Using FAVAR Model to Test the Credit Channel Monetary Policy Transmission Mechanism in Long-term Credit Cycle

Part 1: Using FAVAR Model to Estimate Inventories and Nonresidential Construction Investment Responses to Monetary Policy Shocks in Long-term Credit Cycle

Part 2: Comparison between the FAVAR Model and the VAR model when Testing the Credit Channel Monetary Policy Transmission Mechanism

Master's Thesis
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August 2020

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Acknowledgements

I want to thank my supervisor Michael Halling, Associate Professor at Stockholm School of Economics and Dmitriy Sergeyev, Assistant Professor at Bocconi University for the invaluable guidance and support over the process of completing this graduation thesis for my master degree during this COVID-19 health emergency period.

Part 1: Using FAVAR Model to Estimate Inventories and Nonresidential Construction Investment Responses to Monetary Policy Shocks in Long-term Credit Cycle

Abstract

The study of monetary policy transmission mechanism focused on the specific path of the central bank's implementation of the monetary policy to the macroeconomy. And the supporting theory of this paper is the credit channel transmission mechanism of monetary policy proposed by Ben Bernanke. The credit channel could be divided into two parts: the enterprise balance sheet channel and the bank credit channel. And the concept of the extra costs in the external financing would be very important in explaining the empirical results of this paper.

Based on the FAVAR model created by Ben Bernanke, 115 groups of economic variables' data from January 1959 to December 2014 were selected for empirical analysis. During the period from September 2008 to December 2014, the Wu-Xia shadow fed funds rate was used to substitute for the fed funds rate during the after crisis period so as to let the indicator of the monetary policy to be changeable again and the effect of three rounds of large scale asset purchase program is equal to the effect of lowering the fed funds rate below the zero lower bound by 300 basis points. Based on the theory of the credit channel monetary policy transmission mechanism proposed by Ben Bernanke and the long-term credit cycle theory proposed by Ray Dalio, through the impulse response function of FAVAR model, we have found the difference in the reaction of the inventory and the nonresidential construction investment to the monetary policy shocks after including the data from September 2008 to December 2014 when the US was going through the deleveraging process.

The reason of difference responses of the inventory and the nonresidential construction investment to the monetary policy shocks could be explained by the difference in the related financing resources, the financing costs related to the inventory is the opportunity costs of the company's internal funds and the financing costs related to the nonresidential construction investment is the costs in the company's external financing. And normally costs of the company's internal funds would be lower than the costs in the company's external financing. Because of the existence of the extra costs in the external financing, compared with the inventory investment, the nonresidential construction investment would react more sensitively and negatively to the tightening monetary policy. The existence of the extra costs in the external financing could be further explained by the frictions of the credit markets and the existence of the information asymmetry.

Key Words： Monetary policy transmission mechanism, enterprise balance sheet channel, bank credit channel, FAVAR model, inventory, nonresidential construction investment, extra costs in the external financing

1. Introduction

1.1. Background

In 2008, the global financial crisis triggered by the US subprime mortgage caused the global asset prices to decrease sharply and a lot of the major financial institutions suffered from huge capital losses and faced serious capital shortages. The money market funds suffered from the liquidity problems and the short-term lending rate soared. As the chairman of the federal reserve at that time, Ben Bernanke actively used different monetary policy tools to cope with the biggest financial crisis since the 21st century, and provided the sufficient liquidity support to the financial markets through three rounds of large-scale asset purchase program. Finally with all these measures implemented in time, the loss of the crisis was reduced to the minimum, and the US economy avoided the continued deflationary recession like Japan in the 1990s after the bubble burst.

The entire deflationary recession process began with the bankruptcy of Lehman Brothers in September 2008 and ended with the first round of QE implemented by the federal reserve in March 2009. Compared with what Japan had suffered in last century, the duration of the deflationary recession process was quite short, and this successful crisis management should be attributed to the effective monetary policy implemented during the financial crisis.

Ben Bernanke's performance during the financial crisis fully explained the Neo-Keynesian economic school's proposition, especially through the focus on the microstructure of the macroeconomy. The monetary policy implemented during the financial crisis was based on his deep understanding of the microstructure of the credit market conditions, by implementing three rounds of large-scale asset purchase program and lowering the fed funds rate to zero lower bound, the federal reserve strove to fulfill its "lender of the last resort" duty and injected sufficient liquidity to various systemically important financial institutions, thus avoiding a disaster like the great depression in the 1930s. The effective combination of different monetary policy tools resolved the deflation recession and prompted a rapid recovery of the US economy.

Ben Bernanke's research on the transmission mechanism of the monetary policy has effectively reduced the losses caused by the financial crisis to the minimum, and it is worthwhile to test whether his theoretical research and the empirical models are still valid in the new market environment after the 2008 financial crisis when the fed funds rate was kept at the level of the zero lower bound and the central bank mainly controlled the money supply by unconventional monetary policy tools like large-scale asset purchase program.

Also instead of treating the after-crisis environment as the abnormal situation in short run, we can treat this period as an important part of the long-term credit cycle. Like what Ray Dalio has mentioned in "Principles for Navigating Big Debt Crises", there are two kinds of credit cycle, the short-term credit cycle and the long-term credit cycle. Usually the short-term credit cycle will go on once every 8-10 years, while the long-term credit cycle will go on once every 50-75 years. Under the guidance of this analysis structure, we can understand that the after-crisis environment should be treated as the last stage of the long-term credit cycle, and similar cycles would repeat again and again in the future, with the frequency of once every 50-75 years.

1.2. Purpose

The empirical model used in this paper and the theoretical foundation are based on the FAVAR model proposed by Bernanke and Boivin (2005) and the credit channel monetary policy transmission mechanism theory. By expanding the time period of the data to include the data from 2001 to December 2014, we can include the theory of Ray Dalio's long-term credit cycle.

Also we can test if the credit channel monetary policy transmission mechanism theory proposed by Ben Bernanke (bank credit channel, enterprise balance sheet channel) still holds in the long-term credit channel.

This paper will use the two-step principal components FAVAR model to conduct the empirical analysis and we will include 115 sets of economic variables from 1959 January to 2014 December. We will extract five principal components based on the method introduced in this paper and then combine them with the observable variables of interest, and construct a VAR model.

Through the impulse response function, we can test the effectiveness of the monetary policy in the long-term credit cycle where both the leveraging period and the deleveraging period are included. At the same time, each group of results will be compared with the results achieved by using only the data range from 1959 to 2003 where only the leveraging period is included.

The impulse response function results will be divided into three subgroups: the impulse response function of the macroeconomic indicators, the impulse response function of the enterprise balance sheet channel indicators and the impulse response function of the bank credit channel indicators.

1.3. Contribution

(1) In recent years, there have been many papers on using the VAR, VEC or SVAR models to test the effectiveness of the monetary policy, but one of the major shortages of the traditional VAR model is the lack of the economic information, causing many economic information to be unable to be reflected in the model. The FAVAR model used in this paper can effectively solve the problem of the lack of the economic information, and it can use the impulse response function to reflect the relevant information of all macroeconomic variables.

(2) This paper also focuses on combining Ben Bernanke's theory about the credit channel transmission mechanism of monetary policy with the theory of Ray Dalio's long-term credit cycle. Based on the concept of the enterprise balance sheet channel, this paper explains in detail the difference in the reaction of the enterprise inventory investment and the non-residential construction investment to the monetary policy shocks and the microstructure of the financing resources of the enterprise's inventory and non-residential construction investments. The in depth understanding of the extra costs in the external financing is very important in explaining this difference shown in the impulse response function results of the FAVAR model.

(3) This paper includes 115 sets of economic variables from January 1959 to December 2014. Compared with the economic variables selected by Bernanke (2005) from January 1959 to August 2001, the time period is longer so that both the leveraging period and the deleveraging period are included, and this is an improvement to Bernanke (2005).

