLICY IMPLICATIONS

6.1 Introduction

This chapter presents a summary of the study, including the empirical results and new study issues that emerged as a result of the research. Section 6.2 summarizes the main empirical findings of the research. Section 6.3 discusses the policy implications of the research findings. Section 6.4 points out the limitations of the study and provides suggestions for future research.

6.2 Summary and Main Empirical Findings

China has seen great progress in its monetary policy framework reform in the past three decades, especially after the mid 1990s. First, the PBC was established and it began functioning as a central bank in 1984. Ten years later, the law for the People’s Bank of China was promulgated in 1995. Secondly, monetary policy instruments have switched from direct credit quota control to a combination of indirect methods: reserve requirements, open market operations, central bank discount, and central bank lending and deposit interest rates. The monetary policy goals in China have been set essentially to keep the currency value stable and maintain low inflation, together with promoting economic growth and employment (Zhou, 2008). Therefore, the monetary transmission mechanism in China has also changed accordingly.

Since 1994, a monetary policy framework with monetary aggregate and monetary base as intermediate target and monetary policy instrument separately has been in operation. However, the current adopted monetary targeting regime has recently been under question because some researcher have concluded that there is lack of stable relationships between monetary base and monetary aggregate (M1 and M2), and between the monetary aggregates and general price and real output. Therefore, some studies have been conducted to search for the actually existing policy transmission mechanisms in China, mostly focusing on the possibility of short-term as policy operating objective. However, some ambiguities reviewed in Chapter 2 remain to be
solved. This research focused on three aspects of the monetary policy transmission mechanism in China.

The first was to identify the possibility of using short-run interest rate as a policy operating target for China. To do so, we tested the impact of changes in short-term interest rates on real GDP, general price level and exchange rate based on a standard VAR framework covering the period 1996:Q1 to 2008:Q1. We then identified whether an effective interest rate channel exists in China. If an effective interest rate exists, then it is possible for the PBC to switch from the monetary base to the short-term interest rate as its policy operating objective.

We examined the integration properties of data using ADF and DFGLS tests. Both tests showed that the time series are not stationary but the Johansen cointegration tests showed that cointegration relationships do not exist among short-term interest rates, real GDP, CPI, monetary aggregate (M2) and nominal effective exchange rate. Therefore, we constructed a VAR using the first difference of the data. The results of the Granger causality test showed INTm and NEER significantly predicted the CPI at 10% and 1% separately, but do not Granger-cause GDP. Monetary aggregate Granger caused INTm at the 10% significance level, but not vice versa. The impulse response function showed that, following an exogenous, unexpected and temporary rise in money market short-term interest rates, output increased by about 0.4%, peaking in the second quarter and vanishing completely at the seventh quarter; CPI increased by about 0.2%, peaking in the second quarter and decreasing to below 0.1% by the fifth quarter. The response of the monetary aggregate to the interest rate shock appears to be insignificant. These results show that the response functions of GDP and CPI are inconsistent with what we expected for the effects of a contraction in monetary policy. Only the impulse response function of the nominal effective exchange rate appeared to be consistent with the theoretical prediction that an increase in the interest rate leads to an appreciation of the nominal exchange rate, but it is statistically insignificant. For example, following a one-unit shock of monetary aggregate, GDP declines by 1% immediately, reaching the trough at the second quarter and reverting to 0.5% at the peak of the third quarter; CPI and NEER show insignificant reaction. However, the impact on the short-term interest rate is significant at the 10% level after one quarter. Therefore, the impulse response functions showed that short-term
money market interest rates moved along with money aggregate, not the reverse (see Figure 5.1).

These findings show that under the current monetary aggregate targeting regime in China, a movement in the short-term money market interest rate did not reflect the changes in macro-economy variables. In other words, the response of the assumed central bank’s benchmark interest rate to macro-economy fluctuations fails to transfer effectively to the money market. The weak link between the short-term interest rate and the macro-economy variable implies that China cannot use the short-term money market interest rate as its operating target. An institutional reason for this failure is the existence of two cut-off separate interest rate systems: the central bank interest rate system and the commercial bank loan and deposit interest rates system.

