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## Bank lending channel in China's monetary policy transmission mechanism: a VECM approach

### Abstract

This paper tests the existence of the bank lending channel to explain the monetary policy transmission in China from 1997Q1 through 2008Q4. To disentangle the bank loan supply and bank loan demand effects of monetary policy movement, this study uses a VECM model to test for a number of exclusion and exogeneity restrictions on the existing cointegration relationships among the variables. In the identified loan supply equation, loan supply is negatively related to required reserve ratios and official one-year lending rate in the long term. This confirms the existence of a lending channel for monetary transmission in China. The VECM's short-term dynamics show that the short-run disequilibria in the loan supply are corrected through changes in the lending rate, suggesting that monetary policy plays a role in restoring equilibrium in the credit market by affecting the official commercial bank lending rate. The result shows that under a "window guidance" system bank lending channel plays an important role in China's monetary policy transmission.

**Keywords:** monetary policy transmission, bank lending channel, VECM model, exclusion and exogeneity restrictions.

**JEL Classification:** E10, E44, E52.

### Introduction

To conduct monetary policy successfully, the monetary authorities must have an accurate assessment of their policy effect on the economy, and an understanding of the monetary transmission mechanism. Mishkin (1995), Kutter and Mosser (2002), and Ireland (2005) describe the various monetary policy transmission channels through which monetary policy actions impact real variables, such as interest rate channel, exchange rate channel, monetarist channel, and credit channel. The most popular channel that appears in current monetary policy researches on industrial countries is interest rate channel, because most central banks today conduct monetary policy using interest rate targets. Credit channel also attracted considerable attention from economists and policymakers in the past three decades, built on breakthroughs in the economics of imperfect information in the 1970s, which implies the failure of the Modigliani-Miller theorem<sup>1</sup>, following Bernanke and Blinder's presentation of their credit channel framework (1988). 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 and Bloor et al., 2008). Since the mid-1980s, the fund raising

pattern of the state-owned enterprises (SOEs) in China has changed dramatically from government capital injections to bank lending. To bring the bank lending under control, the People's Bank of China (PBC) introduced the "credit policy" framework in 1986, which is called a credit growth quota system<sup>2</sup>. Lending by quota was a compulsory requirement for banks and it was based on central planning ideology. The modernization of monetary policy tools was part of the financial reform, switching to an indirect policy framework using short-term interest rates and base money. Since 1994, the PBC has adopted a monetary policy target as its intermediate target. The window guidance system<sup>3</sup> replaced the credit growth quota system in January 1998. Under this system, direct control by the PBC on 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).

An effective monetary targeting framework requires a stable relationship between monetary aggregate and economic stability and economic growth. However, a few researches (Xia and Liao, 2001; Xie, 2004; Ginger 2008) have documented that, for the PBC, there is a controllability problem of monetary aggregates and the relationship of monetary aggregate to the real activity has not

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<sup>1</sup> According to Modigliani-Miller theorem, the capital structure of a firm has no influence on its investment decision.

<sup>2</sup> 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 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.

<sup>3</sup> In light of window guidance, the PBC meets officers from commercial banks at set time interval to check whether the operation of the banks is in line with the plan and, if necessary, to give banks additional or adjusted guidance. Therefore, this system is a mechanism to control credit creation by banks and is a tool for PBC's monetary control.

necessarily stayed stable. In addition, Ginger (2008) and Wu (2008) document that interest rate channel also has not been effective in China's monetary policy transmission as in developed economies.

Researches on credit channel in China's monetary policy transmission have been conducted since 2000 (see Wang and Wang, 2000; Jiang, Liu and Zhao, 2005). However, several important questions remain in the current literature. The objective of this study is to improvise the current literature on the credit channel in China's monetary policy transmission in two aspects: the research methodology and the selected variables that are used to identify the existence of credit channel in China's monetary policy transmission. In this study, we use advanced econometric techniques and selected variables to provide clear understanding of credit channel in China, and the role of bank lending in China's monetary policy transmission. Because of the limited availability of data, this study focuses on bank lending channel. The rest of this paper is organized as follows. The next section reviews the theory and recent empirical studies on the credit channel. Section 2 discusses the variables and data sources. Section 3 presents the research methodology. Section 4 reports the empirical results and the last section concludes the study.