In order to solve the problem that during the after crisis period, the fed funds rate couldn't work as an effective indicator of the monetary policy in the empirical models since it was kept at the level of zero lower bound like a constant variable and the main monetary tool used at that time is the three rounds of large scale asset purchase program, this paper uses the Wu-Xia shadow fed funds rate to substitute for the fed funds rate during the after crisis period so as to let the indicator of the monetary policy to be changeable again. The Wu-Xia shadow fed funds rate reached -3% in May 2014, and this means that the effect of three rounds of large scale asset purchase program is equal to the effect of lowering the fed funds rate below the zero lower bound by 300 basis points. By introducing the concept of Wu-Xia shadow fed funds rate, we can make the monetary policy effect more measurable during the after crisis period and then the impulse response analysis generated from the FAVAR model could be more convincing.

1.4. Outline

This paper is mainly divided into six parts:

The first part is an introduction that includes the background, purpose and contribution of this paper.

The second part is a review of the relevant literature on the economic theory of the monetary policy transmission mechanism. This part introduces the theories of the mainstream economics schools according to the chronological order, the main objectives of the central banks when implementing the monetary policy, the monetary policy tools commonly used by the central bank, and four mainstream monetary policy transmission mechanism theories. Among these four transmission mechanism theories, the most important one is the credit channel transmission mechanism, which includes two subchannels: the enterprise balance sheet channel and the bank credit channel. The concepts of the financial accelerator and the extra costs in the external financing are of great importance in explaining the impulse response function results in the empirical analysis part.

The third part is a review of the relevant literature on the empirical model used in this paper. This part introduces in detail the relevant literature from the standard VAR model to the FAVAR model in the field of monetary policy empirical analysis.

The fourth part is the empirical analysis, we use 115 sets of economic variables, and construct the FAVAR model through the two-step principal components method. Through the impulse response function, we can test the effectiveness of the monetary policy in the long-term credit cycle where both the leveraging period and the deleveraging period are included. And we will compare this with the results achieved by using only the data range from 1959 to 2003 where only the leveraging period is included and explain the potential difference.

The fifth part is the summary part.

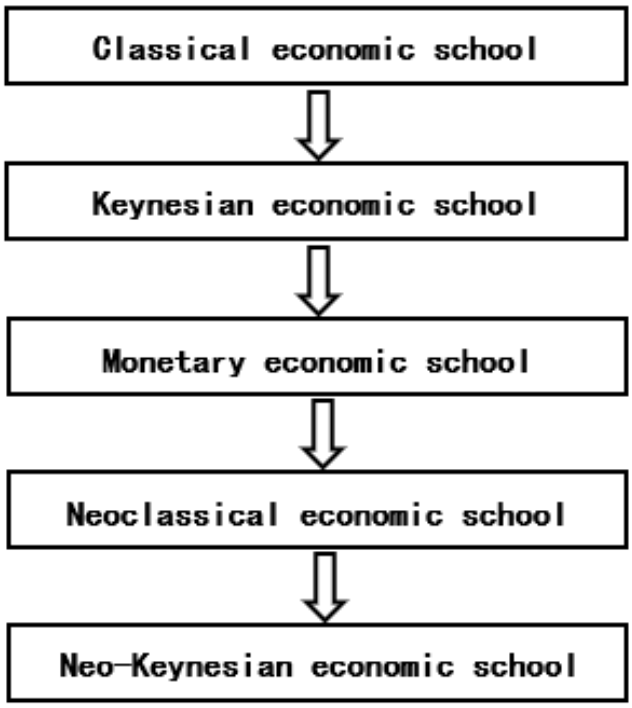
The sixth part is the potential for further improvement.

2. Literature review for monetary policy transmission mechanism theory

2.1. Review of mainstream economic theory

This paper would mainly empirically analyze the effectiveness of the monetary policy transmission mechanism, and the research on the monetary policy transmission mechanism stems from the research on the monetary policy theory from various western economic schools. So the theoretical review of the evolution of mainstream economic schools' theory is necessary. In general, the evolution process is mainly divided into five stages.

Figure 1 the evolution of mainstream economic schools' theory



2.1.1. Classical economic school

Economists in classical economic school believe that the nominal prices and the nominal wages are completely flexible, and there is no involuntary unemployment in the economy. The money supply can only change the price level, and it won't have any effective impact on a country's national outputs level and overall employment rate. From this point of view, the central bank of a country can't actively control the macro economy by actively implementing monetary policies, and therefore we can conclude that the central bank's monetary policy is invalid.

2.1.2. Keynesian economic school

Keynes (1936) refuted the monetary policy ineffectiveness theory advocated by the classical economic school, and proposed his understanding of the interest rate for the first time. He concluded that if we assume that the marginal rate of return on the invested capital remains unchanged, then the decline in the overall interest rate caused by the central bank through monetary policy adjustment will finally lead to an increase in the social investment, and the

increase in the overall interest rate will result in a reduction in the social investment. Eventually, the increase or the decrease in the social investment will cause a change in the overall expenditure and income level in the same direction through the multiplier effect.

Hicks (1937) proposed the IS-LL model to explain the relationship between the income level and the interest rate. Then Hansen (1949) proposed the IS-LM model based on the theory of Hicks and Keynes. The transmission mechanism of the monetary policy to the real economic activities is not an unidirectional process, but a process of cyclical action and counteraction between the currency market and the real economy market. Compared with Keynes's original theory, the IS-LM curve further considers the inherent instability of the monetary policy transmission mechanism.

Keynes's theory of monetary policy transmission mechanism implies two important assumptions: firstly, it is assumed that changes in the total amount of money supply can cause corresponding adjustments to the long-term interest rate; secondly, it is assumed that the social investment is sensitive to the changes in the long-term interest rate level. If a country falls into a liquidity trap or if the social investment becomes less sensitive to the changes in the long-term interest rate level, then the effectiveness of the central bank's monetary policy will be greatly weakened or even become invalid. Therefore, from the Keynesian school's policy proposition, it often lays more emphasis on the effectiveness of the fiscal policy, and usually the economists in Keynes's economic school would believe that the monetary policy is unreliable in the long run.

2.1.3. Monetary economic school

Friedman (1963) analyzed the US monetary system and monetary policy by conducting the empirical analysis with 93 years of data. Based on the empirical analysis result, he concluded that by observing the changes in the money supply level, one can effectively measure the country's overall macroeconomics level, the empirical analysis result clearly showed that there is a stable long-term correlation between the money supply index and other macroeconomic indicators. The fundamental cause of the macroeconomic fluctuations is the changes in the money supply level. The empirical analysis result also revealed that changes in the money supply level could cause changes in the level of national outputs for over two years.

In the 1970s, because the western countries were influenced by the mainstream Keynesian school at that time, they always insisted on increasing the government expenditure by expanding the fiscal deficits. Combined with the background of the two oil crises, the economies of various western countries fell into a situation called the stagflation. At that time, the fiscal expenditure policy that has always been advocated by the Keynesian school had become invalid.

Friedman (1963)divided the great depression period in the 1930s into four stages, and he believed that the systemic crisis in the banking system is the main reason for the continued deterioration during the great depression period in the 1930s.

The systemic crisis in the banking system triggered the continuous deterioration of the real economy through two main transmission channels. Firstly, the systemic crisis in the banking system would trigger the "negative wealth effect" of the banks' shareholders, that is, the significant decrease in the bank stock prices would cause the wealth level of the banks' shareholders to decline rapidly, and thus weakening their ability to invest and consume; Secondly, the systemic crisis in the banking system would lead to a substantial contraction in the overall money supply level, which would further exacerbate the domestic deflation, causing the overall asset price level to continue to decline. His conclusion criticized the effectiveness of Keynesian macroeconomic policies.