Secondly, the research focused on whether PBC could effectively fulfill its policy goal via the control of credit/bank loans. We utilized the VECM approach to identify the existence of bank lending channel in China under monetary targeting and window guidance system. The difficult problem in testing for the existence of a bank lending channel for monetary transmission is disentangling the loan supply and demand effects of monetary-policy movement. Different identification strategies have been proposed, including using aggregate data (Bernanke and Blinder, 1992), disaggregated data on non-financial firms (Gertler & Gilchrist, 1994; Onliner & Rudebusch, 1995), and disaggregated data on banks (Kashyap & Stein, 1995, 2000). Since the reduced-form VAR method cannot clearly distinguish the bank lending channel from the conventional money channel and the unavailability of bank level data, this study tested the exclusion/homogeneity restrictions on multiple cointegration vectors using aggregate data for the period 1997:Q1 to 2008:Q4.

The estimation of a VECM using China’s quarterly aggregate data yielded two cointegration vectors. Based on the signs of the relevant parameters, the vectors $\beta_1$ and $\beta_2$ are interpreted as demand and supply relationships, respectively. The long run exclusion tests suggested that none of the variables included in the VECM can be omitted from the long-run relationships at 5% level of significance. The hypothesis of weak exogeneity cannot be rejected for the required reserve ratio (see Table 5.6). To
identify the supply and demand equations, we imposed joint exclusion and exogeneity restrictions on the cointegration parameters: the loan demand is unaffected by the required reserve ratios, the loan supply is unaffected by GDP and the required reserve ratios are weakly exogenous. The LR test results showed that the hypothesis cannot be rejected at the 5% confidence level. There are negative relations between bank loans and required reserve ratios as well as the bank lending rate on the loan supply side in equation (5.4). The estimated RR and RC coefficients are statistically significant. This finding documented the existence of a bank lending channel in China, since the PBC could affect the supply of loans through its policy changes. In this way, we clearly disentangled the forces of bank loan demand and bank loan supply that drove the changes in bank loans. In addition, the results showed that the inflation rate is positively related to loan supply and statistically significant. The negative relationship between the loan supply and lending interest rate rate implies that China’s economy is not yet a mature market economy. Market-based indirect monetary policy approach (mainly through open-market operations) has been adopted, together with quantity-based monetary measures (credit quota) to achieve the monetary policy targets in China. This result further verified our first result that an efficient interest rate channel did not exist in China.

To confirm these relationships, we checked the short-run dynamics adjustment process. According to the loading matrix (see Table 5.7), the short-run disequilibria in loan supply are corrected only through changes in bank lending rate. The inflation rate in the loading matrix is statistically significant but has an opposite sign to its counterpart in the long-run equation. The disequilibria in loan demand in the short-run are self-correcting. Although GDP and RC are statistically significant, the signs of the parameters are opposite to their counterparts in the long-run equation. Based on these empirical results, we concluded that monetary policy plays an important role in restoring equilibrium in the credit market where excess supply of loans responded to the commercial banks’ lending rates regulated by China’s central bank.

Thirdly, this study identifies a suitable monetary policy guideline for the PBC. The monetary base is still the PBC’s policy operating objective and general price level and real output are the PBC’s policy goals, so we focused on the McCallum Rule. The empirical results of the effect of changes in short-term interest rates on macro-
variables and the result of bank-lending channel fundamentally supported this choice. In addition, we documented that Taylor’s and McCallum’s research supported the fact that in developing countries with monetary base as its policy operating objective, it is preferable to choose a monetary base instrument policy rule.

We employed the counterfactual simulation method to evaluate whether the McCallum Rule could be used as a monetary policy guideline for China based on the data covering 1994:Q1 through 2009:Q1. To confirm the robustness of our empirical results, we employed two simple macroeconomic models to specify the macroeconomic conditions for the rule to operate. The first model followed the framework used in McCallum’s research that specified the relationship between the nominal GDP growth and monetary base growth. The other one is a revised model that includes the exchange rate variable to take into consideration the influence of a managed floating exchange rate regime on monetary policy in China. We assigned different values to the monetary policy response factor when conducting the simulation process to identify an appropriate value for the monetary policy response factor of the rule for the PBC, considering the value of the response factor in the original McCallum Rule was derived based on U.S. data.