## 1. Literature review

### 1.1. Review on money and credit channel theory.

There are two assets in the interest channel: money and bond (which include government bills and bonds, commercial paper, corporate bonds, stocks, bank loan, 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, raising 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 the 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 conditions of commercial banks and firms play no role in affecting investment or other types of spending (Bernanke, 1993; Kashyap and Stein, 1994; Hubbard, 1995).

The balance sheet channel arises when changes in the net worth of the bank-dependent borrowers 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 assets 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), 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) present the logic of bank lending channel in light of the "deposit explanation". Markovic (2006) and Van den Heuvel (2007) present 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 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 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 the monetary policy results in leftward shift in the LM and IS curve simultaneously, because the bank loan rates increase in re-

sponse to the monetary policy contraction and thus reduces 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 credit stock targeting is preferred to monetary targeting when money demand is relatively unstable compared to credit demand.

Unlike Bernanke and Blinder who focus on the asset side of the bank's balance sheet, Stein (1998) focuses 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 are still in the banks' books) – and three liabilities – insured deposit, 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 Stien's analysis, the smaller banks with lower assets values face difficulties in raising non-deposit external finance during monetary contraction, compared to the large banks with higher assets values. Large banks depend exclusively on insured deposits to finance their lending. The author concludes that banks are subject to adverse-selection problems that constrain their lending, and insured deposits can help banks to circumvent such problems and allows them lend more freely. With regard to monetary policy, Stien's model shows that central banks can still influence both bonds rates and loan-bond spreads and thereby has 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 central bank forces banks to substitute 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 the 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 differences 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 traditional lending channel of monetary policy transmission (Kashyap and Stein, 1994): (1) intermediated loans and open market bonds must not be perfect substitute for some firms on the liability side of their balance sheet, so that these firms are unable to offset a decline in the supply of loans by borrowing more 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 intermediated loans. That is, the intermediary sectors as a whole must not be able to completely insulate its lending activities from shocks to reserves, either by switching from deposit to less reserve-intensive forms of finance or by reducing its net holding of bonds; and (3) there must be some forms of imperfect price adjustment that prevents any monetary policy shock from being neutral. If either of the first two conditions fails to hold, bond and loans effectively become perfect substitutes, and then the bank lending view reduces back to the pure money view.

Van den Heuvel (2007) develops 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 lending opportunities and market interest rates. Van den Heuvel focuses on the bank capital equity, not 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 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 and an amplified reaction to the monetary policy shocks, relative to well-capitalized banks. In addition, Van den Heuvel states that bank capital affects lending even when the regulatory constraint is not momentarily binding, and that shocks to bank profits, such as loans defaults, can have a persistent impact on lending.

In Van den Heuvel's model (2007), the risk-based capital requirements of the Basel Accord and imperfect market for bank equity imply a failure of the Modigliani-Miller's 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 shows that a bank with low capital may optimally forgo profitable lending opportunities to lower the risk of future capital inadequacy. Another crucial feature of Van den Heuvel model is the maturity transformation performed by banks, exposing them to interest rate risk. A monetary tightening by raising the short-term interest rate lowers bank profits.

### 1.2. Empirical evidence of bank lending channel in other countries.

Early empirical studies testing the existence of a bank lending channel in U.S. generally focus on the correlations among aggregate output, bank debt, and indicators of monetary policy. Bernanke and Blinder's (1992) study concludes that monetary policy works in part through bank lending channel. However, their result is plagued by the problem in identifying shifts in loan demand from the shifts in loan supply. Ramey (1993) concludes that 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 find supportive evidence for the bank lending channel. Using the Romer and Romer (1989) identified dates that signal contractionary shifts in monetary policy, Kashyap, Stein and Wilcox find 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 results in an increase in the demand for non-bank credit. However, Gertler and Gilchrist (1993), Eichenbaum (1994) and Oliner and Rudebusch (1996) conduct a series of researches using disaggregated data found no evidences to support a bank lending channel in monetary policy transmission.