However, Friedman also accepted some of Keynes's views and he agreed with the assumption

that the wages level and the price level are rigid, and the money supply level can affect the investment and the consumption in the short term. Monetary policies mainly control the money supply level rather than the interest rate, and the money market is directly linked to the product market. Also Friedman suggested that in the long run, the monetary policy effect should be neutral.

2.1.4. Neoclassical economic school

The theoretical framework of neoclassical economics mainly originated from the concept of rational expectations put forward by Muth (1961). Assuming that the market expectations for the future macroeconomic events are based on the complete economic information available today, then the market expectations for the future macroeconomic events will be consistent with the response measures taken by the stakeholders based on the guidance of the economic theory. The representative of neoclassical economist Lucas (1972) believed that the market is completely competitive and there is no friction, so prices can be adjusted in a timely manner. And he established a cycle model to explain the causes of the economic fluctuations. The assumption was that the monetary factors are the main reasons for the economic fluctuations, and the obstacles to access the information in a timely manner are the main transmission mechanism that would cause the economic fluctuations. However, due to the high efficiency of the information transmission channels in our real life, important economic indicators such as the money supply level and the price indexes are usually published on a regular basis. The so-called information transmission barrier would not actually exist, thus confirming his view that the monetary policy effect should be neutral.

Sargent (1973), Sargent and Wallace (1975) proposed that the market mechanism of the macroeconomy could adjust on its own, the complete market clearing could be achieved, all kinds of transaction costs in the market could be ignored, and there was no excess supply in the labor market and the product market. So any active intervention by the government was ineffective and couldn't have any real impact on the economy, and the only thing that would change accordingly was the price level. Out of stakeholders' motivation to maintain the original economic status, the monetary policy that had already been accurately anticipated by the stakeholders would inevitably lead to the measures taken by the stakeholders to counteract the corresponding monetary policy, and these measures would eventually make the central bank's monetary policy lose its effectiveness. Only when the stakeholder couldn't accurately anticipate the central bank's monetary policy can the sudden change of the monetary policy effectively affect the real economy, but the duration of its impact on the real economy would still be short.

For the neoclassical economics school, its shortcomings are the abstractness and the lack of support from the reality of its theoretical assumptions. Its market clearing analysis is completely out of the reality of the capitalism, and its conclusions of the policy inefficiency are also unrealistic. In practice, there is always a certain level of excess supply in the product market and the labor market in the long run, and the market clearing state is only a temporary phenomenon. The reality is completely contrary to the basic assumptions of the neoclassical economics school. Therefore, it is clear that neoclassical economics school's theory lacks the empirical support in practice.

2.1.5. Neo-Keynesian economic school

The Neo-Keynesian economic school adds the concepts from the microeconomics theory to the traditional Keynesian economic school theory, and at the same time widely accepts both the views of the Keynesian economic school and its opposing economic schools. After denying the market clearing model of the neoclassical economics school, the Neo-Keynesian economic school assumes that the wages and the prices are sticky in the non-market clearing model. When faced with monetary policy shocks, the corresponding slow adjustments in the wages and the prices will be made. This sticky assumption has replaced the rigid assumption of the

traditional Keynesian school.

The Neo-Keynesian economic school also adds two assumptions: Firstly, it assumes the principle of utility maximization on the basis of the microeconomics theory. In the Neo-Keynesian economic school's framework, the manufacturers in the economy pursue the profit maximization and the individual pursues the utility maximization; Secondly, it accepts the concept of the so called rational expectations from the neoclassical economic school, Fischer (1977), Phelps and Taylor (1977) demonstrated the effectiveness of the monetary policy on the basis of the neoclassical economic school's rational expectations theory, and proposed the rational restrictive expectation assumptions. When all of the other conditions are unchanged, compared with the effectiveness of the monetary policy under the traditional static expectations, the rational restrictive expectations have significantly improved the effectiveness of the monetary policy. Also another problem of the neoclassical economic school is ignoring the incompleteness of the market, when facing the monetary policy shocks, due to the existence of the price stickiness, it is difficult for the stakeholders to take the measures that the neoclassical economic school claims would have the effect of offsetting the corresponding monetary policy in a timely manner. At the same time, there is a certain degree of weak rational expectations, which would guarantee that the short-term monetary policy is still valid, but in the long run, the Neo-Keynesian economic school also agrees that the monetary policy's effect should be neutral.

2.2. Monetary policy objectives and tools

In order to better analyze the transmission mechanism of the monetary policy, a theoretical review of the monetary policy objectives and the monetary policy tools is also necessary. The description of monetary policy tools includes an explanation of the large-scale asset purchase program's mechanism, and the principle of the large-scale asset purchase program is also very important for understanding the transmission mechanism of the monetary policy after the 2008 financial crisis. The target range of the fed funds rate from December 2008 to 2014 was 0-0.25%.

2.2.1. Monetary policy objectives

According to Bernanke's description in "The Federal Reserve and the Financial Crisis", the central bank has two main functions: The first function is to keep the macroeconomic stability, and try to avoid the large fluctuations while pursuing the stable economic growth (such as the overheated economy and the economic recession), maintain a low inflation rate, a low unemployment rate and the balance of payments. The second function is to maintain the health and the stability of the country's financial system to the greatest extent, and prevent the occurrence of the financial systemic risks and the financial panic events.

In a stable financial market environment, the fed mainly performs its function of keeping the macroeconomic stability. The most common monetary policy tools are: deposit reserve requirement ratio, rediscount rate and open market operations.

At the same time, the function of the fed to maintain the stability of the financial market can't be ignored. The main tool used by the central bank to deal with the financial panic or the financial crisis is liquidity supply. During the financial crisis, the central bank will provide short term loans to the financial institutions to inject the liquidity into the financial system. The fed's large scale asset purchase program(QE) after the 2008 financial crisis is a good example of maintaining the stability of the financial institutions.

2.2.2. Deposit reserve requirement ratio

The deposit reserve ratio policy refers to the adjustment of the statutory deposit reserve ratio

by the central bank of the country, so that the size of the loanable funds of the domestic commercial bank would change accordingly, then it would in turn affect the total amount of the money supply. The central bank can increase the size of the loanable funds in the domestic commercial banking system by lowering the statutory deposit reserve ratio, thereby creating more loans and causing the M2 to expand exponentially, and vice versa.

It is generally believed that the statutory deposit reserve ratio policy is a powerful monetary policy tool with a significant impact on the real economy and should not be used frequently. Nowadays in the developed countries' monetary policy practice, since the statutory deposit reserve ratios are currently maintained at a very low level, and central banks in the developed countries have also rarely adjusted their statutory deposit reserve ratios, its transmission importance in the monetary policy is gradually disappearing.

2.2.3. Rediscount rate

When there is a shortage of the funds in a commercial bank, or when the reserve needs to increase due to the expansion of credit, the commercial bank can rediscount the unexpired commercial paper obtained in its discount business with the central bank, and then the rediscount rate is set by the central bank. In the practice of the monetary policy, the central bank can adjust the overall credit supply of the commercial banks and the overall interest rate level by intervening in the rediscount rate.

In practice, under conventional circumstances, commercial banks in the US tend to rely less on rediscounting. The rediscount rate policy has a strong signaling effect and lacks the flexibility. The discount window is a conventional monetary policy tool for the fed to work as the lender of the last resort. Ben Bernanke mentioned in "The Federal Reserve and the Financial Crisis" that under conventional circumstances in the US banking industry, the rediscount loans would usually expire overnight. During the financial crisis, in order to resolve the liquidity problem within the financial institutions, the fed extended the duration of the rediscount loans. The use of the rediscount loans can ensure that the banking system has sufficient cash to resolve the liquidity problems during the financial crisis.