The study reports on the simulated monetary base growth and the nominal GDP growth paths. The root–mean–squared-error was used to measure the deviations of the simulated and actual values of the nominal GDP from the targets. Using the simulation results, we showed that the $RMSE(\Delta X^* - \Delta X)$ between the target nominal GDP growth rate and the simulated nominal GDP growth rate was much smaller than that between the target nominal GDP growth rate and actual historical nominal GDP growth rate. The McCallum Rule that uses the average nominal GDP growth over the past four quarters for the final term is referred to as the improved (McCallum) rule in this study. With similar values for the monetary policy response factor, the performance of the improved rule is slightly better. We found that a smaller value for the monetary response factor in the McCallum Rule was more appropriate for China. The simulated nominal GDP growth rate is much closer to the target nominal GDP growth rate with a smaller monetary response factor than with a bigger monetary response factor. A bigger monetary response factor resulted in wider economic
growth oscillations. In addition, this study followed the Stuart (1996) method to check the validity of the McCallum Rule as a monetary policy guideline in China. The result showed the rule-specified path of monetary base growth rate could be a monetary policy guideline for China.

6.3 Policy Implications

The results of this research offer a few significant policy implications. Understanding these implications is important for the monetary policy-makers and policy-followers in China.

First, the switch of monetary policy operating target from monetary base to short-term interest rate has been widely accepted by central banks in all developed economies, most emerging countries and many developing economies. However, this does not mean that the PBC currently could use the short-term interest rate as its operating target. The results of this research showed that changes in representative short-term interest rates do not have a significant effect on the general price level and real output. This means that after about 30 years’ reform and advances in the financial system, the relationship among central bank policy interest rates, financial market rates and deposit and lending rates of commercial banks has not been harmonized and therefore the role of interest rates as monetary policy instrument is still limited.

The PBC has been facing some difficulty in controlling monetary aggregate due to the speedy increase of foreign exchange reserves after 2003, because it has adopted a contractionary monetary policy (i.e., increasing the issuance of central bank bills to reduce the money supply), it could not effectively influence the money market short-run interest rate. In this situation, the interest rate on the central bank bills rather than the money market interest rate, acts as the central bank target interest rate (Wu, 2008A). To switch to an official interest rate as a policy instrument and to adopt a short-term money market rate as an operating target, China needs gradually to establish an effective interest rate transmission channel through which financial institutions price their loans with reference to market rates where the market rates move in response to central bank benchmark rate adjustments. This will allow the PBC effectively to influence the short-term money market rate through OMOs. To
complete this process, the precondition is to liberalize interest rates that are still under the PBC control, improve financial institutions’ liquidity management capability and their sensitivity to macro management measures by the central bank.

The development of Shibor is an encouraging sign for interest rate liberalization. Before it can be used as a recognized benchmark interest rate, like the Libor (London interbank offered rate) or Tibor (Tokyo interbank offered rate), to replace the rates for loans and deposits set by the central bank, some progress should be made. First, in terms of global experience, Shibor should be taken as a benchmark for financial product innovation. However, Shibor still has some defects and many innovative financial products are utilizing non-Shibor benchmarks, for instance the 7-day repo. Further, Shibor is not the benchmark for many other financial products. At present, many financial products are linked with certain interest rates set by the PBC. This requires the PBC, when adjusting interest rates, to take into consideration many factors and the balance of interest relations. However, to balance interests among different interest groups, the situation is increasingly complicated. As a result, we need an objective benchmark acceptable to all interest groups. In this respect, Shibor has not been functioning as a benchmark as it should have.

