A Factor-Augmented VAR Analysis of the Monetary Policy in China[1]

Pak-Ho LEUNG, Qing HE and Terence Tai-Leung CHONG

Department of Economics, Chinese University of Hong Kong,

School of Finance, Renmin University of China

Department of Economics, Chinese University of Hong Kong

Abstract:

This paper investigates the effects of monetary policy in China over the past two decades with a typical emphasis on the post-Asian crisis period and the more recent currency regime shift. A Factor-Augmented VAR method is used to study the effectiveness of monetary policy instruments in stabilizing the Chinese economy. We find that the repo rate, benchmark lending rate and a market-based monetary stance are mildly effective while the growth rates of total loan and of money supply are significantly effective. Moreover, the effectiveness of the market-based monetary policies does not improve under a more flexible exchange rate regime. It is concluded that the central bank in China still depend on the administrative instruments in stabilizing domestic inflation, and thereby maintaining macroeconomic and financial stability.

KEYWORDS: Factor Model, Principal Components, VAR, monetary policy

JEL classification: E3, E4, E5, C3

---

[1] We would like to thank Xinhua Gu, Robin Pope and Keen-Meng Choy as well as participants of the 2009 ACE International Conference for their helpful comments on the earlier version of this paper. The financial support from the Key Projects in Philosophy and Social Sciences Research program of the Ministry of Education of the People's Republic of China (Grant Number 08JZD0011) is highly appreciated. All remaining errors are ours. Corresponding Author: Terence Tai-Leung Chong, Department of Economics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. E-mail: chong2064@cuhk.edu.hk. Homepage: http://www.cuhk.edu.hk/eco/staff/tlchong/tlchong3.htm.

1. Introduction

In the post-Asian Crisis period, China has achieved remarkable economic growth for more than a decade, with an average annual growth rate of about 9 percent. Meanwhile, the inflation rate, as measured by the GDP deflator or CPI, has remained moderate[2]. With the termination of official guidance on banks' lending operations in 1998, monetary policy has played an increasing role in the macroeconomic stabilization in China (Green, 2005). However, the transmission mechanism of the monetary policy remains unclear. Since 1998, a variety of monetary policy instruments, such as the base interest rates, open market operation, the discount rate and reserves requirement, have been adopted by the People's Banking of China (PBC) to fine tune the economy. However, as the relationship between these instruments and real economic activities is unstable over time, it complicates the ways that monetary policy affects the real economies. More importantly, with the integration into the global economy, the independence and effectiveness of China's monetary policy have been challenged because of the exchange rate rigidity.[3] As a result, there has been an increasing attention on the effects and mechanisms of the Chinese monetary policy.[4]

In an attempt to shed light on the transmission channels of monetary policy in China, we employ a new methodology – the Factor-augmented VAR (FAVAR), to

[2] The inflation rate remains below 3 percent in most periods. Several researches have found that Chinese economy has experienced a substantial moderation (Brandt and Zhu (2002), He et al. (2009), and Du et al. (2010).

[3] Goodfriend and Prasad (2007) reported that the Chinese monetary policy has operated with difficult constraints.

[4] For instance, the global financial crisis of 2007-2009, originated in the American mortgage market, has vaporized the wealth in the advanced economies. Due to a halt in spending in developed countries, the export-oriented economy of China in jeopardy. In response, the People's Bank of China slashes the lending rate as well as the required reserve ratio to support the financially distressed industries.

investigate the effects of several important monetary policy instruments during the last decade.[5] The FAVAR approach allows us to assess how much of the observed movements of real economy can be attributed to each policy instruments, separately and in combination.

While significant efforts have been devoted to investigate the effect of Chinese monetary policies, most of the previous studies employ only a single policy instrument to measure monetary policy (Mehrotra, 2007; Dickinson and Liu, 2007; and Koivu, 2009). Our study complements the literature by making a comprehensive investigation of different monetary policy instruments in China. By comparing the role of each instrument, our study gains insight into the transmission mechanism of the Chinese monetary policy. Secondly, to the best of our knowledge, this is the first attempt to use a combination of policy instruments in the model estimation. As China usually implements different market-based policy instruments at the same time, the use of the factor approach may provide an overall evaluation of its monetary policy. Finally, most of the previous studies have employed the Vector Autoregression (VAR) approach, which typically comprises of few variables. The use of sparse information sets in VAR analysis may produce inaccurate estimates and impulse response pattern (Sims, 1992; Rudebusch, 1998; and Bernanke et al., 2005). The Factor VAR model combines the standard VAR approach with factor analysis, and can provide a proper identification of the monetary transmission mechanism (Stock and Watson, 1998; Bernanke et al., 2005; Boivin and Giannoni, 2006).

Our results suggest that the Chinese economy is mainly affected by the growth rate

[5] The factor VAR procedure has been widely used on the analysis of U.S. and European monetary policy.

of total loan and M2. Other market policy instruments, such as the repo rate and benchmark lending rate, are only mildly effective in influencing the real economy. We also show that the general monetary stance representing the overall effects of market-based instruments only plays a modest role in curbing inflation.

The rest of the paper is organized as follows. Section 2 gives an overview of the major monetary policies and the transmission mechanism in China. The method of Factor-Augmented Vector Autoregression (FAVAR) is introduced in Section 3. Section 4 dwells on the empirical evidence. Section 5 presents the results and policy implications. Section 6 concludes.

2. Features of Post-Crisis Chinese monetary policy

The People's bank of China (PBC) has become the central bank of China since 1983, while it operates under the control of the State Council. An approach of "direct lending", is widely used for implementing monetary policy. Though a number of reforms have been promulgated in the following years (The People's bank of China, 2005), the lending pattern had little changes till 1998 (Park and Sehrt, 2001), which indicates scant changes in the implementation of monetary policy.

As the Chinese economy is exposed to more external economic uncertainties, an independent and effective monetary policy is increasingly crucial for stabilizing inflation, employment and economic growth (Goodfriend and Prasad, 2007)[6]. Along with the liberation and reform in the banking sector, a series of reforms have been carried out to enhance the effectiveness of the monetary policy. Ever since the

[6] For instance, Lardy (2005) points out that the lack of independence of the PBC may result in counterproductive monetary policy, which leads to a further delay in liberalizing the capital account.

termination of "direct lending" in 1998, a variety of monetary instruments have been implemented. This section will briefly review some important liberalization policies and a number of key policy instruments since 1998.

2.1 Liberalization of China's monetary policy in recent years

The People's Bank of China (PBC) has a dual legal mandate of "maintaining the stability of the currency, and thereby promoting economic growth". However, the persistent double-digit inflation rate in the first half of 1990s, and the outbreak of the Asian Financial Crisis in 1997, have cast doubt on prospect of the Chinese economy. A series of banking and financial reforms, especially the liberalization policies, have shored up the capacity of China's monetary policy. In 1996 and 1997, the upper limits on inter-bank lending rate were abolished, and the bond repo interest rates were liberalized respectively, implying less administrative control over the money market. More importantly, the credit quota control was scrapped in 1998 and the central bank is able to conduct its monetary policy through indirect tools. The PBC further liberalizes the interest rates in order to improve the effectiveness of monetary policy. Since then, the ceiling of RMB lending rate of financial institutions has been climbing and finally abolished in 2004 (except for the Urban Credit Cooperatives and Rural Credit Cooperatives). The floor of deposit rate is also removed in 2004. The lending rate can move unboundedly from 90 percent of the benchmark lending rate while the ceiling on deposit rate still prevails. In 2007, the Shanghai Inter-bank Offered Rate (SHIBOR) was formally launched to shore up the transmission mechanism of the monetary policy (PBC, 2007).

2.2 Monetary policy instruments and their transmission mechanism

Since 1998, the PBC is forced to update its monetary tool box to increase the effectiveness of policy reaction as a consequence of economic environment change. Besides the administrative instruments, a reform toward market-based instruments has also been implemented.[7] The following section briefly reviews several important monetary instruments used by the People's bank of China.

A. Open Market Operation

Open market operation is a major monetary policy used by the PBC to influence the money market interest rate and the money supply.[8] As the open market operation is carried out on a repo basis, the repo rate is often used as an indicator of China's monetary policy[9] (Peng et al., 2006). Figure 1 shows that the repo rate declined from 8.6 percent in 1998 to barely 1 percent in 2005. This rate has been climbing since 2005 to curb the overheating economy and the escalating inflation. While, the plunge of repo rate in 2008 provides extensive liquidity for the real economy.

[Insert Figure 1 here]

B. Benchmark lending interest rate

The benchmark interest rate is the reference rate set by the PBC, around which

[7] The market-based instruments include open market operation, central bank lending rate, rediscount rate, required reserve interest rate, excess reserve interest rate, required reserve ratio and benchmark lending and deposit rate. The administrative instruments are the regulatory change and window guidance, which is a quantitative manipulation of the bank credit.

[8] When the pressure of inflation increases, the PBC can sell central bank bills on a cash or repo basis in the money market and withdraw money from the commercial banks. With less capital available for lending, the banks have to raise the lending rate to reflect the real price of capital. The drop in demand for loan will also lower the consumption, investment and aggregate demand. Consequently, the pressure of inflation will be relieved. For instance, the issuance of central bank bills in 2008 has decreased gradually to ensure an ample money supply in the market during the global financial crisis.

[9] The 7-day repo rate is often used as a benchmark (Green, 2005)

differentiated financial institutions can set their respective commercial lending rates. As the restrictions of the benchmark interest rate are gradually removed in recent years, financial institutions are allowed to set their own interest rates according to the market conditions.

The benchmark interest rate is a key market-based monetary policy to adjust the broad money supply. Figure 2 shows that the one-year benchmark lending rate has declined substantially during 1998 and 1999 and remained around two percent until early 2007. The rate climbs to four percent in 2008 and is slashed again in 2009 due to the stimulation monetary policy to cope with the Subprime Crisis.

[Insert Figure 2 here]

C. Total Loan

The total amount of credit provided by financial institutions to the economy could be adjusted by the central bank in various ways. The PBC could employ market-based instruments, such as the interest rates or required reserve ratio, to indirectly control the total credit. Though the credit quota is scrapped in 1998, window guidance[10] is still crucial for managing the total amount of credit.