Considering the borrowers' heterogeneity in their sensitivity to the business cycle and the types of credit they use, evidence based on Ramey (1993), Kashyap, Stein and Wilcox (1993), aggregate credit measure can be problematic. To avoid this problem, Kashyap and Stein (1995) use quarterly data on individual banks operating in the U.S. from 1976:Q1 to 1992:Q2. They classified banks by their asset size and use the Fed Fund rate as the monetary policy instrument. Their results show: (1) a tightening in monetary policy reduces deposits across all different sizes of banks in 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 Fed funds 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 find that small bank securities holdings are more sensitive to changes in monetary policy. Kashyap and Stein (2000) conduct another study on the bank lending channel using bank level data that includes quarterly observations of every insured U.S. commercial bank from 1976 to 1993. They conclude that within the class of small banks, changes in monetary policy matter more for banks' lending with the least liquid balance sheets. Kashyap and Stein conclude that it is difficult to answer how important the bank lending channel is for aggregate activity quantitatively, but can not deny the existence of a lending channel in monetary transmission. Kishan and Opiela (2000), Peek, Rosengren and Tootell (2003), and Cetorelli and Goldberg (2008) support 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 make it difficult to quantify the impact of monetary policy on aggregate credit. To avoid this aggregation problem, the vector error correction models (VECMs) have been widely used. Within the VECMs framework, the supply and demand for loans can be identified by testing for the presence of multiple cointegrating relationships and exclusions, and exogeneity and homogeneity restrictions in the cointegrating relationships. Loan supply and demand can therefore be modeled jointly, rather than in a one-equation reduced-form format (Mello and Pisu, 2009).

Researches on bank lending channel on other countries include 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 support the existence of 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 from 1995:12 through 2008:6. Mello and Pisu argue 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 test for exclusion/homogeneity restrictions on multiple cointegration vectors in the VECM to disentangle the loan supply and demand effects of monetary policy shocks. They document the existence of a bank lending channel in Brazil and find that a comparatively low credit-to-GDP ratio does not preclude the transmission of monetary policy through a bank lending channel.

**1.3. Overview of China's financial institutions development.** The salient characteristic of the banking sector in the pre-reform era of China is a mono bank system. Between 1949 and late 1970s, the PBC functioned both as the central bank and the only deposit-taking and lending institution. Hence, it was not a real bank in the profit seeking financial intermediation services (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 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 objective 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 to meet their financial requirement. 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 allows the government to involve 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 are 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, developed 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 1).

Table 1. Assets, deposits, and loans of Chinese banking institutions, as of December 31, 2008

Type of institution	No. of institutions	Assets	Deposits	Loans
		Percent of total	Percent of total	Percent of total
Big Four Commercial banks	4	48.4	53.5	45.58
Policy banks	3	8.99	0.90	13.27
Joint stock commercial banks	12	18.4	18.0	20.04
Urban commercial banks	91	6.49	7.27	6.813
Foreign-investment banks	267	2.14	1.188	2.146
Others		12.86	11.06	12.33

Source: The People's Bank of China quarterly statistical bulletin from 1997Q1 to 2009Q1.

The declining asset quality of state-owned banks forced the government to inject public funds to clean up the banks' balance sheets. In addition, China began opening its banking sector to foreign competition in late 2006, as mandated by the World Trade Organization (WTO). Furthermore, in regards 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 behavior

of bank executives. Chinese banks have 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).

**1.4. Review of credit channel in China's monetary policy transmission.** Wang and Wang (2000), Li (2001) and Zhou and Jiang (2002) support the existence of credit channel in China based on the cointegration method and Granger causality test. Sun (2004) examines the relationships among mone-

tary aggregates ( $M_1$  and  $M_2$ ), credit aggregate, and GDP to identify the 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 conducts the Granger-causality test and finds that credit aggregate does not Granger cause GDP and monetary aggregate, but monetary aggregate Granger causes credit aggregate and GDP. Therefore, Sun concludes that it is the money channel rather than the credit channel that plays an important role in China's monetary policy transmission.

Jiang, Liu and Zhao (2005) adopt 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 money and credit channels in monetary transmission in China. According to the impulse response function, Jiang, Liu and Zhao find that monetary aggregate has a more immediate and a stronger impact on inflation rate and GDP than monetary aggregate  $M_2$  in eight quarters. The magnitude of the impact reaches the peak at four quarters lag and is significant even in the ten quarters lag but begins to decline. The impact of credit on GDP is much stronger than monetary aggregate in ten quarters. The authors conclude that credit channel plays an important role in China's monetary policy transmission.