Thirdly, Shibor has not played its due role in internal transfer pricing. The significance of Shibor also lies in its link with the market and internal transfer pricing in commercial banks. Many Chinese commercial banks are big banks across the nation, and there are many internal transfer prices in terms of region, products, deposits and loans, and assets and liabilities. Branches that have more deposits than loans bring pressure on their headquarters for higher deposit rates. Branches with more loans ask for the opposite. The only reasonable and convincing way to strike a balance is to introduce Shibor into internal transfer pricing. Shibor is a market-based interest rate indicator, linking the internal with the external. However, in current Chinese commercial banks’ internal transfer pricing, Shibor has not been widely adopted. The fundamental reason why Shibor has not been functioning as Libor and Tibor in other countries is due to problems in the authenticity and quality of Shibor. Currently, the spread between quoted and concluded interest rates is narrow for Shibor below 3 months, and the trading is active. However, the gap for medium- and long-term Shibor above 3 months is still wide. This means the correlation is not high
between Shibor quotations and the concluded price of interbank lending above 3 months. The gap between the quoted and concluded prices, particularly for Shibor above 3 months, is still the key factor that undermines the quality, credibility and authority of Shibor quotations (Yi, 2008).

Secondly, China’s central bank started adopting a monetary targeting policy in 1994 and abandoned direct credit control in 1998. However, the PBC still closely monitors and influences bank loans with window guidance (moral suasion) because of the unstable short-run relationship between monetary aggregate nominal GDP that is attributed to financial deregulation and innovation, monetization process (Yi, 1991; Zhou, 2006), and the pegged foreign exchange rate regime (Goldstein & Lardy, 2008; Zhou, 2008). With regard to the relationship between monetary base and monetary aggregate (M1, M2), we consider the base multiplier approach that emphasizes the availability of reserve as a constraint on bank lending. In testing the role of bank lending channel in monetary policy transmission mechanism, we consider the availability of reserves that constrain the ability of a commercial bank to lend to the non-bank public. Therefore, when the relationship between the monetary aggregate and policy goal is unstable in China, identifying the existence of bank lending channel will assist the PBC in improving its policy effectiveness.

According to some researchers, the unstable relationship between monetary aggregate and nominal GDP does not imply that monetary targeting regime is completely ineffective. Zhou (2006) stated that when we study the relationship between monetary supply and output and general price level, we should take into consideration the monetization process that occurred in China. Monetization has accompanied economic reform and transition. Monetization, a process in which the market-based allocation of sources such as housing that were distributed in a way adopted by government during planned economy era, may require the prices of these sources to rise in tandem with the worker’s income. As a result, unlike the basic parallel growth of money supply and nominal GDP in mature market economies, money supply for many years has grown slightly faster than nominal GDP in China. Under this condition, if the PBC is able to control the bank loan volume and further to influence the money supply process, the credit indicator will be a supplement of monetary...
aggregate indicator. When the credit indicator operates in tandem with monetary aggregate indicator, the monetary targeting regime is still operational.

Our research result showed that the PBC is able to influence bank loans through its constraint on bank reserves. Policy-makers of the PBC (Hu 2007, Wu 2008B) addressed their viewpoints on more than one occasion that also argued for this result. According to Wu (2008B), the growing trade surplus, under the pegged exchange rate regime, resulted in increased foreign exchange reserves for China. However, during 1997-2007, using an open-market operation and an increase in the required reserve ratio, the PBC has successfully carried out the sterilization policy to control the growth of base money as well as the liquidity of the bank sector.

According to the flow of funds approach to money supply determination, flows of bank lending to non-bank public affect the stock of monetary aggregate (Bain and Howells, 2009, p.49). Considering the role of the government in economic growth in China, the PBC should keep an eye on bank loans. Following 30 years of economic reform, the Chinese economy is still characteristic of a transition economy. The government still plays a significant role in resource allocation. Local governments compete for economic growth. When domestic consumption cannot drive economic growth, exporting is out of local government control and the only way to promote local economic growth is to increase investment. Currently, local governments have less authority to issue local government bonds freely, so most of the investment funds rely on bank loans. Due to the local government investment impulse, the PBC should pay more attention to the credit policy when it tries to constrain overheating investment. At the other extreme, when the economy is in recession, loosening the credit policy will be part of the expansionary monetary policy.