2.2.4. Open market operations

Among the normal monetary policy tools, the open market operations are the most commonly used monetary policy tools in the developed countries. The central bank buys or sells the short term treasury bills in the open market to change the amount of the monetary base, which would then affect the total money supply and the interest rate in the financial market.

The central bank's purchase of the short term treasury bills in the open market can increase the money supply and reduce the interest rate in the financial market. This is mainly reflected in two aspects, on the one hand, when the money demand is unchanged, as the money supply rises, the market interest rate would fall accordingly. On the other hand, the purchase of the short term treasury bills in the open market will increase the demand for the short term treasury bills, thereby raising the price of the short term treasury bills, and the corresponding interest rate will be lowered accordingly, and vice versa.

The fed funds rate is the target rate of the open market operations, in the interbank lending market, the fed, as the largest participant, will first sell the short term treasury bills in the open market if it wants to raise the fed funds rate. As the demand for the short term treasury bills declines significantly, the price would fall, and the corresponding interest rate would increase, thus causing the cost of inter-bank lending to rise accordingly, and eventually the central bank would achieve the goal of simultaneously increasing the inter-bank lending rate and the fed funds rate. Also if the fed wants to lower the fed funds rate, it will first lower the fed's lending rate to the commercial banks, then since the interest rate cost of borrowing from the fed is lower than the inter-bank lending rate, commercial banks would choose to borrow

from the fed, thus causing the inter-bank lending rate to decrease accordingly, and eventually the central bank would achieve the goal of simultaneously lowering the inter-bank lending rate and the fed funds rate. Normally the fed's monetary policy is mainly based on the open market operations, and the adjustment of the monetary base in the market is flexible and rapid.

2.2.5. Large-scale asset purchase program

In response to the 2008 financial crisis. the fed had carried out three rounds of large-scale asset purchase program. The first round began in March 2009, the second round began in November 2010 and the third round began in September 2012. Three rounds of large-scale asset purchases had increased the fed's balance sheet by more than two trillion dollars in the asset side.

The theoretical basis of the large-scale asset purchase program comes from the monetary economic school's theory represented by Friedman. When the fed buys the treasury bonds or the senior secured corporate bonds guaranteed by the government on a large scale, and hold these securities on the asset side of the central bank's balance sheet, the number of the corresponding securities available for sale in the financial markets will decrease dramatically. With the reduced supply of the corresponding securities, the price would increase and the rate of return would decrease. At the same time, due to the decrease in the supply of securities guaranteed by the government, many investors will turn to other corporate bonds that are not guaranteed by the government, and this purchase action will further increase the price of other corporate bonds, thereby reducing the financing costs of the corporate bonds and stimulating the economy.

However, there is difference between the adjustment of the fed funds rate through the open market operations and the large-scale asset purchase program. The conventional open market operations only focus on the short-term interest rate, and the fed funds rate is a typical short term interest rate. Under conventional circumstances, the transmission mechanism from the short term interest rate to the long term interest rate is quite smooth. But during the financial crisis, due to the disfunction of the financial market, there is a failure of this transmission channel.

The large-scale asset purchase program is focused on the long term interest rate, and the economy can be stimulated by effectively reducing the long term interest rate. Also the large-scale asset purchase program's payment method is special, the payment from the fed would only increase the amount of commercial bank's reserves in the fed's account. So in fact the fed's quantitative easing policy will not actually affect the currency in circulation, only the balance of the reserve on the commercial bank's balance sheet is increased. Such reserve can be regarded as the liquidity injected by the central bank to the commercial banks and normally it would be stored in the fed in digital form and won't actually participate in the currency circulation and won't be counted as part of the broad money supply. The amount of the reserve will be included in the monetary base, but its role in macroeconomy is very different from cash.

2.3. Review of monetary policy transmission mechanism theory

The research on the transmission mechanism of monetary policy emerged in the 1980s. The research in this field mainly focuses on describing the specific path how the monetary policy implemented by the central bank can influence the macro economy. The traditional theoretical research on monetary policy is mainly from the perspective of macroeconomics, the study of the transmission mechanism of monetary policy adds more micro-level factors on the traditional theoretical research, so as to more accurately verify the effectiveness of the monetary policy.

There are four main types of monetary policy transmission mechanisms：the interest rate

channel transmission mechanism represented by Keynes and Taylor (1995);the exchange rate channel transmission mechanism represented by Obstfeld and Rogoff (1995); the asset price channel transmission mechanism represented by Meltzer (1995), Tobin (1969) and Modigliani (1971) and the credit channel transmission mechanism represented by Bernanke and Gertler (1995).

The above four main types of monetary policy transmission mechanisms have been empirically analyzed. Among these four transmission mechanisms, the interest rate channel transmission mechanism, the exchange rate channel transmission mechanism, and the asset price channel transmission mechanism have been questioned by other scholars, while the credit channel transmission mechanism has always been used in the empirical analysis by the subsequent scholars and it has been proven to be effective.

2.3.1. The interest rate channel transmission mechanism

The interest rate channel transmission mechanism of the monetary policy was first proposed by Keynes. The core assumption of this transmission mechanism is that the investor's financial asset portfolio holds only cash and bonds. At the same time, from Keynes' point of view, the bank loans would appear to be equivalent to the bonds, and they should both belong to the same asset class. The fed can affect the real interest rate by changing the money supply and demand, so as to achieve a balance of employment, outputs and income, and achieve the goal of controlling the macroeconomy through the monetary policy.

When the fed increases the amount of the money supply, the overall supply of the money will be in a state of short-term oversupply, and the investor's demand for the bonds will increase accordingly, and the excess liquidity would further lead to the increase in the price of the bonds. Due to the increased price of the bonds, the enterprises would then be able to issue the bonds with lower interest costs, and the reduction of the enterprises' financing costs would encourage the enterprises' production investment, thereby further increasing the total outputs level.

However, Keynes's interpretation of the interest rate channel transmission mechanism has many shortcomings. Its core assumption of the substitution relationship between the bank loans and the bonds was refuted by Bernanke and Blinder (1988), and Bernanke and Gertler (1995) pointed out that the capital cost theory in the interest rate channel transmission mechanism didn't make sense because the monetary policy is mainly aimed at the short-term interest rate like the fed funds rate, and the impact on the real long-term interest rates should be very small. In other words, for enterprise decision makers, the long-term cost of capital is less affected by the monetary policy implemented by the fed and its open market operations where the fed funds rate is used as the target rate. So it would be very difficult to explain why the monetary policy implemented by the fed has such a significant impact on the enterprises' purchase behavior of the long-term assets. Taylor (1995) pointed out that the transmission process from the short-term interest rate changes to the long-term interest rate changes is caused by the market expectations. However, the explanation on how the market expectations work is still not clear enough, and the quantitative relationship between the long-term interest rate changes and the short-term interest rate changes is also still not clear enough. In a word, the interest rate channel transmission mechanism proposed by Keynes has some flaws, and the theoretical assumptions and the specific transmission mechanism still need to be improved.

2.3.2. The exchange rate channel transmission mechanism

Since the crash of the Bretton Woods system in 1971, the floating exchange rate system has become the main currency system adopted by most countries. With the expansion of the overall volume of the international trade, the monetary policy of a country under the floating exchange rate system is significantly affecting the country's employment rate, outputs level

and the income level. So the exchange rate channel transmission mechanism of the monetary policy has become an important area of the monetary policy's transmission mechanism research.

Obstfeld and Rogoff (1995) pointed out that under the floating exchange rate system, the exchange rate channel transmission mechanism of the monetary policy would exist. When the central bank increases the money supply and causes the interest rate to fall accordingly, then compared with the domestic currency, the rate of return on the foreign currency deposits would appear to be more attractive than the rate of return on the domestic currency deposits. Out of the profit-seeking nature of the capital, a large amount of hot money in the international market would flow out of the domestic market where the rate of return on the deposits is not attractive enough, resulting in a substantial increase in the supply of the domestic currency on the market and the significant depreciation of the domestic currency against the foreign currency.