Sheng and Wu (2008) utilize 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 group Granger causality test, Sheng and Wu find that (1) credit Granger causes  $M_2$ ; and (2)  $M_2$  and credit aggregate Granger cause industrial value-added. Sheng and Wu conclude that changes in credit aggregate give rise to the changes in monetary aggregate, not vice versa; and that bank credit aggregate instead of monetary aggregate is the actual intermediate target. Therefore, money channel does not exist in China and credit channel plays an important role in monetary policy transmission. This result supports Wang's (2003) finding.

Some questions remain concerning the credit channel in China's monetary policy transmission. Firstly, previous researchers test the relationships among bank loan aggregate, GDP (or industrial value), price level and monetary aggregate. However, they did not identify whether the bank loan supply or bank loan demand drives the changes in bank loan aggregate. Secondly, none of the researchers exam-

ines whether the loan volume responds to changes in the stance of monetary policy of the PBC. According to Kashyap and Stein's viewpoint (1994), if bank lending channel exists in China, changes in the required reserve ratio by the PBC should affect the supply of bank loan because it changes the quantity of reserves available to the banking system. Thirdly, the results based on Granger causality test are ambiguous, because it is difficult to ascertain clear conclusions unless the data can be described by a simple two-dimensional system (Bent, 2005). As Sims described (1977), the conclusion of Granger-causality test depends on the right choice of the conditioning set. In reality, one can never be sure that the conditioning set has been chosen large enough. Another problem regarding the 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 money aggregates. According to Bernanke and Gertler (1995), this approach to test the credit channel is invalid and suffers from the incorrect premise, which treats credit aggregates as an independent causal factor affecting the economy. In addition, credit is rarely a primitive driving force and credit condition (measured by 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. Variables and data description

Aguiar and Drummond, (2006), Van den Heuvel, (2007), and Gomez-Gonzalez and Grosz (2007) noted that bank capital influences loan supply through changes in capital requirement. Furthermore, 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 costs of bank's borrowing which further affects bank's lending. However, in this study, we do not utilize these two variables for the following reasons. Firstly, commercial banks in China have not imposed capital adequacy regulations strictly. Secondly, the interbank interest rate does not influence commercial bank lending rates that are under the PBC's regulation. Geiger (2006, 2008) research shows that changes in interbank interest rates do not have effect on the bank loans in China.

This research uses total loan 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 two policy instrument variable that influences loan

demand and supply, respectively. The interest rates on required reserve changed frequently by the PBC. Therefore, it is important to consider the effects of changes in required reserve ratio on the variations of bank credit in China. Since 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 consumer price index (CPI) and defined in log terms. We also included seasonal dummy variables in the VECM, which consider the possibility of seasonal factor in GDP and loan aggregate.

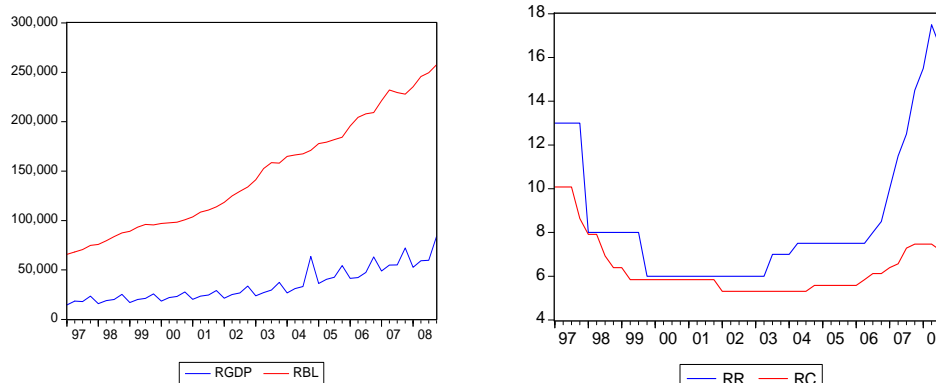


Fig. 1. Level of real GDP (RGDP), real credit aggregate (RBL), required reserve ratio (RR) and one-year lending interest rate (RC)

We first check for the stationarity of the series. A variable is called integrated order of  $d$ ,  $I(d)$ , if it has to be differenced  $d$  times to become stationary. We utilize the Augmented Dickey-Fuller (ADF) test with GLS detrending (DF-GLS) test (Elliott, Rothenberg and Stock, 1996) to test for stationarity. The ADF-GLS test avoids having to include

Quarterly data from 1997:Q1 to 2008:Q4 were obtained from the PBC quarterly statistical bulletin. Figure 1 shows the trends of the real GDP, real bank loan aggregate, RR, and RC.