Finally, we discussed the policy implications of evaluating the possibility of taking McCallum Rule as an appropriate monetary policy guideline for China. If an effective interest rate transmission channel does not exist, the short-term interest rate cannot be used as an operating objective and the only appropriate choice of policy operating objective for the PBC is the monetary base. Meanwhile, a pre-specified price level and real GDP growth rate are the ultimate policy goals for China. In this situation, the McCallum Rule provides an appropriate framework for the PBC. The simulation
results in this research showed that the rule-specified path of monetary base growth rate could be a monetary policy guideline for China. If the PBC had taken this rule as its policy benchmark, nominal GDP fluctuations would have been reduced significantly in China. For this reason, we recommend the PCB to use the McCallum Rule as an illustrative benchmark instead of strictly following the simple McCallum Rule. Adoption of this rule implies that the PBC will accept the three ideas proposed by Mishkin (2007B): 1) expectations are critical to monetary policy outcomes; 2) monetary policy is subject to the time-inconsistency problem; and 3) a strong nominal anchor is the key to producing good monetary policy outcomes.

One implication of rational expectations in a world of flexible wages and prices is the policy ineffectiveness proposition, which indicates that if monetary policy were anticipated, it would have no real effect on output; only unanticipated monetary policy could have a significant impact. Although the evidence for the policy ineffectiveness proposition turns out to be weak, the point of the rational expectation revolution has become widely accepted that monetary policy impact on the economy is substantially influenced by whether it is anticipated (Mishkin 2007A). Most macroeconomic models attribute the short-run real effects of monetary disturbance to the presence of nominal wage and/or price rigidities. These rigidities mean that nominal wages and prices fail to adjust immediately and completely to changes in the nominal quantity of money (Fisher, 1977; Taylor, 1979B, 1980; Calvo, 1983).

The expectations of market agents regarding the rate of inflation depend on their view of the likely behaviour of the authorities, specifically the expected conduct of monetary policy. Following a monetary rule, the monetary authorities could assist market agents in their forming of monetary policy expectations. After 30 years of economic reform, market agents’ expectations have significantly influenced the PBC’s policy effects in nominal prices and wages. If the PBC adopted the McCallum Rule, it would lead market agents to make good judgments regarding the credibility of the policy announcement of the authorities. This will be helpful for the PBC in fulfilling its policy goals.

In addition, adopting the McCallum Rule will provide the PBC with a reference nominal anchor: nominal GDP. Many economists (see Hess, Small & Brayton, 1993;
Feldstein & Stock, 1994; Hall & Mankiw, 1994) have discussed and supported nominal GDP as a nominal anchor. Recently, Bernanke et al. (1999), Bernanke and Woodford (2005), Mishkin (2000,) and Jonas & Mishkin (2003) support inflation targeting as a nominal anchor and inflation targeting has been adopted as a nominal anchor in some countries, such as New Zealand and Canada. From the viewpoint of Zhou (2006), the PBC currently does not support the inflation targeting because, in a transition economy, if currency (Yuan) instability occurs, it is more likely due to the special traits of the economy, rather than the quantity or price of money. In addition, for a low-income developing country and an emerging market economy, economic growth and employment are important objectives of the country. Therefore, nominal income as a nominal anchor is more suitable for China. A stable nominal income growth indicator implies a stable price level and stable real output growth.

When adopting a rule, according to Taylor (2000B, 2010) and McCallum (2002B), central banks should not follow a policy rule in a “mechanical-looking” algebraic form. Instead, policy makers should use the rule as a policy guideline or benchmark in making policies. It focuses on whether there is a deviation from a policy rule. Large persistent deviations serve as measures of accountability for monetary policy makers. The policy recommendation is that the rule should be used as an aid in making decisions in a more predictable, rule-like, manner. Central bank staff would use the information from the paths described by a policy rule in making the decision about whether to change the policy operating target.

The rationale for using deviations from policy rules as measures of accountability is based on historical and international experience over the past decades (Taylor, 2010). The simulation results in this research showed that there are big deviations from the policy rule and, at times, that performance is less than satisfactory. A question is whether, in future, the policy rule will be used more often as a measure of accountability rather than as simply a guide or aid for policy decision. If rules become more commonly used for accountability, then policy makers will have to explain the reasons for the deviations from the rules and be held accountable (Taylor, 2010).
6.4 Contributions of the Study

Much research on China’s monetary policy has been conducted before this study (see Chapter 2). However, as an emerging economy still under transition, China’s monetary policy transmission keeps changing from policy instruments to policy goals. A good understanding of current monetary policy transmission enables the PBC to choose an appropriate policy instrument to fulfil its policy goals. The PBC has been studying the experience of central banks of developed economies in conducting monetary policy and has been trying to set up an effective monetary transmission mechanism, from direct transmission mechanism to indirect transmission mechanism. This study contributes to three aspects of China’s monetary policy development.