As the window guidance and regulation changes are not quantifiable, one could shed light on the general monetary direction by tracking the total amount of credit

[10] Window guidance is another policy controlling the amount of bank credit and the M2 without going through the money market and affecting the interest rate. This instrument can also be treated as a measure to promote certain types of industries. For instance, commercial banks may be instructed to refrain from lending to industries with high energy consumption, and reinforce the support to the agricultural sector. Besides, in order to ease the upward pressure of the currency, the PBC has to keep the interest rates in China significantly lower than those in the United States. The PBC thus employs the window guidance to control the money supply when other monetary instruments are not feasible (Lardy, 2005).

growth. Figure 3a shows that the growth of financial institution loan has risen from 5 percent in early 2000s to 15 percent in the mid-2000s. The central bank accelerated the credit creation after 2008, implying a loosening of monetary policy upon the outbreak of global financial crisis.

[Insert Figure 3a here]

D. Money Supply (M2)

The broad money supply, M2, is the intermediate target of monetary policy of the PBC and its annual target growth rate is usually announced at the beginning of a year. The PBC tends to use both market-based and administrative monetary tools to achieve the target of the M2[11]. Figure 3 shows that the annual growth rate of money supply fluctuates around 15 percent between 1998 and 2007. This growth rate increases substantially to over 25 percent in 2009.

[Insert Figure 4 here]

2.3 Exchange Rate reform and the monetary policy

The Chinese currency, the Renminbi, was actually pegged to the US dollar before July 2005[12]. The rigidity of exchange rate has limited the capacity of the PBC in controlling the price level and growth rate via its monetary policy (Prasad et al.,

[11] Though M2 and total loan capture the impacts of most policy instruments, their growth targets are determined separately and their actual growth rates are not necessarily coincide. We consider both indicators to gauge the general monetary stance in China.

[12] Though PBC has announced that the exchange rate was allowed to move around the parity by 0.3 percent, the official rate seldom deviates from the fixed parity.

2005). On 21 July 2005, the PBC promulgated reforms in its exchange rate policy by allowing Renminbi to float in a managed way with reference to a basket of currencies.[13] As shown in Figure 4, the exchange rate between RMB and the US dollar has climbed from 8.28 in July 2005 to 6.83 February 2010. The reform in the exchange rate policy has provided the PBC more flexibility in managing the economy via its monetary policy.

[Insert Figure 4 here]

2.4 Effects of Monetary Policy on the Industrial Production and Inflation

The Chinese economy is characterized by high inflation in the first half of 1990s. Between 1993 and 1995, there was a huge build-up of price pressure in the domestic market with the consumer price index rose to 27% in October 1994. The monetary authorities adopt tightening administrated policies in 1993 and finally brought the inflation down to a single digit in 1996.

The sustainability of economic growth became a big concern for the Chinese authorities in the second half of 1990s when the Renminbi remained fixed against the US dollar, while many Asian countries have depreciated their currencies. Figure 6 shows that China has lost its export competitiveness as the growth of industrial production has been slowing down since the mid 1990s[14]. The consumer price index (Figure 5) fell from its peak in 1994 to nearly zero in 1998. Given the relatively low

[13] The intra-day variation of the Renminbi exchange rate against the US dollar was within 0.3%. This band was widened to 0.5% in May 2007.

[14] The average growth rate between 1994 and 1996 is 17.5, while it is a merely 10.9 percent between 1997 and 1999. Such a low rate of industrial growth is partly due to the Asian Financial Crisis in 1997.

inflation rate, the PBC was able to loosen its monetary policy to stimulate the economy. From 1998, the repo rate has been slashed from 8.6 percent to below three percent in 2000 and the benchmark interest rate fell from 5.7 percent to 2.25 percent in 1999. These drastic measures, coupled with the window guidance, helped to increase the money supply growth to ward off the potential downturn in industrial output.

Between 1999 and 2003, the price level is mildly trending down due to strong productivity growth. To ease the deflationary pressure, the central bank has to cut its interest rates and increase the money supply. The broad money growth shot up from 14% in 2000 to 20% in 2003. Due to this loose monetary environment in 2000-2003, the growth rate of industrial production has rebounded to 16.2 percent from its trough in 2000, while the consumer price index has started to climb since 2004. The overheating economy has alerted the monetary authorities. To rein in asset prices and the overheating economy, the PBC tightened its monetary stance by raising the interest rates as well as setting a higher reserve ratio for commercial banks.

The Global Financial Crisis of 2007-2009 triggered by the US subprime mortgage market, however, has reversed the contractionary monetary stance. The worsening economic environment of industrial countries had adversely affected the industrial production in China. The growth rate of industrial production plunged from above 15 percent in the early 2008 to merely 5 percent in December 2008. The fear of the high inflation has vanished as the consumer price index dipped into the negative in 2009. In addition to the government's fiscal stimulation, the PBC cut its interest rates and increase financial loans to sustain the eight percent economic growth target. The repo rate is cut from above 3 percent in late 2008 to less than 1 percent

in early 2009 while the growth rate of broad money supply rose to nearly 30 percent in late 2009 from solely 15 percent in 2008.

[Insert Figure 5 here]

[Insert Figure 6 here]

3. Methodology

Although the Vector Autoregression (VAR) approach is widely employed to estimate the effect and efficiency of monetary policy, it is subject to the relatively sparse information because of the low-dimensional VARs. To conserve the degrees of freedom, normally no more than six variables will be used in the VAR analysis. To control for the estimation bias due to the sparse information, we consider a large-dimensional dynamic factor model in this paper. It extracts a few number of latent factors from a large pool of observed data series of use to the central bank (Stock and Watson, 2002a, 2002b; Favero et al., 2004; Forni, et al., 2005 and Breitung and Eickmeier, 2006).

Our model is based on the Factor-Augmented VAR (Bernanke, Boivin and Eliasz, 2005). Similar to the standard VAR, this model defines a transition equation (1) which captures the transition mechanism of the economy.

$$(1) \quad \begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t$$

In the transition equation, Y_t is an $M \times 1$ vector of observable economic variables

assumed to drive the dynamics of the economy, such as industrial production, interest rates and consumer price index. F_t is a $K \times 1$ vector of unobservable factors, which are supposed to capture the theoretical concept of "real economic activity", "price pressures", or "financial market conditions". If there is no factor in the transition equation, the FAVAR will be reduced to the standard VAR with only observable economic variables, which implies the standard VAR is a sub-model of the FAVAR. To conserve the degree of freedom and include the information set of the monetary authority, we have to augment the VAR with several factors, which summarize a large number of data series. The vector of factor F_t is extracted from the observation equation (2) below.

(2) $$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t$$

In this observation equation, X_t is an $N \times 1$ vector of observable informational time series, where N is large relative to the sum of M and K (i.e. N>>M+K). The matrix Λ^f and Λ^y are the factor loadings of dimension conformable to X_t, F_t and Y_t. The error terms e_t are assumed to have a zero mean. This observation equation implies that the dimension of the entire information set in X_t, which cannot be spanned by Y_t, will be spanned by the factors. In this study, we will estimate the factors with a two-step principal components approach[15] to extract the factors.

4. Data Description

Our sample consists of 100 monthly data series (1998M1 – 2010M2), and are

[15] The program we employed in the estimation is based on Bernanke, Boivin and Eliasz (2005).

categorized into twelve groups.[16] The first eleven groups focus on different aspects of economic performance in China, including real activities, price index, investment, government revenue and expenditure, retail sales, international trade, interest rate, money aggregate, financial market, exchange rate and consumer index. With the integration into the world economy, China is inevitably exposed to worldwide economic uncertainties, especially that of the United States. Thus, the US data are also included.

The data which are conceived to have seasonality are first adjusted by X-12 ARIMA. The Augmented Dickey Fuller test is employed to test the stationarity of the data series. In case of non-stationarity, the series will be transformed by first log difference to attain stationarity. Following Bernank, Boivin and Eliasz (2005), we distinguish two categories of data series in this paper, namely, fast-moving and slow-moving data. Fast moving data, such as interest rates, monetary aggregates, asset prices, exchange rate and consumer indexes, are contemporaneously affected by a monetary shock. Slow moving data, including the data of real activity, price level and international trade, are affected by a monetary shock for a lag of one period.

5. Empirical Results

We estimate a Factor-Augmented VAR model with a number of frequently-employed policy instruments, namely the repo rate, benchmark lending rate, total financial institution loans and M2 to evaluate their respective effectiveness. In addition, as the PBC usually uses several market-based instruments

[16] A detailed description of each data series is presented in the appendix.

simultaneously to achieve its objectives, we also use a factor, which tracks a wide range of market based policy instruments at the disposal of the PBC, to represent a general stance of the monetary policy. By estimating the FAVAR with this policy factor, we should observe the impacts on the economy from a sudden change, which is a 25-basis-point innovation for the policy instrument, of the market-based monetary stance. For each of the five models, we augment the VAR with three factors.[17]

Besides, the exchange rate policy has undergone substantial reform since 2005. To evaluate the change of the effectiveness from this reform, we estimate the models with two different subsamples, which are January 1998 - June 2005 and September 2002 - February 2010. The first subsample covers the period before the exchange rate reform while the second subsample covers the period under a more flexible currency regime. By comparing the performance of monetary policy in the two subsample periods, one could shed light on the evolution of monetary policy due to a loosened control on the exchange rate. To understand the effects of a shock from monetary policy on the economy, we also present the impulse response function for a wide range of economic indicators along with the industrial output and consumer price level.

5.1 Estimation of FAVAR with Repo Rate as the instrument

First, we estimate the model with the repo rate as the policy instrument. Figure 8 displays the resulting impulses response functions generated by the FAVAR before

[17] Following Bernanke, Boivin, Eliazs (2005), we use FAVAR with three factors and one policy instrument as the baseline model. Stock and Watson (1999, 2002b) also show that a few, perhaps two, dynamic factors can account for a large amount of variation in the macroeconomic data series.

the exchange rate reform given an increase in the repo rate. The response of the industrial production is insignificant[18]. The consumer price index exhibits a moderate increase initially but fall after a few months. The real estate investment also plunges for an extended period of time. Consequently, the repo rate is ineffective in promoting economic growth and weak at maintaining the price level under the fixed exchange rate.

Figure 9 shows the impulse response function generated by FAVAR from September 2002 to February 2010. Given a positive shock in repo rate, the industrial production has gently come down a few months after the shock while the consumer price index goes up for the fifteen months, displaying a sign of price puzzle. In comparison with the response under a fixed exchange rate, the repo rate is more capable of stimulating the real economic performance, but may not be an effective tool in containing inflation.