At the same time, the significant depreciation of the domestic currency would give the price advantage to the domestic exporters, compared with the similar foreign products, the domestic products would be able to be sold at a lower price to the foreign importers when these domestic products are priced in the domestic currency, thereby promoting the domestic exports. Similarly, the domestic consumers would be more willing to choose the domestic products which are more cost-effective, since with the significant depreciation of the domestic currency, foreign products would lose the price advantage and become less attractive to the domestic consumers, thereby contributing to the decline of the domestic imports. The significant increase in the domestic exports and the significant decrease in the domestic imports would lead to an increase in the net domestic exports, thereby improving the country's international trade balance of payments, and ultimately this would lead to an increase in the total domestic outputs level.

However, , the theory of the exchange rate channel transmission mechanism of the monetary policy still has many shortcomings. According to Obstfeld and Rogoff's view, if the domestic currency appreciates significantly against the foreign currencies, it would eventually lead to a reduction in the domestic exports and an increase in the domestic imports, and this would in turn lead to a reduction in the net domestic exports and the overall domestic outputs level. However this transmission mechanism can be flawed in many situations, and one good example is Germany in the 1970s mentioned by George Soros in "The Alchemy of finance ". When a large part of a country's exported products come from the processed imported products, then the country's economic situation can continue to be improved and the continued appreciation of the domestic currency would not stop the sustained and stable growth of the domestic outputs level.

This fact is obviously inconsistent with the theory of the exchange rate channel transmission mechanism of monetary policy. The reason is that Obstfeld and Rogoff didn't pay attention to the structure of a country's imported products and exported products. For Germany in the 1970s, a large number of exported products were the processed imported products, and when it comes to the proportion of total GDP, the difference between the imported products and the exported products is not large. Therefore, the transmission mechanism of the exchange rate channel of monetary policy also has certain defects and needs to be improved.

Figure 2 German real GDP growth rate and USD/DM

(**column:** German real GDP growth rate **line:** USD/DM)

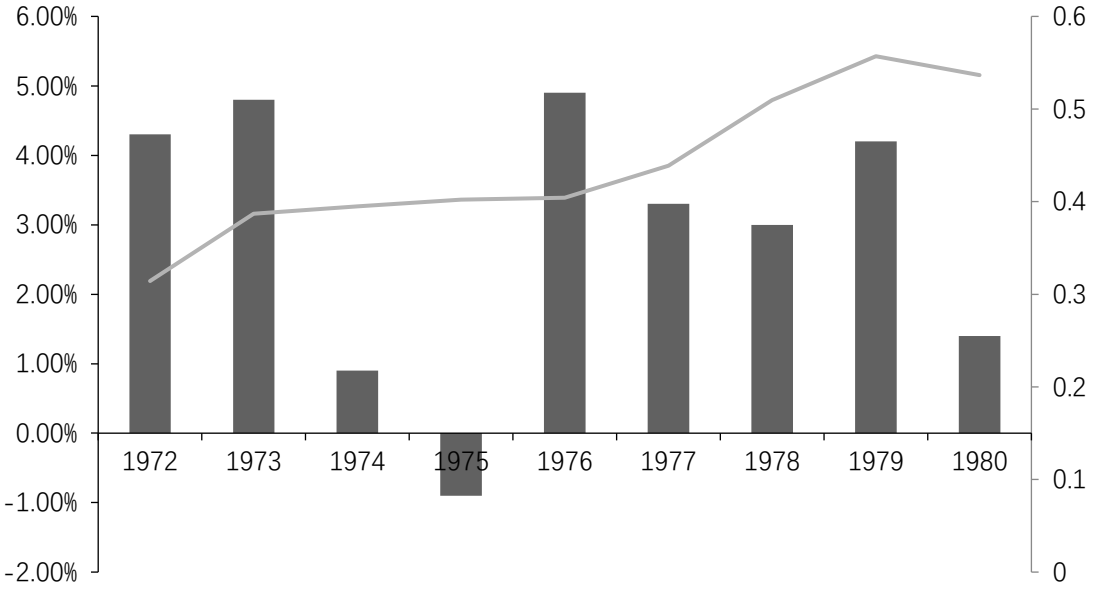


Table 1 the structure of German imported and exported products

Year	Proportion of exports in GDP	Proportion of imports in GDP
1970	16.43%	17.90%
1971	15.82%	17.58%
1972	15.80%	17.47%
1973	16.68%	17.65%
1974	19.81%	20.21%
1975	18.60%	20.30%
1976	19.63%	21.92%
1977	19.53%	21.76%
1978	19.15%	21.10%
1979	19.36%	23.11%
1980	20.22%	25.09%

2.3.3. The asset price channel transmission mechanism

Meltzer (1995) emphasized the monetary economic school's point of view, under the assumption that the capital market system of the country is mature and perfect, the central bank can operate the monetary policy tools on the open market to cause the general asset price adjustments, through the " Tobin's q theory ", the central bank can affect enterprises' production and through the "wealth effect theory", the central bank can affect the consumer's consumption behavior and finally realize the goal of affecting the total outputs level through the investment and the consumption.

2.3.3.1.Tobin’s q theory

Tobin (1969) proposed the definition of the q ratio: the market value of the enterprise/the replacement cost of the enterprise’s capital. According to his theory, the central bank can control the overall asset price level by controlling the supply of money, which would in turn affect the value of the q ratio. When the value of the q ratio is high, the market value of the enterprise would be higher than the replacement cost of the enterprise’s capital. Compared with the market value of the enterprise, the replacement cost of the plants used by the enterprise for production would be relatively low. So in this case, the company can raise the funds at a high price by issuing additional shares, and then use the raised funds to purchase the plants required for production. This part of the newly raised funds will be used as an increase in the capital expenditure, and it will eventually lead to an increase in the overall outputs level. When the value of the q ratio is low, then the market value of the enterprise would be lower than the replacement cost of the enterprise’s capital. In this case, if an enterprise wants to obtain more plants to expand its production capacity, it would choose to acquire another enterprise at a lower price in the secondary market so as to achieve the purpose of expanding its production capacity, since in this case no additional capital would be invested at the replacement cost in the capital expenditure, the secondary market purchase would lead to the decrease in the overall level of the capital expenditure in the real economy. And this decline in the capital expenditure would eventually lead to a decline in the overall outputs level.

2.3.3.2.Wealth effect theory

Based on the permanent income hypothesis, Modigliani (1971) argued that consumers’ consumption behavior is related to the prices level of the asset that they hold. According to the monetary economic school’s point of view, the central bank can influence the asset prices level by controlling the supply of money, and the consumers would change their consumption behavior due to changes in the asset prices level. When the central bank implements the expansionary monetary policy, the consumers who hold the financial assets would become richer because of the rise in the asset price, and the increase in the wealth would in turn cause these consumers’ demand to increase accordingly and ultimately the increased consumption level would further lead to an increase in the overall outputs level. When the central bank implements the tightening monetary policy, the consumers who hold the financial assets would begin to cut the consumption due to the shrinking of the asset prices and the reduction in the demand for consumption. And the reduction in the consumers’ demand would further exacerbate the decline in the overall outputs level.

However, for the monetary economic school’s theory, Bernanke (1995) pointed out that in the empirical analysis of the asset price channel transmission mechanism of monetary policy, the whole process is just like a "black box", regardless of whether it is the Tobin's q theory or the wealth effect theory, neither of them has well revealed the transmission mechanism of monetary policy from an empirical perspective and this "black box" still needs to be improved.