First, much previous research denied the existence of an effective interest rate channel in China’s monetary policy transmission (Xie, 2004; Ginger, 2006, 2008; Wu, 2008A). However, recently, the PBC has been trying to foster an effective yield curve so that an effective interest rate channel could be developed. The reforms and developments of the financial system and financial market in China convince us that a new study was necessary to identify more clearly the role of interest rate in monetary policy transmission in China. In this study, we used the VAR method, based on appropriately selected variables and data, to test the shock of short-term interest rates on real variables: output and price level. The results of the impulse response function and variance decomposition revealed that changes in the short-term interest rate do not have a significant impact on output and price level. Therefore, an effective interest rate channel has not been developed. Before the PBC could take advantage of interest rate channel to carry out its policy, the interest rate regime and bond market still need further reforms and advances until an effective yield curve comes into existence.

Secondly, because, since mid 1980s, interest rates have been under the control of the PBC and bank credit has long played an important role in monetary policy transmission in China, a little research regarding the role of bank credit in China’s monetary policy transmission has been conducted. However, in our opinion, the variables selected and the research methods used in previous studies (Jiang, Liu & Zhao, 2005; Sheng & Wu, 2008) could not provide robust results. Therefore, we use advanced econometric methods to identify the long-run and short-run structure in a
cointegrated VAR model and to disentangle the bank loan supply and bank loan demand forces. The results of this study show that the PBC could effectively use a required reserve ratio to control the bank loan supply, but bank lending rate is negatively related to bank loan supply. This finding proves that the PBC currently still relies heavily on quantity and not price instrument and that it needs time before the PBC could effectively use the interest rate as its main policy instrument to fulfil its policy goals.

Thirdly, to provide the PBC with a policy benchmark so that it could improve its policy performance, we evaluated the McCallum Rule when considering money supply as the PBC main policy operating target. In this study, we used the counterfactual simulation method and the identified variables to avoid the shortcomings in previous research. The simulation results in this study showed that following the McCallum Rule could significantly reduce the RMSE. This implies that following the McCallum Rule could improve the PBC policy performance.

In summary, this study identifies: 1) that an effective interest rate channel does not currently exist in China, 2) that the quantity instrument now is still the main policy instrument for the PBC, and 3) that the McCallum Rule could be used as a policy benchmark for the PBC to improve its policy performance. These results could be used as references for the PBC in making and conducting its policies.

6.5 Limitations and Suggestions for Future Research

Some limitations remain in this research. We now discuss these limitations and point out the direction for future research.

First, in examining the effectiveness of the interest rate channel, we adopted the standard VAR method. Although this method has the desirable property that all variables are treated symmetrically so that the econometrician does not rely on any “incredible identification restrictions”, it has been criticized as being devoid of any economic content. In identifying the underlying structural model from the reduced-form VAR model, the innovations in Choleski decomposition do not have a direct economic interpretation. Innovation accounting does require an ordering of the
variables in the Choleski decompostition, but the selection of the ordering is generally ad hoc. If the correlation coefficients among residuals are low, the ordering is not likely to be important. However, in a VAR with several variables, it is improbable that all correlations will be small. In some instances, innovation accounting derived based on the Choleski decomposition is not a reasonable interpretation of the related economics relationships (Enders, 2010).

Sims (1986) and Bernanke (1986) proposed an alternative to the Choleski decomposition. In their identification scheme, a priori information is used to impose a contemporaneous restriction on the elements of coefficient matrices of the structural model innovation vector and reduced form VAR residual vector, different from the Choleski ordering. The basic idea is to estimate the relationships among the structural shocks using an economic model. Blanchard and Quah (1989) proposed another alternative to Choleski decomposition. Long-run behaviour of shocks often provides restrictions acceptable within a wide range of theoretical models. A typical restriction compatible with virtually all macroeconomic models is that the long-run demand shocks have zero impact on output. Blanchard and Quah showed how these restrictions can be used to identify VARs. In future, these methods could be used to identify related VAR by giving more attention to the underlying macroeconomic theory in examining the interest rate channel in China.