[Insert Figure 8 here]

[Insert Figure 9 here]

5.2 Estimation of FAVAR with Benchmark Lending Rate as the instrument

In the second model, we estimate the response of industrial production and inflation from a positive shock in the benchmark lending rate. Figure 10 depicts that the industrial production is not responding to a contractionary monetary policy shock. Though the price indexes are gently reduced, the reduction only lasts for fifteen

[18] For the results figures (Figure 8-11, 14-19), the green line shows the point estimate of the response function. The light blue line and the red line represent the 90% upper and lower confidence level respectively.

months. Figure 11 shows the response functions under a more flexible currency regime. The industrial production responds with a prolonged and moderate reduction to an upward shock of the interest rate. However, the price indexes soar, resulting in price puzzles for about twenty months following a tightening policy shock.

Before the exchange rate reform, both the repo rate and the benchmark lending rate were not effective in stimulating the economic performance. When the central bank raises the lending rate, the industrial production and price indexes show insignificant and short-lived response in Figure 8 and Figure 10. When the exchange rate is more relaxed, it has a mildly significant and long-lasting downward impact on the industrial production after a few months of the shock, implying a more effective policy to stimulate economic growth. Yet, the interest rates also give rise the price puzzles for both the consumer and producer price indexes. Therefore, the effectiveness of market-based monetary policy does not show any sign of improvement given a more flexible exchange rate policy.

[Insert Figure 10 here]

[Insert Figure 11 here]

5.3 Estimation of FAVAR with the monetary factor as the instrument

Thirdly, we assess the impact of a change of market-based monetary stance by the PBC on the real economy. As the monetary and financial markets have not been fully liberalized, the transmission channels of the policy instrument are not as efficient as those in the developed countries. The PBC has to rely on a number of

policy instruments simultaneously to influence the economy. We consider 15 market-based measures which are directly or indirectly managed by the PBC as potential monetary instruments[19]. We extract a policy factor from these 15 data series by maximum likelihood estimation. Table 12 shows that this factor is positively related to the interest rates. The movement of this policy factor, as depicted in Figure 13, resembles those of the repo rate and benchmark lending rate. As a result, an upward shock of this factor could be interpreted as a tightening monetary stance.

[Insert Table 12 here]

[Insert Figure 13 here]

Figure 14 displays the impulse response functions from an upward shock of the policy factor before the exchange rate reform. When the central bank takes a contractionary monetary stance, the negative impact on industrial production and price indexes are small but significant. These notable responses suggest a combination of market-based instruments is more effective than a single instrument, such as the repo rate or the benchmark rate. Besides, Figure 15 presents the impulse responses generated from the FAVAR between September 2002 and February 2010. Not surprisingly, a downward and persistent pressure on the industrial production is building up after a few months of the onset of contractionary policy. Nonetheless, the price puzzle in consumer price index emerges and prevails for nearly twenty months.

[19] These series include rediscount rate, repo rate (7 days, 1 month and 3 months), benchmark lending rate (6 months and 1 year), central bank lending rate (20 days and 3 months), Interbank Interest Rate (7 days, 30 days, 90 days) Interest rate on required reserve and excess reserve, saving rate and time deposit rate (1y). All these 18 series are seasonally adjusted and stationary.

[Insert Figure 14 here]

[Insert Figure 15 here]

5.4 Estimation of FAVAR with total loan as the instrument

Other than market-based instruments, the PBC also employ non-market-based instruments to prop up the economy and contain the price level. The total loan, which is affected by both interest rates and the administrative measures, is a principal indicator for the general monetary stance of the central bank. The PBC can tighten bank lending by raising the interest rates or by window guidance. Figure 16 and Figure 17 show the impulse responses of economic variables to a lowering of the growth rate of total loans. Under the fixed exchange rate (as shown in Figure 16), a negative shock in total loan results in a rapid and persistent decline in industrial production. The price indexes are also lowered a few months after the monetary policy is tightened. When the exchange rate is more flexible, a decreased total loan also hugely reduces the industrial production and consumer price index. These results reveal that the control of total loan is highly effective in regulating the economy.

[Insert Figure 16 here]

[Insert Figure 17 here]

5.5 Estimation of FAVAR with M2 as the instrument

For the last model, we estimate the impulse response functions of industrial production and inflation for a downward shock in the growth rate of M2. Figure 18

shows that, under the pegged exchange rate regime, the M2 shock initiates mild response from the industrial production and the consumer price index. This means an increase in money supply can only play a role to stimulate the real economic activities and raise the general price level. The impact of M2 on the economy has also been explicit, though less significant, after the exchange rate reform. From Figure 19, an increase in the growth rate of M2 can boost the industrial production and the consumer price index but the impacts die out about 15 months after the shock.

As compared to the estimation results of the repo rates and benchmark rates, the growth rate of total loan and of money supply are more successful in managing the real economic activity and price level. As explained in Section 2.2C and 2.2D, the total loan and M2 can either be adjusted by varying the interest rates and by window guidance. Neither the repo rate nor the benchmark rates, however, are shown to have a significant impact on the M2 as depicted in Figures 8 and 10, implying that the window guidance is the apparent driving force of the change of the money supply.

[Insert Figure 18 here]

[Insert Figure 19 here]

5.6 Policy discussion

In the above estimation exercise, we could shed light on the policy implication in two dimensions – the effectiveness of market-based and non-market-based

instruments, and the effectiveness of instruments under a fixed or more flexible exchange rate regime. By comparing the results of different policy instruments, we show that the growth rate of total loan and growth rate of money supply are more effective than the interest-rate based monetary instruments in regulating the economy. When quantity of loan or broad money supply grows at a higher rate, the industrial production and consumer price index will follow with a rise immediately after the shock. Nevertheless, the real economy and price level respond with a longer lag and less significant amount to the shocks of repo rate and benchmark rate. This shows that the central bank could not solely rely on the use of interest rates to fine tune the economy. Window guidance and regulatory adjustment are still crucial and effective to monetary policy implementation.

Our results also suggest that market-based policies have generally mild impacts on industrial production and price level. There are several explanations for this. The first is the high level of excess reserve in the banking industry (Green, 2005). The high excess reserve ratio, about 4 percent from 2005 to 2007[20], absorbs much of the influence of the monetary policies. Secondly, the partially liberalized money market also restrains the capacity of market-based policies. Though plenty of interest rate liberalization reforms have been implemented in the past decades, the ceiling on deposit rates and floor on lending rates are still in place, thus constraining the capacity for effective monetary policy.

In addition, the policy factor which tracks the monetary stance for market-based policies has a more pronounced impact on the economy than other monetary instruments before the exchange rate reform in 2005. This suggests that a wide

[20] In United States, the excess reserves are usually less than 2 percent of the deposit.

range of market-based monetary instruments is more effective to manage the economy than a single interest rate adjustment.

Regarding the change of exchange rate regimes, our estimation results are less explicit. As the Renminbi is fixed against US dollar before 2005, the Chinese central bank can hardly set its monetary policy independent of its American counterpart. Since the exchange rate reform in 2005, the Renminbi appreciated significantly against the US dollar. When the PBC carries out market-based tightening policies, the industrial production displays a more significant decline under a more flexible exchange rate regime. Nevertheless, the price indexes rise amid a monetary tightening condition in the second subsample. There are several reasons for the emergence of price puzzles in the estimation. First, the Renminbi is effectively repegged to US dollars since 2008. This highly restricts the sample size for estimation in this paper. Besides, the central bank still relies heavily on the window guidance as a principal monetary instrument, especially after the outbreak of global financial crisis. Moreover, the emergence of price puzzles given a shock from the market-based instruments may also suggest that those instruments are not designed for fighting against inflation in China.

6. Conclusion

In order to have a better understanding of the monetary transmission mechanism in China, this paper improves the conventional VAR model by including factor variables. It is found that the interest rates and the market-based monetary policies have little impact on the real economy and the price level under the fixed exchange rate regime. These policy instruments become slightly more effective on the

industrial production when the exchange rate is more market determined. We also track the market-based monetary stance of the PBC by summarizing 15 policy variables in one policy factor. This policy factor is more effective than any individual policy instrument, implying that the PBC may employ a wide range of monetary instruments.

Admittedly, the market-based instruments are slightly more influential on the economy under a more flexible currency regime. Nevertheless, the non-market-based measures at the disposal of the central bank are much more effective. These results are not surprising as the central bank could control the total financial loans as well as the broad money supply with a higher flexibility than the interest rates, which are highly restricted due to rigid currency regime. As a result, China could still carry out effective monetary policy through non-market-based measures under the rigid exchange rate system.

References

Belviso, F. and F. Milani, 2006, "Structural Factor-Augmented VARs and the effects of monetary policy," *The B.E. Journal of Macroeconomics*, 6(3).

Bernanke, B., J. Boivin, and P. Eliasz, 2005, "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach," *Quarterly Journal of Economics*, 120(1): 387-422.

Boivin, J. and M. Giannoni, 2006, "Has Monetary Policy Become More Effective?" *Review of Economics and Statistics*, 88(3): 445-462.

Brandt, L. and X. D. Zhu (2002), "What Ails China: A Long-Run Perspective on Growth and Inflation (or Deflation) in China," *East Asia in Transition: Economic and Security Challenges*, 49-72, University of Toronto Press.

Breitung, J. and Eickmeier, S. 2005. "Dynamic Factor Models," *Deutsche Bundesbank Discussion Paper* 38/2005.

Dickinson, D. and J. Liu, 2007, "The Real Effects of Monetary Policy in China: An Empirical Analysis," *China Economic Review*, 18(1): 87-111.

Du, J., Q. He, and O. Rui, 2010, "Does Financial Deepening Promote the Risk Sharing in China," *Journal of the Asia Pacific Economy*, forthcoming.

Favero, C., M. Marcellino, and F. Neglia, 2005, "Principal Components at Work:

The Empirical Analysis of Monetary Policy with Large Data Sets," *Journal of Applied Econometrics*, 20: 603-620.

Forni, M., D. Giannone, M. Lippi, and L. Reichlin, 2005, "The Generalized Dynamic Factor Model: One-Sided Estimation and Forecasting," *Journal of the American Statistical Association*, 100: 830-840.

Forni, M., D. Giannone, M. Lippi, and L. Reichlin, 2009, "Opening the Black Box: Structural Factor Models with Large Cross Sections," *Econometric Theory*, 25(05): 1319-1347.