A visual inspection of Figure 1 shows that the stock of bank loan grew sharply after 2000 and the ratio of the stock of bank loan to GDP increases. The effective required reserve ratios and official loan interest rate show a declining trend up to 2000, following a relative stability between 2002 and 2006, and a short period of increase from early 2007 to the second quarter of 2008.

a constant, or a constant and linear trend in the ADF test regression. This test substantially improves the power of the test when an unknown mean or trend is present. Table 2 shows that all variables in level cannot reject the presence of unit roots at 10% significance level, and all variables are  $I(1)$ .

Table 2. Results of Unit roots test

Variables	K	DF-GLS Statistic	1%	5%	10%
Level					
GDP	1	2.021	-2.616	-1.948	-1.612
BL	3	0.884	-2.618	-1.948	-1.612
PI	4	-0.982	-2.619	-1.948	-1.612
RR	1	-0.988	-2.616	-1.948	-1.612
RC	1	-0.688	-2.616	-1.948	-1.612
RM	0	-0.493	-2.615	-1.948	-1.612
Difference					
GDP	0	-10.13	-2.616***	-1.948	-1.612
BL	0	-5.440	-2.616***	-1.948	-1.612
PI	4	-2.083	-2.621	-1.948**	-1.612
RR	0	-5.181	-2.616	-1.948	-1.612
RC	0	-3.303	-2.616***	-1.948	-1.612
RM	2	-2.564	-2.618	-1.948**	-1.612

Notes: \*\*\* Significant at 1% level; \*\* significant at 5% level. 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. Research methodology

**3.1. Johansen cointegration method.** In this section, we present the econometric framework, and

describe the procedures used to identify the bank lending channel. We model China's bank lending activity using a vector error correction model (VECM).

We proceed to test for cointegration using Johansen procedure. Consider the following VECM for a  $n \times 1$  vector of I(1) variables,  $X$ ,

$$\Delta X_t = A_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t,$$

$$\Gamma_i = -(I - A_1 - \dots - A_i), \quad t = 1, 2, \dots, T, \quad (1)$$

$$\Pi = -(I - A_1 - \dots - A_k),$$

where  $k$  is the number of lags in the unrestricted VAR representation of  $X_t$ , and  $A_0$  is vector of  $n$  intercepts. The equilibrium properties in equation (1) are characterized by the rank of  $\Pi$ . If the elements of  $X_t$  are I(1) and cointegrated with  $rank(\Pi) = r < n$ ,  $\Pi$  can be decomposed into two  $n \times r$  full rank matrices  $\alpha$  and  $\beta$ , where  $\Pi = \alpha\beta'$ . This implies that there exist  $r < n$  stationary linear combinations of  $X_t$ , such that  $\beta'X_t \sim I(0)$ . The matrix of adjustment coefficients,  $\alpha$ , governs the speed of adjustment when equation (1) is out of equilibrium. Therefore, an important part of cointegration analysis involves making inference about  $r$ ,  $\alpha$  and  $\beta$ .

The rank of  $\Pi$  is equal to the number of its characteristic roots that differ from zero, so the number of independent cointegrating vectors in the system can be determined by checking the significance of the characteristic roots of the coefficient matrix. The test for the number of cointegrating vectors using the trace and max eigenvalue test statistics is given as follows:

trace test:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i), \quad (2)$$

max eigenvalue test

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}), \quad (3)$$

where  $\hat{\lambda}_i$  is the estimated value of the characteristic roots or eigenvalue obtained from the estimated  $\pi$  matrix, and  $T$  is the number of usable observations.

The trace test tests for the null hypothesis that the number of cointegrating vectors is less than or equal to  $r$  against a general alternative. The maximum eigenvalue test tests the number of cointegrating vectors  $r$  against the alternative of  $(r+1)$  cointegrating vectors. Given a vector of  $n$  I(1) variables, there can be at most  $n-1$  independent cointegrating relationships between these variables,  $0 \leq r \leq n-1$  (Enders, 2004).