2.3.4.The credit channel transmission mechanism

Before Ben Bernanke proposed the theory of the credit channel transmission mechanism of monetary policy, the assumption behind the mainstream macroeconomic model proposed by Modigliani-Miller (1958) was that the structure of the financial market couldn’t be determined and would have nothing to do with the real economy. The frictions in the financial market are very small, and their importance could be negligible in the research.

The research on the conditions of the credit market can be traced back to the research of Fisher (1933). He believed that the deterioration of the conditions of the credit market, such as corporate insolvency, bankruptcy and liquidation, a sharp decline in the asset prices, and a systemic crisis in the banking system, are not completely passive phenomena caused by the

actual economic recession in the country, instead these factors further actively aggravated the recession of the actual economy of the country. The deflation during the great depression exacerbated the debt burden of the enterprises, and finally triggered the most serious financial crisis in the 20th century.

Ben Bernanke (1983) re-focused on the impact of credit market conditions on the macroeconomics, arguing that the incompleteness of the credit market and the existence of the frictions in the credit market are very helpful in explaining the historical events like the great depression. From this perspective, Bernanke and James (1991) explained the impact of deflation under the gold standard on the financial crisis during the great depression. Bernanke and Lown (1992) explained that after experiencing a recession from 1990 to 1991, the reason for the slow economic recovery in US was due to the heavy burden of the corporate debt and the fact that the banking system was undercapitalized. The economic recession experienced by Scandinavian countries during the 1980s was also caused by the heavy debt burden of domestic companies and insufficient capital reserve in the banking system.

Bernanke and Blinder (1988), Bernanke and Gertler (1995) introduced the concept of the credit channel transmission mechanism based on the theory of the information asymmetry, pointing out that the direct impact of the monetary policy on the interest rates is amplified by the extra costs in the external financing. the traditional cost of capital theory ignored the change of the extra costs in the external financing. Because of the existence of the extra costs in the external financing, the impact of the monetary policy on the real expenditures and the real economy would be amplified. The extra costs in the external financing means the difference between the costs paid by the company's external financing and the opportunity costs of the company's internal funds.

Bernanke and Gertler (1995) pointed out that the credit channel transmission mechanism could be divided into two channels, bank credit channel and enterprise balance sheet channel.

2.3.4.1. The bank credit channel

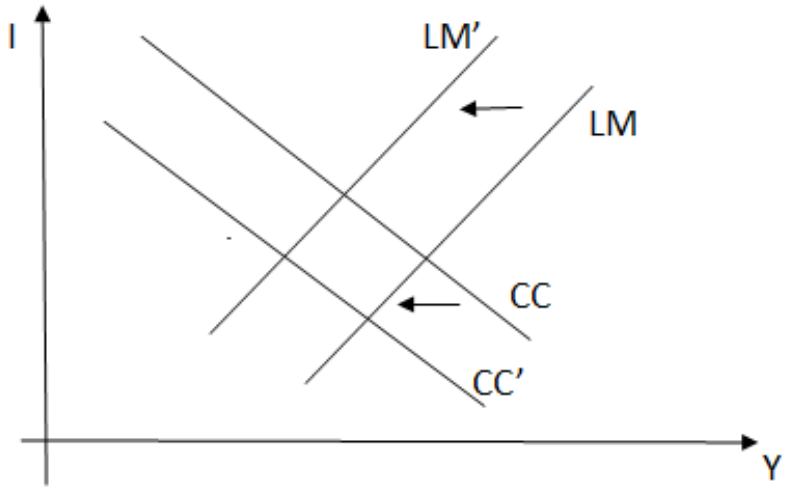
Bernanke and Blinder (1988) believed that the banking system had the nature of the financial accelerator. There are entities in the economic system that would have a special dependence on the bank loans and there is no other way for these entities to obtain the funds with lower cost outside of the bank loans channels. So there is a difference between the bank loans and the bonds financing. For the analysis on the borrowing activities in the macro economy, bank loans can't be simply classified as bonds. Based on this key assumption, Ben Bernanke's theory is very different from the interest rate channel transmission mechanism proposed by Keynes. Based on the IS-LM model and the function of loan's supply and demand, the CC-LM model could be constructed. The CC curve has replaced the IS curve to represent the combination of the interest rate and total outputs, so that it can better describe the changes in the bank's total amount of funds available for lending. The traditional IS-LM model only emphasizes the relationship between the money supply and the interest rate.

Because the bank's asset and liability structure can't be adjusted quickly enough to avoid the impact of the fed's monetary policy, the size of the bank's loanable funds is subject to the fed's monetary policy, and changes in the size of the loanable funds will lead to the changes in the total supply of the bank loans. And it will directly affect the entities that depend on the bank loans, thereby affecting their investment decisions, and ultimately influence the real economy.

According to the CC-LM model, when the fed adopts a tightening monetary policy, the LM curve would first move left to LM', the outputs would decrease and the interest rate would rise, and the central bank would reduce the money supply, resulting in a reduction in the total amount of the bank's loanable funds. As the loan interest rate rises, the corporate loans would become difficult to obtain, thereby reducing the production investment, which would lead to the further contraction of the outputs. Then the CC curve would move left to CC', and finally

intersect with LM' to obtain the final equilibrium interest rate and outputs level. The final interest rate would be lower than the initial one and the outputs would be lower.

Figure 3 CC-LM model



2.3.4.2. The enterprise balance sheet channel

Bernanke and Gertler (1989) constructed a model of banks, companies and consumers to demonstrate the effectiveness of the enterprise balance sheet channel in the monetary policy transmission mechanism. Due to the existence of the adverse selection and the moral hazard issues in the economic system, the tightening monetary policy would directly deteriorate the company's balance sheet in at least two ways. Firstly, companies often have outstanding short term bonds or floating rate bonds, when the interest rate rises, the company's interest costs would increase accordingly, resulting in an increase in the financing expenses and a reduction in the company's cash flow, and this would in turn worsen the company's financial situation. Secondly, the rise in the interest rate would lead to a decline in the company's asset prices, and this would in turn reduce the value of the company's collateral and the company's credit rating.

In order to better show how could the monetary policy shocks affect the components of the enterprises' cash flow, Bernanke and Gertler (1995) showed the dynamic changes of the non-financial enterprises' interest expenditure, revenue, gross income and employees' income due to the monetary policy shocks through the impulse response function of the VAR model. The results further revealed two reasons for the decline in the enterprises' profits and cash flows due to the tightening monetary policy shocks. Firstly, the increase in the interest expenditures would directly cause the decrease in the enterprises' profits. According to the results of the VAR impulse response function, the increase in interest expenditures would cause the profits to fall by 40% in short term. Secondly, the impulse response function results showed that the increase in the market interest rate would cause the enterprises' revenue to decline faster than the costs, and this would lead to the deterioration of the company's cash flow situation.

In order to better describe the enterprise balance sheet channel transmission mechanism, Bernanke defined the borrower's net asset value: enterprise liquid assets + collateral value of the illiquid assets – the outstanding debts. Due to the existence of the frictions in the credit market, the monetary policy shocks can achieve the goal of controlling the macroeconomy by affecting the borrower's net asset value, and there is a clear transmission mechanism.