Goodfriend, M. and E. Prasad, 2007, "A Framework for Independent Monetary Policy in China," *CESifo Economic Studies*, 53(1): 2-41.

Green, S., 2005, "Making Monetary Policy Work in China: A Report from the Money Market Front Line," Manuscript, Standard Chartered Bank, Shanghai, China.

He, Q., T. T. Chong, and K. Shi (2009), "What Accounts for Chinese Business Cycle", China Economic Review, 20, 650-661

Koivu, T., 2009, "Has the Chinese Economy Become More Sensitive to Interest Rates? Studying Credit Demand in China," *China Economic Review*, 20(3): 455-470.

Lardy, N**.,** 2005, "Exchange Rate and Monetary Policy in China," *Cato Journal*, 25(1): 41-47.

Laurens, B. and R. Maino, 2007, "China: Strengthening Monetary Policy Implementation," *IMF Working Paper No*. 07/14.

Mehrotra, A., 2007, "Exchange and Interest Rate Channels during a Deflationary Era - Evidence from Japan, Hong Kong and China," *Journal of Comparative Economics*, 35: 188-210.

The People's Bank of China, 2005, "Report on Steadily Progress in Interest Rate Liberalization".

The People's Bank of China, 2007, "China Monetary Policy Report Quarter Four 2006".

Park, A. and K. Sehrt, 2001, "Tests of Financial Intermediation and Banking Reform in China," *Journal of Comparative Economics*, 29(4): 608-644.

Peng, W., H. Chen, and W. Fan. 2006. "Interest Rate Structure and Monetary Policy Implementation in Mainland China," 1/06. *China Economic Issue*. HKMA

Prasad, E., Rumbaugh, T. and Wang, Q., 2005, "Putting the Cart before the Horse? Capital Account Liberalization and Exchange Rate Flexibility in China," International Monetary Fund, *IMF Policy Discussion Paper*: No. 05/1,

Rudebusch, G., 1998, "Do Measures of Monetary Policy in a VAR make Sense?" *International Economic Review*, 39(4): 907-931.

Sims, C., 1992, "Interpreting the Macroeconomic Time Series Facts," *European Economic Review*, 36(5): 975-1011.

Stock, J. and M. Watson, 1998, "Diffusion Indexes," *NBER Working Paper*.

Stock, J. and M. Watson, 1999, "Forecasting Inflation," *Journal of Monetary Economics*, 44(2): 293-335.

Stock, J. and M. Watson, 2002a, "Forecasting using Principal Components from a Large Number of Predictors," *Journal of American Statistical Association*, 97(460): 1167-1179.

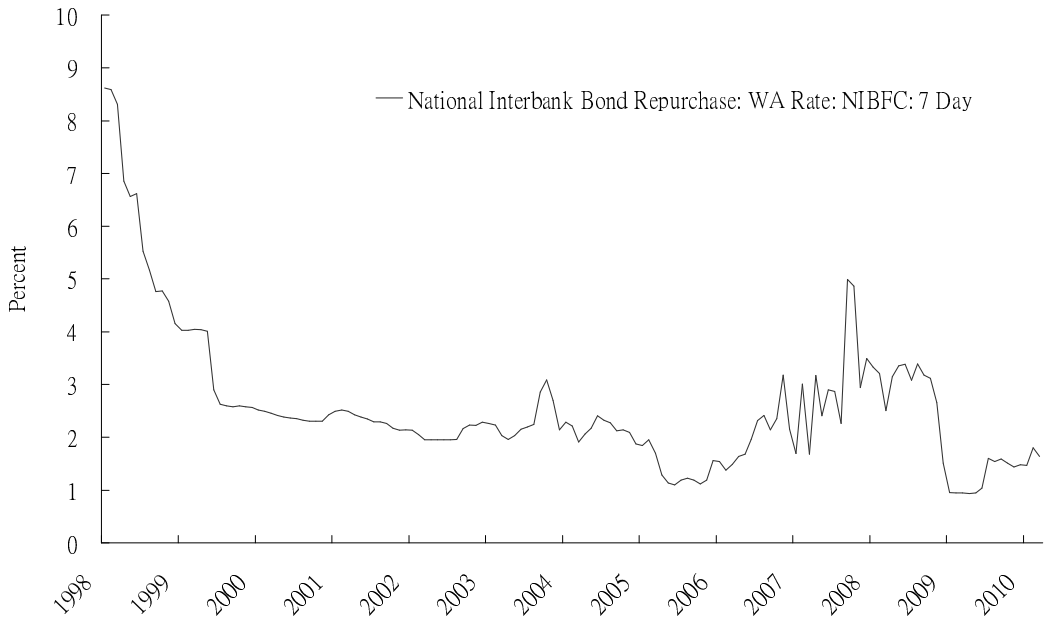
Stock, J. and M. Watson, 2002b, "Macroeconomic Forecasting using Diffusion Indexes," *Journal of Business & Economic Statistics*, 20(2): 147-162.

Stock, J. and M. Watson, 2005, "Implications of Dynamic Factor Models for VAR Analysis," *NBER working paper.*

Yi, G. 2008, "The Monetary Policy Transmission Mechanism in China," In Transmission Mechanisms for Monetary Policy in Emerging Market Economies, 179-181. Vol. 35: Bank for International Settlements.

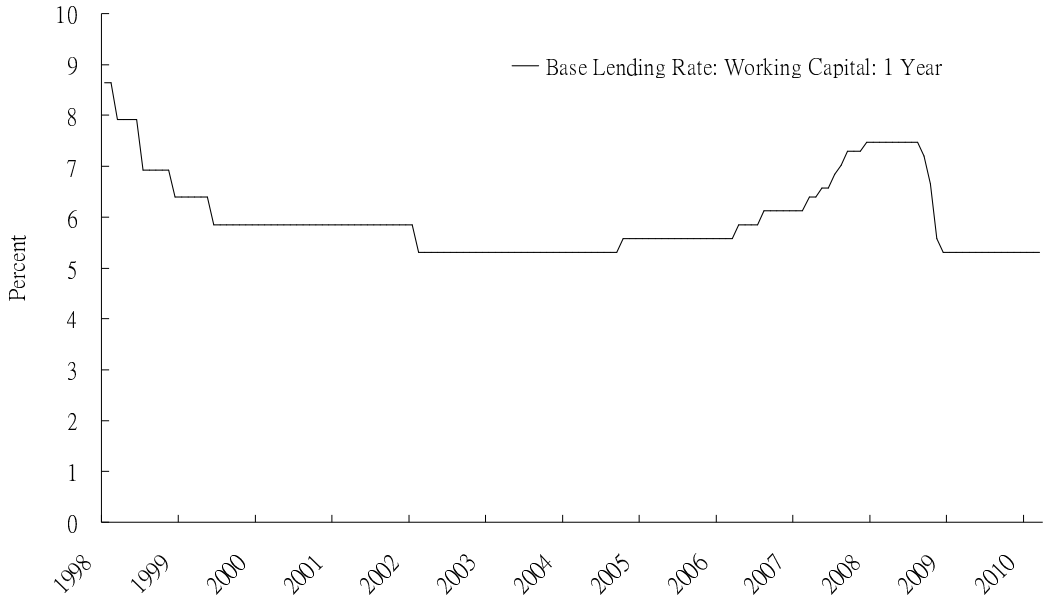
Appendix I:

Figure 1. Repo Rate



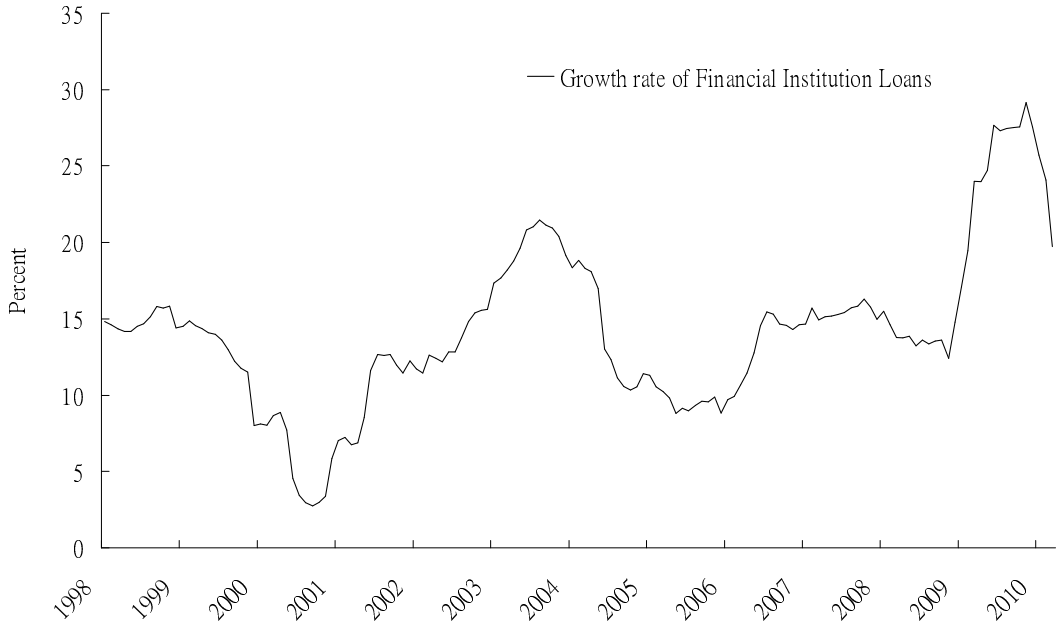
Source: CEIC Database

Figure 2: Benchmark Lending Rate (1 year)