Another limitation in identifying the interest rate channel is concerned with the variable chosen. We chose the 7-day interbank interest rate and 7-day interbank repo rate as the assumed policy interest rates. In January 2007, SHIBOR started operation. Three years later, it should have, to some extent, the characteristics of the short-term interest rate used as operating target, like Libor and Tibor. Due to the short duration and monthly data unavailability, we could not examine the effects of the SHIBOR on policy goals in China, future research could attempt to solve this problem and test the term structure of interest rates by taking the SHIBOR overnight rate as the operating target rate.

Secondly, in testing the bank lending channel, we used aggregate credit data of financial institutions to identify the bank lending channel. In this instance, we could test the changes in availability of loanable funds for commercial banks because of the
PBC’s policy changes at the aggregate level. However, we cannot identify the sensitivity of bank lending to the PBC policy changes for different type of banks (small banks and big banks) using such a method. Currently, commercial banks in China could be classified into state-owned commercial banks, regional banks and local banks in light of the region where their branches are located. The three types of banks have different sensitivity to the PBC policy signal in their bank loan practices, because of the difference in the availability of source of loan funds. The four big state-owned commercial banks can obtain loanable funds relatively more easily under a tightening policy due to their large volume collateral assets relative to regional and local commercial banks. Future research could be conducted based on bank level data so that the results of the research could reflect the role of different type of banks in the monetary policy transmission through bank lending channel.

In addition, we used the required reserve ratio and the official one-year commercial bank lending interest rate as the PBC’s policy instrument variables to identity the bank lending channel in our research. These two variables are the PBC quantity and price instruments. However, we left out another important policy indicator regarding bank credit, “window guidance”, due to lack of relevant information. This indicator could be taken into consideration in future studies, so that the results will be more robust. “Window guidance”, to some extent, stands for the administrative measures of the PBC that reflect the complex of the monetary policy in an immature market economy.

The dates when the “window guidance” occurs could be viewed as the time when the PBC attempts to make a decision with reference to bank credit policy in the following period: easing or tightening. In this aspect, Romer and Romer (1989) have done a pioneering work in testing the bank lending channel in the U.S. by identifying dates that signal contractionary shifts in monetary policy,

Thirdly, we used a backward-looking single equation model to specify the macroeconomic condition in evaluating the feasibility of the McCallum Rule as a

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10 A major point of the concept is the temptation to influence the market participants through words rather than strict rules. Despite the phrase guidance, which implies a voluntarily aspect in the system, the PBC has a major influence on the lending decisions especially of the Big Four state-owned commercial banks (Ginger, 2006).
monetary policy guideline for China. Linde (2002) documented that a backward-looking model exhibits significant parameter instability that is economically important, but that a standard econometric tests for detecting this instability fails to do so accurately in small samples. The author’s finding suggests that the relative merit of alternative policy rules should be checked based on well-motivated theoretical foundations.

Currently, the widely used models are dynamic, stochastic, and empirically estimated. More importantly, these empirical models incorporate both rational expectations and sticky prices, and they are sophisticated enough to be used to examine how policy rules would work in practice (Taylor, 2010). In the early 1970, Robert E. Lucas and Thomas J. Sargent, and their coauthors stressed the role of expectations as a crucial element in many structural relationships of macroeconomic models. The recognition, that economic behaviour is forward-looking in character and thus the effects of government policy upon expectations are critical to its overall effects, is fundamental to current ways of thinking about monetary and fiscal policy. It is now widely accepted by central banks that the way in which the public perceives monetary policy should be a critical concern of central bankers (Woodford, 1999).