**3.2. Testing parameter restrictions on the long-run cointegration relationships.** 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 of particular importance since the objective is to extract estimates of the structural equations which 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 we regard as the dependent variable in the relationship is given as 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  $\beta$  in an attempt to obtain the structural relationships between the variable. 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).

The tests of 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  $a_{i1} = a_{i2} = \dots = a_{ir} = 0$ , the  $i$ -th endogenous variable,  $x_i$ , is weakly exogenous for the system as a whole, and 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 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  $j^{\text{th}}$  cointegrating vector does not enter the  $i^{\text{th}}$  equation in the VAR (Viegi, 2005).

#### 4. Empirical results

We consider a simple aggregate model of loan supply ( $L^s$ ) and demand ( $L^D$ ). Loan supply depends on 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 macroeconomic conditions, proxy by economic activity ( $GDP$ ), inflation rate, and the bank lending rate, which affects the bank credit profits. This simple model allows for the identification of loan supply and demand, thus avoiding the identification problem that arises in the estimation of reduced-form credit supply equations. The model can be written as:

$$\begin{aligned} L^s &= \gamma_0 + \gamma_1 RR + \gamma_2 RC + \gamma_3 \pi + \varepsilon_1, \\ L^D &= \lambda_0 + \lambda_1 GDP + \lambda_2 RC + \lambda_3 \pi + \varepsilon_2. \end{aligned} \quad (4)$$

If the presence of two cointegration relationships cannot be rejected by the data, 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 equation. However, this does not reflect the classical economic theory. In classical economic theory, the bank lending rate is regarded as the bank loan return rate and is positively related to loan supply. However, Ginger (2008) finds that China's domestic credits increase with the declining official one-year lending interest rate during 1994-2006. In addition, the identification depends on testing for two exclusion restrictions: required reserve ratio should not enter the demand function (while negatively related to loan supply), and GDP should not enter the loan supply function (while positively related 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 course 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 3.

Table 3. VAR lag order selection criteria

Lag	Logl	LR	FPE	AIC	SC	HQ
0	44.959	NA	2.22e-07	-1.134	-0.323	-0.833
1	314.2	428.42*	3.34e-12*	-12.238*	-10.414*	-11.56*

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

Table 4 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 4. Results of Johansen's cointegration test

Null hypothesis	Eigenvalue	Trace statistic	5% Critical value	5% P value
$r = 0$	0.666	94.553	69.818	0.002**
$r \leq 1$	0.428	52.196	47.856	0.018**
$r \leq 2$	0.344	26.466	29.797	0.115

Note: \*\* Mackinnon-Haug-Michelis (1999) p-values.

Table 5. Unrestricted cointegration vectors and restriction tests

	Loan	GDP	RR	RC	CPI
Unrestricted vector					
$\beta_1$	16.449	-17.636	-0.285	1.365	46.181
$\beta_2$	-3.865	-8.1544	-0.838	-0.374	106.87
Hypothesis tests (1)					
Long run exclusion	17.702 [0.000]	17.928 [0.000]	4.481 [0.006]	10.115 [0.006]	8.950 [0.011]
Weak exogeneity	5.937 [0.051]	5.890 [0.052]	0.743 [0.689]	8.304 [0.015]	5.627 [0.059]

Note: (1) The test statistics are distributed as  $\chi^2$  with 2 degree of freedom ( $\rho$ -values are reported in brackets).

The estimated unrestricted cointegrating vectors are reported in the top panel of Table 5. 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 Table 5 reports the hypothesis tests conditional on the selected rank. The long-run exclusion tests suggest 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.

To identify the supply and demand equations, we imposed the following joint exclusion and exogeneity restrictions 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 5% level based on the LR test ( $\chi^2(2) = 743$ ,  $p$ -value = 0.689). As a result, the parameters in the supply and demand equations normalized in bank loan (L) are given as follows (absolute t-statistics in parentheses):

$$\begin{aligned} L^D &= 0.811GDP - 0.085RC - 0.359CPI, \\ &\quad (10.79) \quad (7.08) \quad (0.61) \\ L^S &= -0.0471RR - 0.098RC + 7.059CPI. \quad (5) \\ &\quad (2.88) \quad (3.629) \quad (9.617) \end{aligned}$$