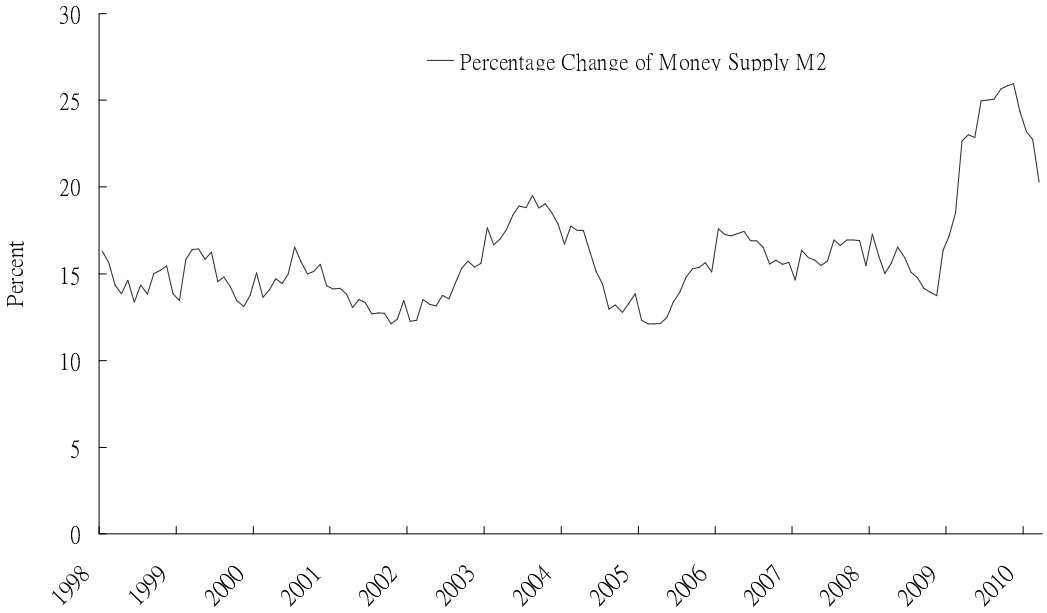
Source: CEIC Database

Figure 3: Percentage Change of Financial Institution Loans (Year-on-year)



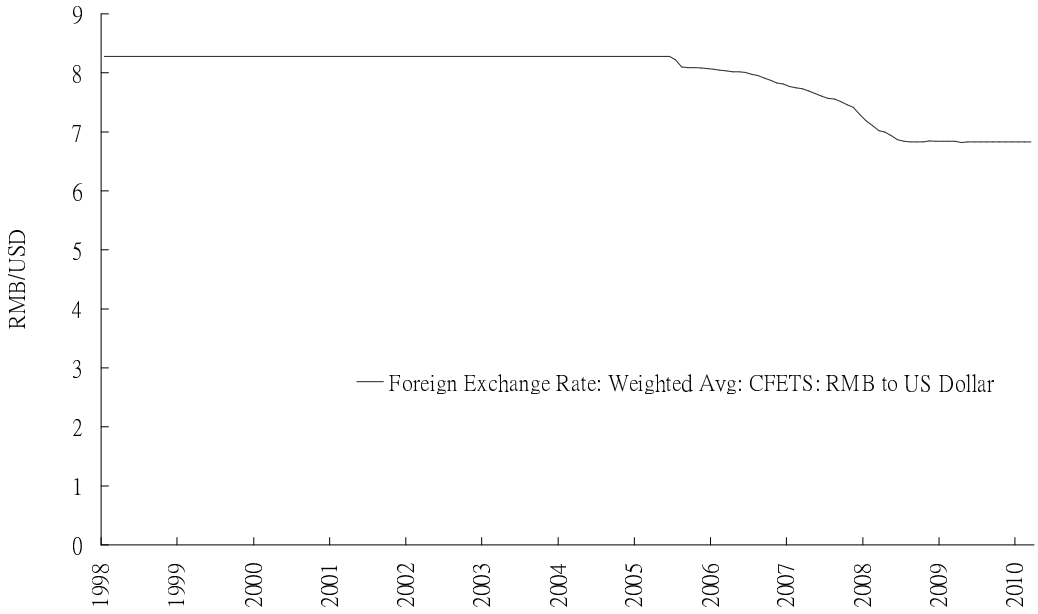
Source: CEIC Database

Figure 4: Percentage Change of Money Supply M2 (Year-on-year)



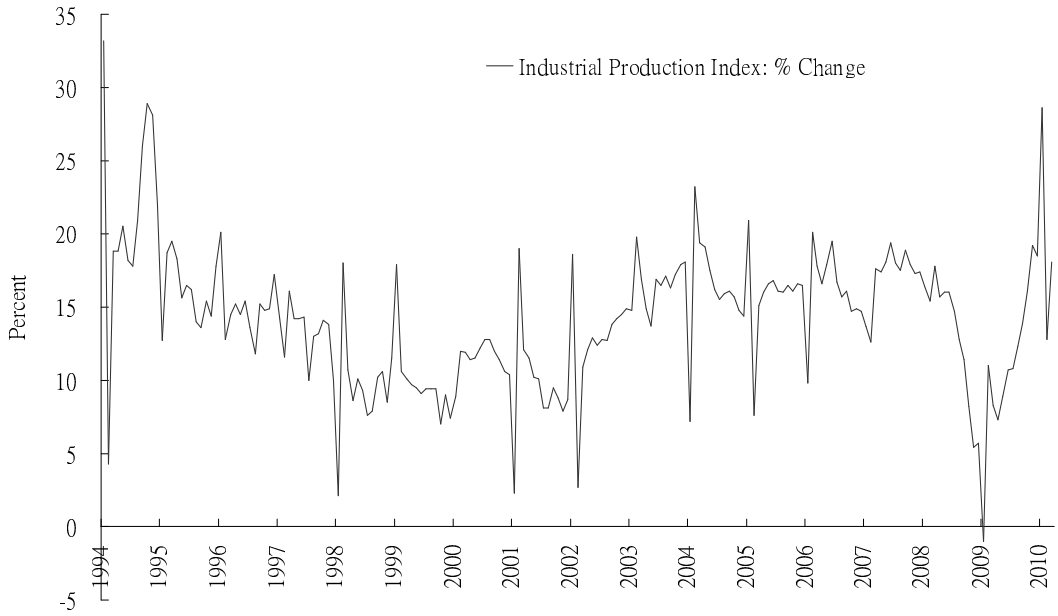
Source: CEIC Database

Figure 5: The Renminbi exchange rate against the US Dollar



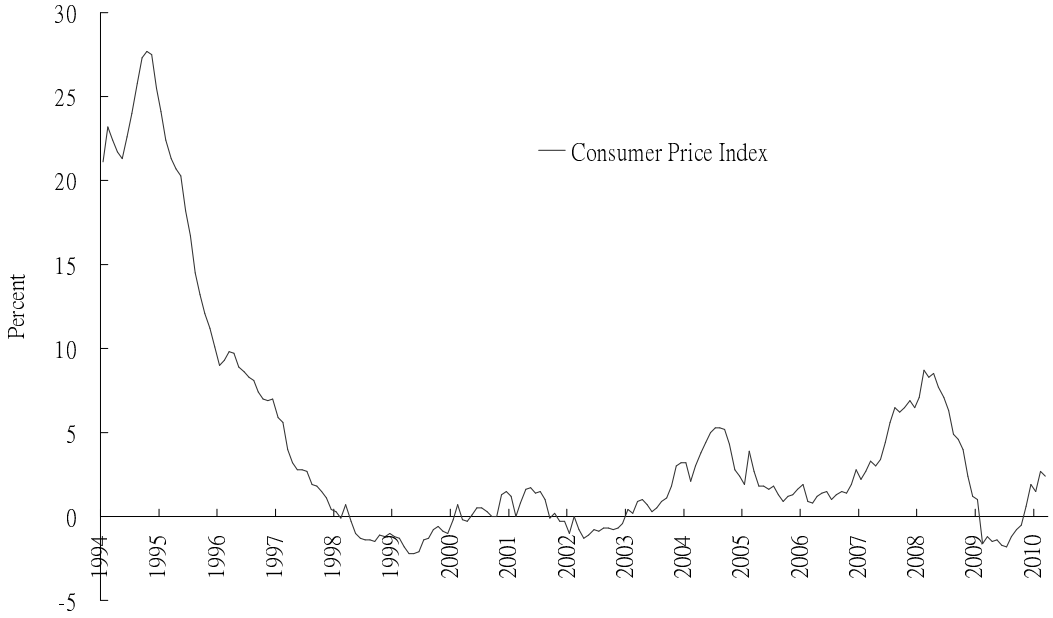
Source: CEIC Database

Figure 6: Annual growth rate of Industrial Production



Source: CEIC Database

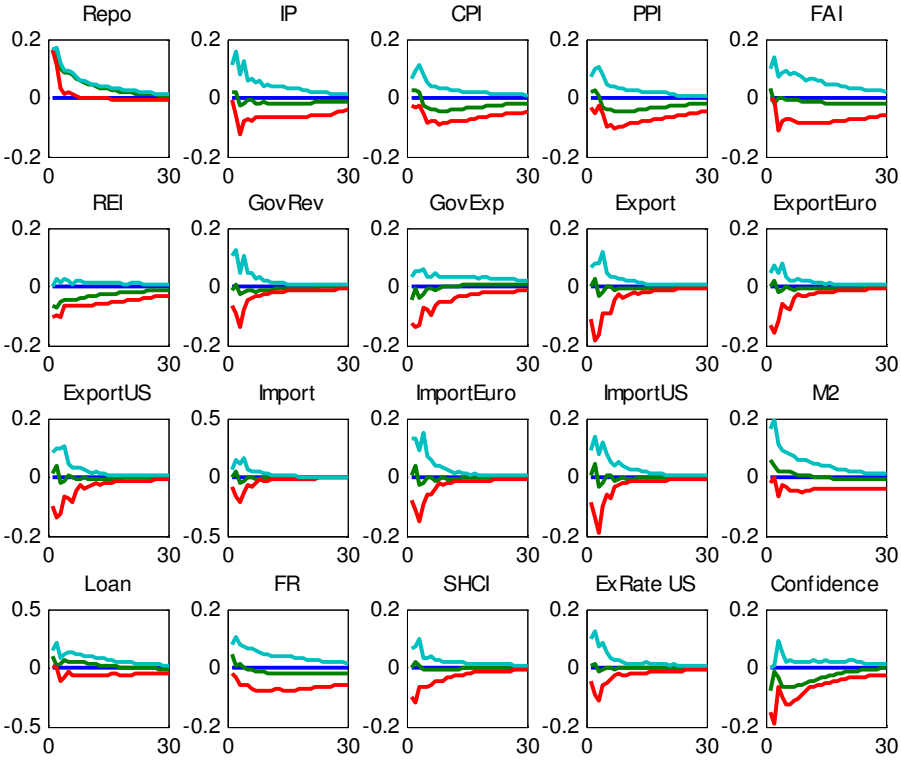
Figure 7: Annual inflation rate (Consumer Price Index)



Source: CEIC Database

Figure 8: Impulse Response from FAVAR with three factors and repo rate

Estimated by principal components with two-step bootstrap (1998M1-2005M6)[21]