Bernanke, Gertler and Gilchrist (1994) systematically revealed the "financial accelerator" theory, the endogenous changes in the credit market would magnify the macroeconomic fluctuations. The key channel of the "financial accelerator" is the relationship between the extra costs in the external financing and the borrower's net asset value. Due to the existence of the frictions in the credit market and the information asymmetry, the correlation between the extra costs in the external financing and the borrower's net asset value should be negative. Because when the borrower who needs to borrow money to finance the project is in shortage of funds and the net asset value is low, the divergence of interest between the borrower and the lender would increase due to the information asymmetry. The agency cost during the financing process would increase, therefore the lender would require the borrower to pay a higher interest rate. Since the borrower's net asset value changes positively with the economic cycle, combined with the existence of the information asymmetry in the credit market, the extra costs in the external financing would change in reverse with the economic cycle, thus causing the interest cost paid by the borrower's actual financing activities to move reversely with the economic cycle. Also the impact on the enterprises' production, expenditure, and the investment activities could be explained accordingly. Aoki, Ptoudman and Vlieghe (2004) also proved that the impact of the monetary policy shocks on the housing prices could be explained by the "financial accelerator" theory. Generally speaking, the brief transmission mechanism can be shown below:

(1) The bank credit channel：

When the fed is implementing the expansionary monetary policy by lowering the fed funds rate, the increased money supply would cause the loanable funds of the commercial banks to increase accordingly, thus causing the interest costs of the bank loans and the enterprises' extra costs in the external financing to decrease accordingly. Lower interest costs would encourage the enterprises to invest more by borrowing the funds from the commercial banks, and finally with the increased production investment, the overall outputs level would increase.

(2) The enterprise balance sheet channel：

When the fed is implementing the expansionary monetary policy by lowering the fed funds rate, the decreased interest expenses and the increased collateral value would strengthen the enterprises' income statement and balance sheet at the same time. With the increased net asset value, the extra costs in the external financing would decrease accordingly and the enterprises would be able to increase the production investment by borrowing with lower interest costs, and finally with the increased production investment, the overall outputs level would increase.

3. Literature review from VAR to FAVAR model

3.1. Use the VAR model to test the effectiveness of monetary policy

Sims (1980)created the unrestricted VAR model for the first time, and the VAR model was used to conduct an empirical analysis on the causal relationship that exists in macroeconomic variables. Through the impulse response function, the dynamics of the macroeconomic variables could be captured.

The standard VAR model proposed by Sims is expressed in the form of simultaneous equations, and the variables contained on the right side of each equation in the simultaneous equations are the same, including the lag values of the endogenous variables in all of the equations. All of the current endogenous variables are regressed to their corresponding lag values, so as to estimate the dynamic relationship contained in all the endogenous variables. The typical mathematical formula of the standard VAR model proposed by Sims where no exogenous variables are included is expressed as:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \qquad (1)$$

In equation (1),Y_t is the endogenous variable, and p is the lag order used in the standard VAR model. And A_1 to A_p are the coefficient matrix to be estimated, ε_t is the random error term with zero mean and the covariance matrix of Q.

Since then, various VAR models have been widely used by the academia to test the effect of central bank's monetary policy shocks. The VAR family models can achieve good empirical results in testing the transmission mechanism of the central bank's monetary policy shocks, evaluating the time lag of the monetary policy shocks, and testing the effect of monetary policy shocks on various macroeconomic variables.

Sims (1992) explained the so-called "price puzzle", that is, in the traditional standard VAR model, it was found that after the tightening monetary policy, the price level was slightly increased, which was contrary to the traditional monetary policy transmission mechanism theory, normally we would expect the price level to fall immediately after the tightening monetary policy. Regarding the "price puzzle", Sims believed that this was due to the incompleteness of the central bank's knowledge of the future inflation rate. The main reason for the central bank's tightening monetary policy at the beginning of the period was based on the expectations of high future inflation, and the expected economic variable index was not well included in the time series of economic variables of the standard VAR model, so the central bank's tightening monetary policy in the standard VAR model was accompanied by the impulse response function effect of the price level rising. It may actually be caused by the central bank's new information about the future inflation rate. The price level suppression effect caused by the tightening monetary policy only partially offset the pressure of the rising inflation rate, but the pressure of the rising inflation rate in the future cannot be completely eliminated by the suppression effect caused by the tightening monetary policy.

Bernanke and Gertler (1995) used the standard VAR model to empirically test the bank credit channel and enterprise balance sheet channel in the monetary policy credit channel transmission mechanism, and introduced the concept of extra costs in the external financing. The enterprise balance sheet channel pointed out that the extra costs in the external financing faced by a company depends on the company's financial situation. The larger a company's net assets value, the lower the extra costs in the external financing would be. The bank credit channel pointed out that changes in the monetary policy would lead to the changes in the total credit supply of the financial intermediaries in the financial system, which would in turn lead

to the changes in the extra costs in the external financing of the enterprises.

Leeper, Sims and Zha (1996)established a standard VAR model with 18 variables, and used the discount rate and the fed funds rate to describe the fed's monetary policy. The empirical analysis results showed that the impact of the tightening monetary policy shocks adopted by the fed on the price level had a time lag. The price level CPI would not begin to reflect the impact of the fed's tightening monetary policy until the 48th month.

Christiano, Eichenbaum and Evans (2000) used the standard VAR models to test the impact of the central bank's tightening monetary policy shocks on the outputs levels, and they had found out that the negative impact was maximized in the 24th month and the impact disappeared completely in the 36th month. On the contrary, there was a time lag in the impact of central bank's tightening monetary policy shocks on the price levels, the price levels would not begin to reflect this negative impact until the 36th month. This empirical analysis result is consistent with the price level time lag phenomenon discovered by Leeper, Sims and Zha (1996), and the "price puzzle" do exist.

Massimo (2005) used the standard VAR model and he found that the central bank's monetary policy shocks can influence the real estate price level, which would in turn have a significant impact on the national consumption expenditure level.

Matteo and Raoul (2008) used the standard VAR models to conduct the empirical analysis on the real estate markets of western countries such as Finland and Germany. The research result showed that the tightening monetary policy implemented by the central bank of the country will mainly influence the domestic real estate market through the bank credit channels. And the specific effect on the domestic real estate market was also closely connected to the structural characteristics of the specific country's real estate market at the micro level.

3.2. Use the SVAR model to test the effectiveness of monetary policy

The standard VAR model proposed by Sims does not take the structural economic shocks into account when conducting the empirical analysis, and this shortage of the standard VAR model will result in a certain degree of discrepancy between the impulse response results of the VAR model and the actual situation of the real economy, making it difficult to describe the actual effect of the central bank's monetary policy on the macroeconomic variables that we care about. Also in the standard VAR model, we can't take the contemporary effect between different economic variables into account. In order to solve these shortages of the standard VAR model, Blanchard and Quah (1990) proposed the structural vector autoregressive model (SVAR model) based on the foundation of the standard VAR model. The SVAR model adds the identification constraints of each variable into the model and the mathematical formula of the SVAR model is expressed as:

$$A_0 Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t \quad (2)$$

In equation (2),Y_t is the endogenous variable, and p is the lag order used in the standard VAR model. And A_1 to A_p are the coefficient matrix to be estimated, u_t is the random error term with zero mean and the covariance matrix of Q.

To determine the coefficient matrix A_1 to A_p, the process includes two steps:

In the first step, the SVAR model is simplified to the reduced form VAR model, which is quite easy to estimate.

In the second step, combined with the identification constraints and the estimated results in the first step, the coefficient matrix of the SVAR model are derived.

In order to obtain the VAR model in reduced form, we should multiply the left side and the right side of equation (2) by A_0^{-1} at the same time to obtain the equation (3):

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_p Y_{t-p} + \varepsilon_t \quad (3)$$

In equation (3), $B_i=A_0^{-1}A_i$ (i=0,1...,p), $\varepsilon_t=A_0^{-1}u_t$, ε_t is the random error term in reduced form, but the shocks here are not all structural. In equation (2), the random error term u_t includes the structural shocks. Based on equation (3) and the identification constraints which are in accordance with the economic theory, equation (3) can be transformed back to equation (2), and the SVAR model is then estimated.