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

There are negative relations between bank loans and required reserve ratios as well as bank lending rate in the loan supply in equation (5). The estimated RR and RC coefficients are statistically significant. This finding documents the existence of bank lending channel in China, since monetary policy movement affects the supply of loans. In addition, 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

either. 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 situation, if the PBC increases interest rate to fight inflation and uses quantity-based instruments simultaneously that primarily aim at a given amount of money without considering prices, the higher interest rate for 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 test the short-term dynamic adjustment process to confirm these relationships. The short-term dynamics loan supply and demand can be assessed using the loading matrix ( $\alpha$ ) in conjunction with the normalized restricted cointegrating vectors reported in equation (5). According to Juselius (2006), if  $a_{ij}$  and  $\beta_{ij}$  have the same signs, the  $i$  variable adjusts towards equilibrium defined by the cointegrating relationship. If they have opposite signs, the  $i$  variable does not converge to 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 6, the demand in equation (5) is equilibrium-correcting in regard to the loan volume, but this is not true for the supply equation ( $\alpha_{12}$  is not significant statistically). 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  $\alpha_{GDP1}$  and  $\alpha_{RC1}$  signs are opposite to the  $\beta_{GDP1}$  and  $\beta_{RC1}$  signs in the long-run equation (5), so convergence is not achieved through their movements. On the other hand, the short-run disequilibria in the long-run supply equation (5) are corrected through changes in the lending rate only. Inflation rate ( $\alpha_{\pi 2}$ ) is statistically significant but has an opposite sign to the  $\beta_{\pi 2}$ . 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.

Table 6. Loading matrix

	Demand ( $\alpha_1$ )	Supply ( $\alpha_2$ )
$\Delta L$	-0.129 (2.186)	0.053 (1.403)
$\Delta GDP$	-0.630 (2.560)	0.247 (1.563)

Table 6 (cont.). Loading matrix

	Demand ( $\alpha_1$ )	Supply ( $\alpha_2$ )
$\Delta RR$	0.000 (-)	0.000 (-)
$\Delta RC$	5.253 (4.694)	-2.807 (3.909)
$\Delta \pi$	0.041 (1.863)	-0.061 (4.357)

Note: Absolute t-statistics are in parentheses.

## Conclusion

The difficult problem in testing for the existence of a bank lending channel for monetary transmission is to disentangle 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 and Gilchrist, 1994, Onliner and Rudebusch, 1995), and disaggregated data on banks (Kashyap and Stein, 1995, 2000). Since the reduced-form VAR method cannot clearly distinguish the bank lending channel from conventional money channel and the unavailability of bank level data, this study tests the exclusion/homogeneity restrictions on multiple cointegration vectors in a VECM using aggregate data.

The estimation of a VECM using China's quarterly aggregate data for the period 1997:Q1 to 2008:Q4 yields two cointegration vectors, which could be identified as loan demand and supply equations based on the exclusion restrictions on the cointegrating vectors and exogeneity restrictions on the VECM's loading parameters. Based on this result, we identify the existence of bank lending channel for China. The

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<sup>1</sup> 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).

results show that the required reserve ratios and the official one-year lending interest rate are negatively related with bank loans in China. China's central bank could effectively control loan supply through its policy instrument.

This result has important practical implications for China's policymakers. Firstly, China's central bank has abandoned direct credit control since 1998 and adopted a monetary targeting policy together with a window guidance system. However, the short-run relationship between monetary aggregate and the economy broke down from time to time because of financial deregulation and innovation. Therefore, the PBC still attaches great importance to the effect of credit on real economy. Secondly, due to the local government investment impulse and because most of the local government investment funds are obtained through bank credit, the PBC should pay more attention to the credit policy, when it tries to constrain the investment boom.

There are some limitations in this study. First, this study uses aggregate credit data of the financial institutions, and we cannot identify the sensitivity of bank lending between different banks (small banks and big banks) with regard to the PBC policy changes. Research based on bank level data could complement the results of this study. Second, we use required reserve ratio and official one-year commercial bank lending interest rate to identify the bank lending channel. These two variables reflect the PBC quantity and price instrument, but another important policy indicator, "window guidance"<sup>1</sup>, has been left out, due to lack of relevant information. This indicator should be included in future studies to obtain more robust results.

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