[21] Label for panel (Abbreviation): Repo Rate – 7 day (Repo); Percentage Change of Industrial Production (IP); Consumer Price Index (CPI); Producer Price Index (PPI); Percentage Change of Fixed Asset Investment (FAI); Percentage Change of Real Estate Investment (REI); Percentage Change of Government Revenue (GovRev); Percentage Change of Government Expenditure (GovExp); Percentage Change of Export (Export); Percentage Change of Export to Europe (ExportEuro); Percentage Change of Export to US (ExportUS); Import (Import); Percentage Change of Import from Europe (ImportEuro); Percentage Change of Import from US (ImportUS); Percentage Change of M2 (M2); Percentage Change of Loan (Loan); Percentage Change of Foreign Reserve (FR); Shanghai Composite Index (SHCI); Nominal Exchange Rate against US Dollar (ExRate US); Consumer Confidence Index (Confidence)

Figure 9: Impulse Response from FAVAR with three factors and repo rate

Estimated by principal components with two-step bootstrap (2002M9-2010M2)

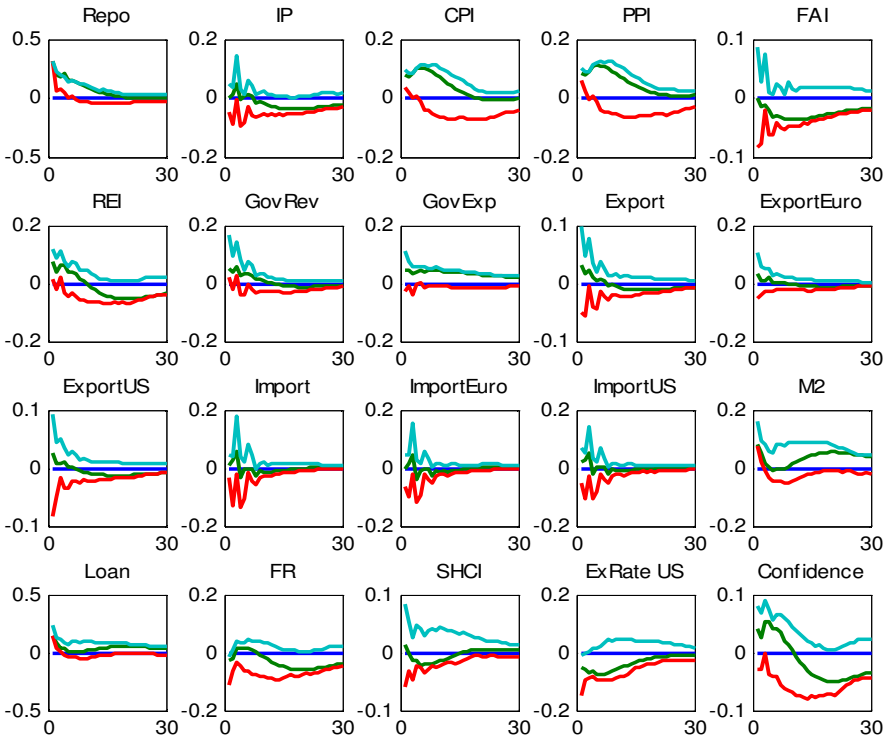


Figure 10: Impulse response from FAVAR with three factors and benchmark rate

Estimated by principal components with two-step bootstrap (1998M1-2005M6)

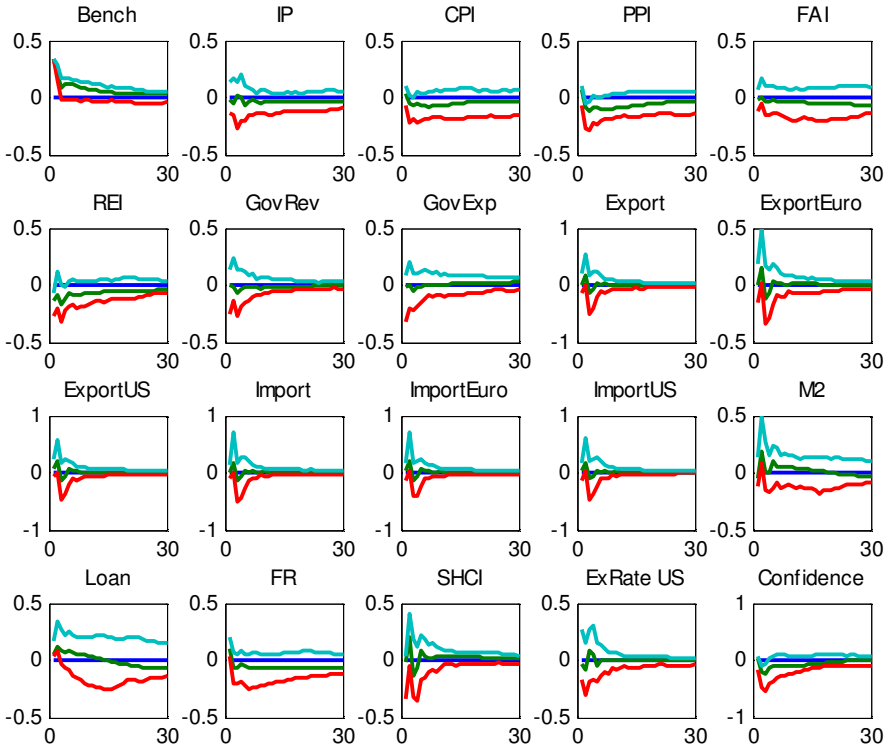


Figure 11: Impulse response from FAVAR with three factors and benchmark rate

Estimated by principal components with two-step bootstrap (2002M9-2010M2)

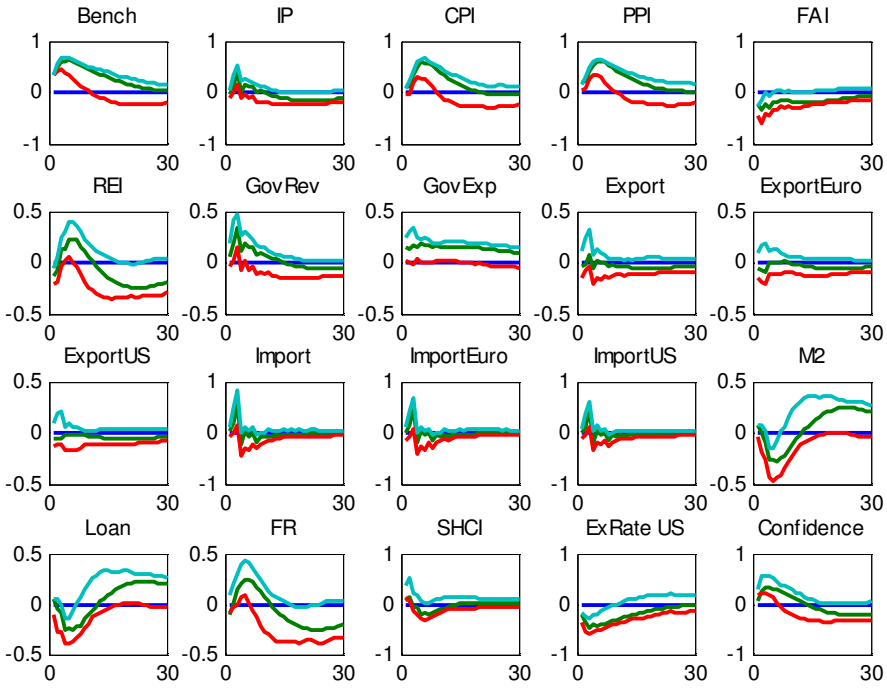


Table 12: The Factor Loadings of the representative factor

Data Series	Loadings	Data Series	Loadings
Benchmark Lending Rate (6m)	0.876	Interbank Rate (7d)	0.530
Benchmark Lending Rate (1y)	0.916	Interbank Rate (30d)	0.520
Central Bank Lending Rate (20d)	0.566	Interbank Rate (90d)	0.415
Central Bank Lending Rate (3m)	0.563	Repo Rate (7d)	0.537
Saving Rate	0.359	Repo Rate (1m)	0.561
Time Deposit Rate (1y)	0.799	Repo Rate (3m)	0.610
Rediscount Rate	0.556	Required Reserve Rate	0.328
		Excess Reserve Interest Rate	0.153

Figure 13: The policy factor for general monetary stance

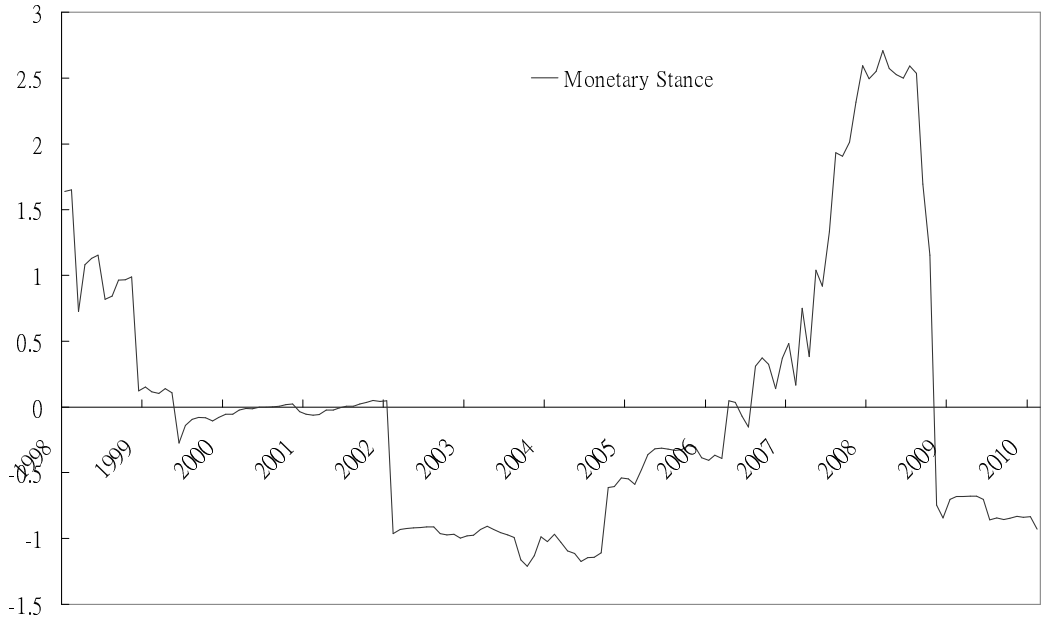


Figure 14: Impulse response from FAVAR with three factors and Factor

Estimated by principal components with two-step bootstrap (1998M1-2005M6)