Since the 1980s, it has been common to model nominal rigidities by imposing the assumption that prices (wages) are fixed for multi-periods so that the impact of monetary disturbances on real output was persistent (Taylor, 1979, 1980; Calvo, 1983). Examples of empirical models with rational expectations and sticky price include the simple three equation econometric model of Taylor (1979), the multi-equation international models in the comparative studies by Bryant, Hooper & Mann (1993), and the econometric models in robustness analysis of Levin, Wieland, and Williams (1999). In the face of uncertainty about the true structure of the economy, a robust rule should work well across a wide range of structural models. The performance of a rule can be measured by the policy objective function that is to minimize the weighted sum of the unconditional variances of the inflation rate and the output gap. Today, the standard approach in monetary policy analysis is to incorporate nominal wage or price rigidity into a dynamic stochastic general equilibrium framework that is based on optimizing behaviour by the agents in the model.
Therefore, future research on China’s monetary policy rule can use a range of different structural models.

Finally, this research focused on only three closely related aspects of China’s monetary policy transmission mechanism in current monetary policy framework. The impacts of monetary policy changes on assets prices, such as stock market and housing prices, and further on general price level and real output are still debatable.

In developed countries, the impact of asset price bubbles on monetary policy has drawn considerable attention and debate, namely, the proper role of asset prices in the determination of monetary policy (Kohn, 2006, 2009; Mishkin, 2001, 2008; Trichet, 2005). In line with conventional strategy, a central bank focuses exclusively on the stability of prices and economy activity over the next several years. Under this policy, a central bank responds to stock prices, home values, and other asset prices only insofar as they have implication for future output and inflation over the medium term. The influence of monetary policy on asset prices is at the heart of the transmission of the policy decision to real activity and inflation (Kohn, 2006).

According to the extra action strategy (Trichet, 2005), the central bank would adopt a somewhat tighter policy stance in the face of an inflation asset market than it would otherwise allow if confronted with a similar macroeconomic outlook under more normal market condition. Since the initial operation of China’s stock market, it has experienced several marked fluctuations. Therefore, the role of the stock price variable in China’s monetary policy transmission deserves close attention. In addition, since the 2000 housing policy reform, housing prices have been increasing, especially after 2004. Currently, whether severe housing market bubbles exist and how the central bank should respond to the current situation is still debatable. Future research should give more attention to the role of asset price in monetary policy transmission in China.

The impact of the current manageable floating exchange rate regime on monetary policy in China has also drawn considerable attention of researchers interested in China’s monetary policy. Previous research provided two opposing answers. In the light of the “impossible triangle” (Obstfeld and Taylor, 1998), a government can
select only two out of the following three goals: an independent monetary policy, a fixed exchange rate, and capital mobility. Nevertheless, neither theory can explain any other combination except for the extreme cases of these three elements, which can be applied to the current situation in China (Yi and Tang 2001).

Anderson (2004) argued that China can run an independent monetary policy under any exchange rate regime. The author believes China’s capital controls are relatively effective and that sterilization has been successful and can be maintained indefinitely. Green (2007a, 2007b) held a similar view that the PBC has little difficulty in retaining control of the growth of the domestic money supply using the sterilization operation. Jin (2008) and Wei (2008) argued the virtue of a flexible exchange rate regime in enhancing the effectiveness of China’s macroeconomic policy may be overrated, because the effectiveness of a monetary policy is constrained by factors beyond the currency regime.

In contrast, Greenwood (2008) argued that the PBC is capable of using sterilization to control the monetary aggregate growth in short-term but is not able to control it long term. Meanwhile, sterilization creates significant distortions in the financial sector, namely distorting interest rates and the asset portfolio of Chinese commercial banks. Prasad (2008) also argued that a flexible exchange rate is required to deliver an effective monetary policy and further capital account liberalization and, without such a monetary policy and capital account regime, it is much harder to achieve stable macroeconomic policies and an efficient and well functioning financial market.

Due to these conflicting results, further research regarding the impact of the current exchange rate regime on the effectiveness of China’s monetary policy is necessary. A large economy like China cannot give up the independence of monetary policy. Therefore, accurate assessment of the impact of the ongoing exchange rate regime on macroeconomic policy is a precondition for PBC to choose and conduct proper monetary policy.
REFERENCES


Green, S., (2007A). This—is—Sparta!, Standard Chartered on the Ground, Asia, April 12.


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