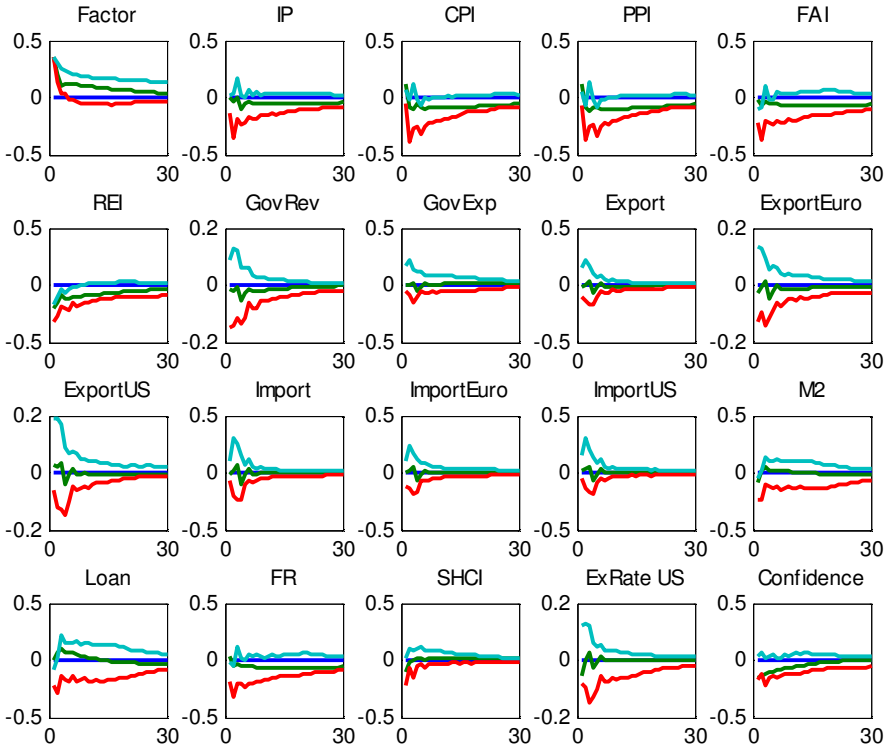


Figure 15: Impulse response from FAVAR with three factors and Factor

Estimated by principal components with two-step bootstrap (2002M9-2010M2)

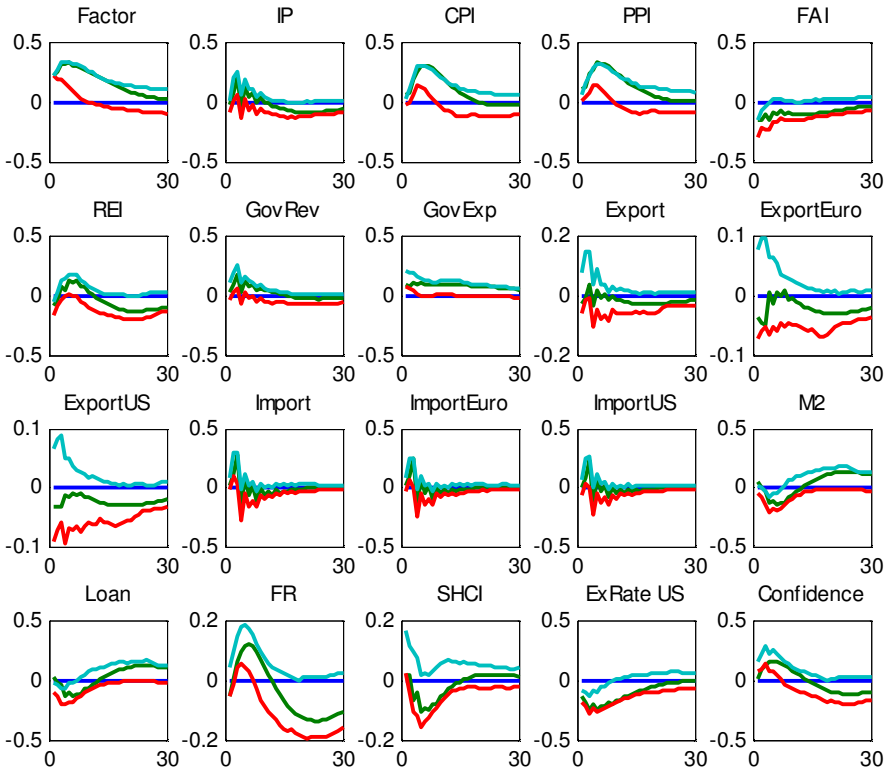


Figure 16: Impulse response from FAVAR with three factors and Total Loan

Estimated by principal components with two-step bootstrap (1998M1-2005M6)

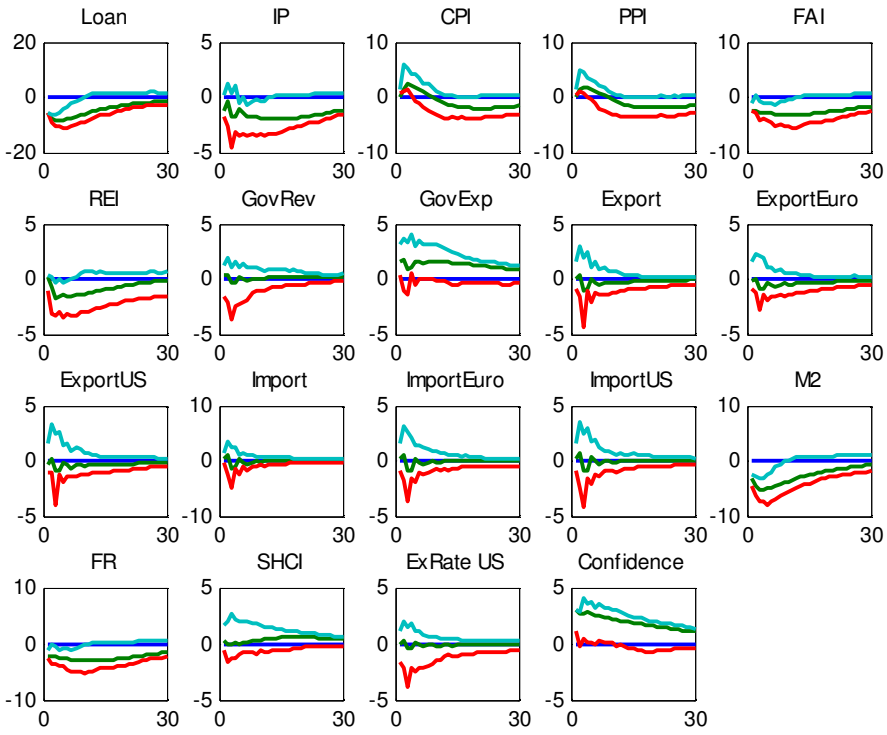


Figure 17: Impulse response from FAVAR with three factors and Total Loan

Estimated by principal components with two-step bootstrap (2002M9-2010M2)

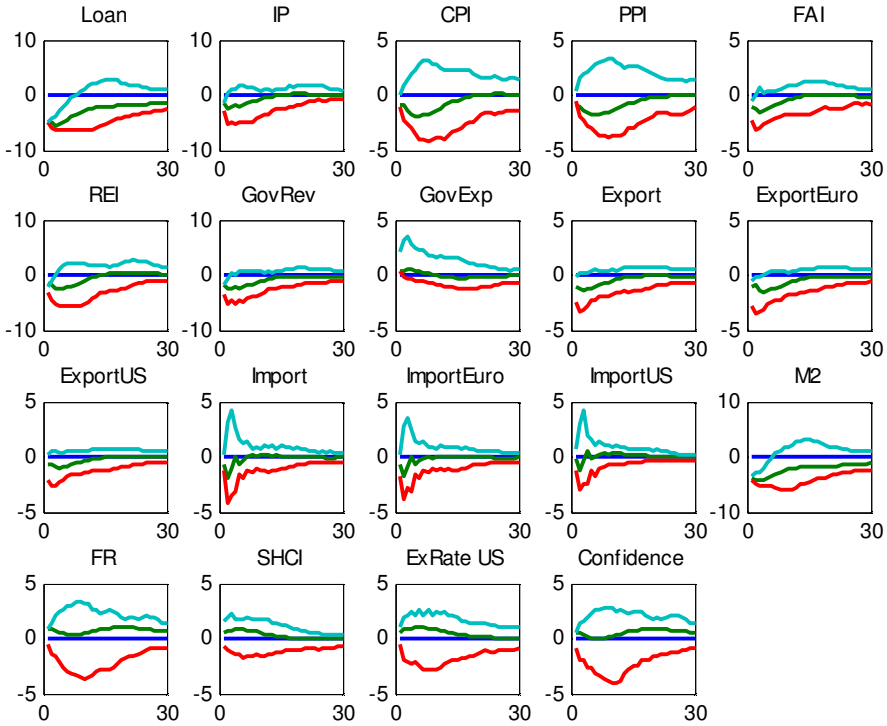


Figure 18: Impulse response from FAVAR with three factors and M2

Estimated by principal components with two-step bootstrap (1998M1-2005M6)

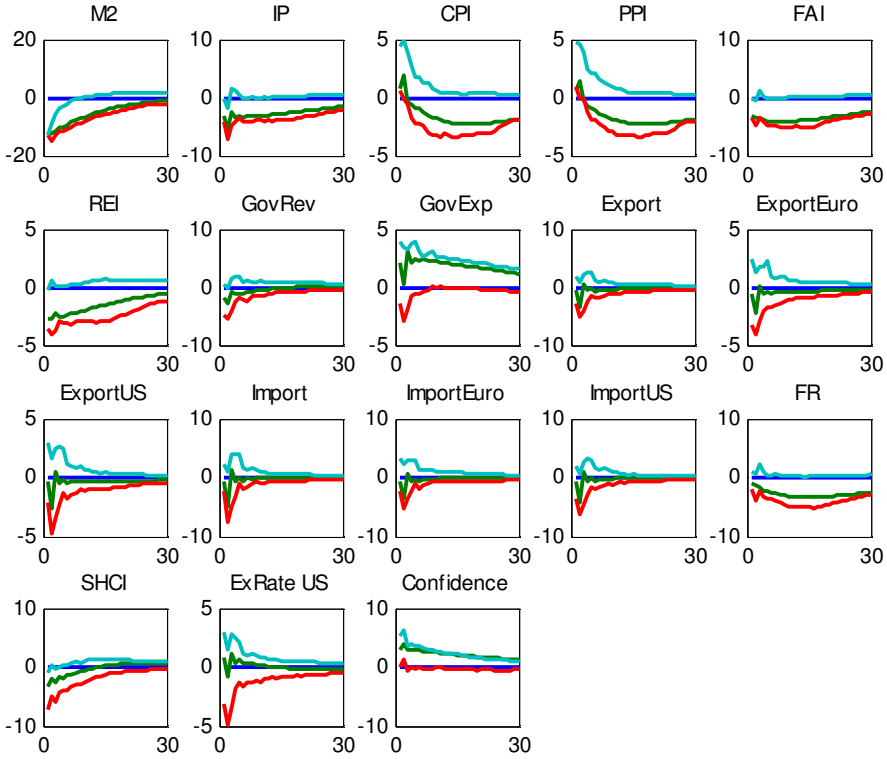
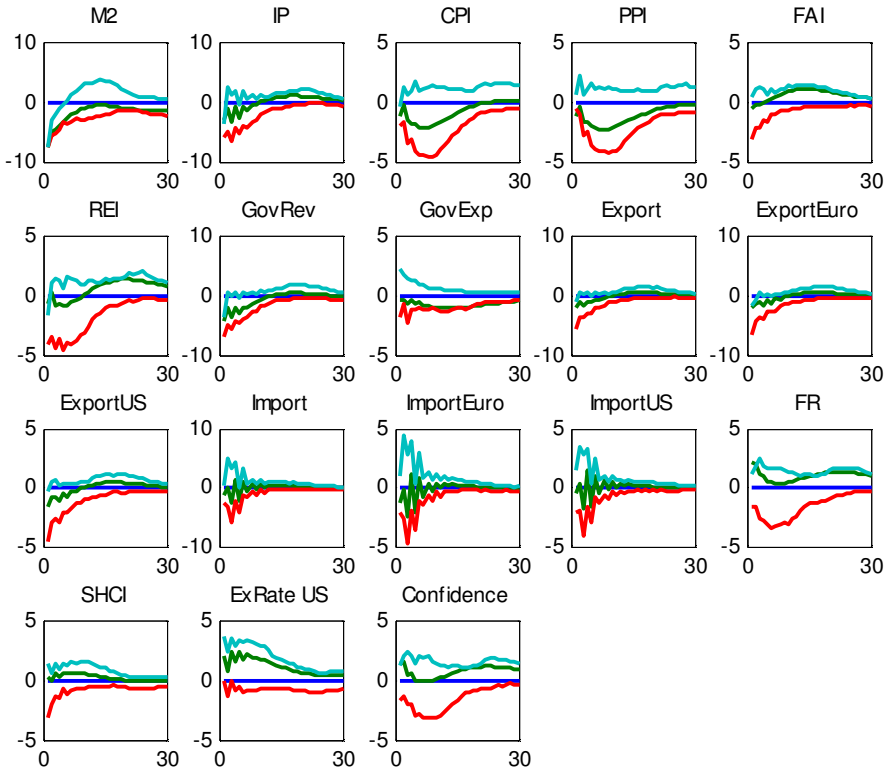


Figure 19: Impulse response from FAVAR with three factors and M2

Estimated by principal components with two-step bootstrap (2002M9-2010M2)



Appendix II:

The time series data are all taken from CEIC Database. All of the series are monthly data from January 1998 to August 2009. Each of the series is labeled as either fast or slow. The transformation code: 1 – No transformation and 5 – First Difference of Logarithm. The seasonally adjusted: SA – Seasonally adjusted by Census X-12, NSA – Not seasonally adjusted.

No.	Category	Item	Fast/Slow	SA	TC
1	Real Activities	Industrial Production Index: % Change		Y	1
2		Industrial Production: Salt	Slow	Y	5
3		Industrial Production: Canned Food	Slow	Y	5
4		Industrial Production: Cloth	Slow	Y	5
5		Industrial Production: Household Refrigerator	Slow	Y	5
6		Industrial Production: Automobiles	Slow	Y	5
7		Industrial Production: Motor Cycles	Slow	Y	5
8		Industrial Production: Air Conditioner	Slow	Y	5
9		Industrial Production: Televison Sets: Colour	Slow	Y	5
10		Industrial Production: Camera	Slow	Y	5
11		Industrial Production: Micro Computer	Slow	Y	5
12		Industrial Production: Plastic Products (PP)	Slow	Y	5
13		Industrial Production: Cement	Slow	Y	5
14		Industrial Production: Steel	Slow	Y	5
15		Production of Primary Energy: COAL	Slow	Y	5
16		Industrial Production: Coke	Slow	Y	5
17		Industrial Production: Rubber Tyre	Slow	Y	5
18		Industrial Production: Processed Crude Oil	Slow	Y	5

19	Industrial Production: Diesel Oil	Slow	Y	5
20	Industrial Production: Bicyles	Slow	Y	5
21	Industrial Production: Sewing Machines	Slow	Y	5
22	Industrial Production: Hi Fi	Slow	Y	5
23	Industrial Production: Household Washing Machines	Slow	Y	5
24	Industrial Production: Sugar	Slow	Y	5
25	Industrial Production: Synthetic Detergents	Slow	Y	5
26	Industrial Production: Kerosene	Slow	Y	5
27	Industrial Production: Sulphuric Acid	Slow	Y	5
28	Industrial Production: Chemical Fertilizer(100% purity)	Slow	Y	5
29	Industrial Production: Plated Glass	Slow	Y	5
30	Industrial Production: Freight Wagons	Slow	Y	5
31	Industrial Production: Cloth: Pure Cotton	Slow	Y	5
32	Industrial Production: Civil Steel Ships	Slow	Y	5
33	Industrial Sales	Slow	Y	5
34	Industrial Sales: Heavy Industry	Slow	Y	5
35 Price Index	Consumer Price Index	Slow	Y	1
36	Consumer Price Index: Food	Slow	Y	1
37	Consumer Price Index: Food: Grain	Slow	Y	1
38	Consumer Price Index: Clothing	Slow	Y	1
39	Consumer Price Index: Residence	Slow	Y	1
40	Consumer Price Index: Medicines and Medical	Slow	Y	1
41	Retail Price Index	Slow	Y	1
42	Retail Price Index: Food	Slow	Y	5
43	Producer Price Index: Industrial Products	Slow	Y	1

44	PPI: IP: Consumer Goods	Slow	Y	1
45	Purchasing PI: Raw Materials (RM): Total	Slow	Y	1
46	Purchasing PI: RM: Fuels and Power	Slow	Y	1
47 Investment	Fixed Assets Investment: ytd	Slow	Y	1
48	FDI: Utilized: ytd: Total	Slow	Y	1
49	Real Estate Investment: ytd: Total	Slow	Y	1
50	Real Estate Inv: ytd: Residential Buildings	Slow	Y	1
51 Government	Government Revenue	Slow	Y	1
52	Government Expenditure	Slow	Y	1
53 Retail Sales	Retail Sales of Consumer Goods: Total	Slow	Y	1
54 International Trade	Exports fob	Slow	Y	5
55	Exports: Europe	Slow	Y	5
56	Exports: USA	Slow	Y	5
57	Exports: ASEAN	Slow	Y	5
58	Imports cif	Slow	Y	5
59	Imports: Europe	Slow	Y	5
60	Imports: United States	Slow	Y	5
61	Imports: ASEAN	Slow	Y	5
62 Interest Rate	Policy Rate: Month End: Rediscount	Fast	N	1
63	Savings Deposits Rate	Fast	N	1
64	Time Deposits Rate: 1 Year	Fast	N	1
65	Central Bank Base Interest Rate: Less Than 20 Days	Fast	N	1
66	Central Bank Base Interest Rate: 3 Months or Less	Fast	N	1
67	Base Lending Rate: Working Capital: 6 Months	Fast	N	1
68	Base Lending Rate: Working Capital: 1 Year	Fast	N	1

69		Central Bank Base Interest Rate: Required Reserve	Fast	N	1
70		Central Bank Base Interest Rate: Excess Reserve	Fast	N	1
71		National Interbank Offered Rate: Weighted Avg: NIBFC: 7 Days	Fast	N	1
72		National Interbank Offered Rate: Weighted Avg: NIBFC: 30 Days	Fast	N	1
73		National Interbank Offered Rate: Weighted Avg: NIBFC: 90 Days	Fast	N	1
74		National Interbank Bond Repurchase: WA Rate: NIBFC: 7 Day	Fast	N	1
75		National Interbank Bond Repurchase: WA Rate: NIBFC: 1 Month	Fast	N	1
76		National Interbank Bond Repurchase: WA Rate: NIBFC: 3 Month	Fast	N	1
77	Money Supply	Money Supply M0	Fast	Y	1
78		Money Supply M1	Fast	Y	1
79		Money Supply M2	Fast	Y	1
80		Quasi Money	Fast	Y	1
81		Saving Deposits	Fast	Y	1
82		Financial Institution Deposits	Fast	Y	1
83		Financial Institution Loans	Fast	Y	1
84		Foreign Reserves	Fast	Y	1
85	Financial Market	Index: Shanghai Stock Exchange: Composite	Fast	N	5
86		Index: Shanghai Stock Exchange: A Share	Fast	N	5
87		Index: Shanghai Stock Exchange: B Share	Fast	N	5
88		Index: Shenzhen Stock Exchange: Composite	Fast	N	5
89	Exchange Rate	Foreign Exchange Rate: Weighted Avg: CFETS: RMB to US Dollar	Fast	N	5
90		Foreign Exchange Rate: Weighted Avg: CFETS: RMB to Japanese Yen	Fast	N	5
91	Consumer Index	Consumer Confidence Index	Slow	N	1

92	Consumer Expectation Index	Slow	N	1
93	Consumer Satisfactory Index	Slow	N	1
94 US Data	M2 Money Stock (NSA)	Slow	Y	5
95	Commercial and Industrial Loans at All Commercial Banks	Slow	Y	1
96	3-Month Treasury Bill: Secondary Market Rate	Slow	N	1
97	Producer Price Index: All Commodities	Slow	Y	1
98	Consumer Price Index for All Urban Consumers: All Items	Slow	Y	1
99	Disposable Personal Income	Slow	Y	1
100	Personal Consumption Expenditures	Slow	Y	1