3.3. Use the FAVAR model to test the effectiveness of monetary policy

Based on the dynamic factor model proposed by Stock and Watson (2002) and the VAR model proposed by Sims (1980), Bernanke and Boivin (2005) combined the factor analysis method with the traditional standard VAR model and established the FAVAR model, thereby solving the standard VAR model's shortcomings of being only able to contain too few economic variables, making the VAR model more relevant to the actual situation when the fed is deciding the monetary policy. The FAVAR model is better than the standard VAR model in describing the transmission mechanism of the central bank's monetary policy.

Haroon and Paolo (2007) used the FAVAR model to empirically test the impact of the international monetary policy shocks (interest rates, money supply and so on) on the British economy. According to the empirical analysis results, they found that the decline in interest rates worldwide would effectively promote the real estate market in the UK. The price level, inflation rate, investment, GDP and the national consumption would increase and reach the peak in the 12th month, the hourly earnings level would reach the peak in the 24th months, and the CPI and GDP would reach the peak in the 36th months.

Masahiko Shibanoto (2007) and Vargas Silva (2008) used the FAVAR model to conduct an empirical analysis on the impact of the monetary policies of Japan and the United States on the domestic real estate market. According to the empirical analysis results, compared with the standard VAR model, The impact of the central bank's monetary policy on the domestic real estate market can be represented better by using the FAVAR model.

Haroon, Zabczyk and Ellis (2009) used the FAVAR model to conduct an empirical analysis on the impact of certain economic factors at the macroeconomic and the microeconomic levels on the overall price level of the UK. According to the empirical analysis results, they found that the impact on the overall price level of the UK is higher than the impact on the price level of the sub-sectors, and the duration of the impact on the overall price level is longer than that of the sub-sectors.

Gupta and Kabundi (2009) constructed the FAVAR model based on the quarterly economic data from the first quarter of 1980 to the fourth quarter of 2006. The FAVAR model analyzed the impact of the central bank's monetary policy on the actual housing price level. According to the empirical analysis results, the impact of monetary policy of the central bank on different segments of the housing market is inconsistent, and there is no "price puzzle" phenomenon mentioned by Sims (1992) in the empirical analysis result.

Liu, Haroon, and Angeliki (2011) analyzed the impact of other countries' monetary policies

on the British real economic activities by using the FAVAR model. Based on the empirical analysis results, they found that other countries' tightening monetary policies(such as a reduction in the money supply) would promote the growth of the British real economy before 1990, and this promotion effect had failed gradually since 1990.

Fujii, Hiraga and Kozuka (2013) used the FAVAR model to analyze the crowding out effects and the crowding in effects of public sector investment on private sector investment. According to the empirical analysis results, they found that from a micro-level point of view, different industries were affected by the public sector investment differently. In different industries, public sector investment had significant crowding out effects or crowding in effects on private sector investment, and the differences among different industries are large.

Qing He (2013) used the FAVAR model to analyze the transmission mechanism of Chinese monetary policy and to test the effectiveness of monetary policy tools in affecting Chinese economy. According to the empirical analysis results, he found that the growth rate of total loans and the growth rate of the money supply had significant impact on Chinese economy and the overall price level.

Garima and Philipp (2013) used FAVAR to analyze the impact of global economy development on Canadian domestic economy. According to the empirical analysis results, Canada was considered to be a typical small open economy. The impacts of the foreign economy development and the international commodity prices on Canadian domestic economy were quite significant, while the impacts of the global interest rate level and the inflation rate level on Canadian domestic economy were not significant. The reason was that a large part of the Canadian national outputs was achieved by the energy sector, and the outputs of the energy sector mainly came from the export of commodities. The sound economy growth of foreign countries (especially the countries that import the commodities) would boost the demand for international commodities, thereby increasing the price level of the international commodities and ultimately affecting the Canadian domestic economy.

We also need to note that when using the VAR family models, we should try to avoid the situation that the data relationship deviates from the economics theory basis. Attention should be paid to avoid simple statistical data relationship orientation, because usually these relationships could just be the spurious regression and have no economic meanings. VAR family models emphasize that the variables should be endogenous and it is important to let the data speak, so it is more necessary to determine the correct VAR model based on the economic theory so as to better combine the priori theory and the characteristics of the VAR family models.

4. Effectiveness test of the credit channels of the monetary policy--based on FAVAR model

4.1. Model description

Sims (1992)had pointed out that one of the shortages of the traditional VAR model is that it can't include many economic variables, otherwise the number of the parameters to be estimated would be too large. Gupta (2010)had pointed out that now it is only possible to use VAR, VEC and SVAR model to handle at most 12 economic variables and this conclusion is in accordance with Sims' view. Bernanke and Boivin (2005)thought that the number of economic variables that the monetary policy makers working at the federal funds need to consider when they are formulating the monetary policy is extremely large, the traditional VAR model is not suitable as it can at most handle 12 variables at the same time, the limited number of economic variables has greatly restricted the effect of the VAR model to reflect the effect of central bank's monetary policy on the real economy. Also, the traditional standard VAR model contains too few economic variables and there are doubts about the lack of support from economic theory to cause spurious regression. Similarly, too few economic variables can hardly reflect the rational expectation information put forward by the "Lucas criticism". Based on the purpose of solving the problem that the standard VAR model contains too few variables, Bernanke and Boivin proposed the FAVAR model to solve the shortcomings of the standard VAR model, so that it can contain more macroeconomic variables and better reflect the effect of the central bank's monetary policy on the actual economy.

In FAVAR model， firstly we need to identify an (M×1) matrix Y_t to represent the observable economic variables, at the same time, we need to identify a (K×1) matrix F_t to represent the non-observable economic variables. Basically, F_t is used to represent the economic variables that are not included in Y_t, but they are still important in our empirical model.

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = B(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \varepsilon_t \quad (4)$$

In the equation (4), B(L) represents the polynomial with lag p, ε_t represents the error term with mean of 0 and covariance matrix of Q. The above equation (4) looks exactly like the model proposed by Sims in 1980, but the difference is that here F_t is the non-observable economic variables, so the whole equation can't be estimated directly. To estimate the matrix F_t,we can now introduce an (N×1) matrix X_t to represent the overall group of the economic variables, and N is the number of economic variables in the matrix X_t, and it should fulfill the requirement that N≫K+M, now we also suppose X_t can be linearly expressed by the observable variables Y_t (M×1) and the non-observable variables F_t (K×1), then we can get the equation (5).

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + \mu_t \qquad (5)$$

In the equation (5), the Λ^f is the (N×K) factor loading matrix, Λ^y is the (N×M) factor loading matrix, ε_t represents the error term with mean of 0 and covariance matrix of Q. This equation (5) is the standard orthogonal factor model, and now we can use $\widehat{F}_t$ to estimate F_t, and we replace F_t by $\hat{F}_t$ in the equation (4) to realize the combination between the traditional VAR model and the factor model.

We will estimate $\hat{F}_t$ by using two-step principle components analysis, the principle

components analysis method was introduced by Hotelling (1936). It is a multivariate statistical method used to discover the correlation between multiple variables, and it can fully reflect the idea of dimensionality reduction. By extracting a few main components from a large number of original variables, the internal structure between the original variables can be revealed and the original data information can be maintained.

The reason for selecting the two-step principal component analysis in this paper is that based on the dynamic factor model proposed by Stock and Watson (2002), Bernanke and Boivin (2005) use the two-step principal component analysis method, Gibbs sampling method and iterative method to extract the factors of the FAVAR model, Boivin (2009) used the Gibbs sampling method to test the effectiveness of monetary policy, Gupta, Marius and Kabundi (2010) found that the effect of Gibbs sampling is the poorest, and Hwang (2009) proved that the two-step principal component analysis method is the best, so this paper will choose to use the two-step principal component analysis method for factors extraction.

In the two-step principal component analysis, firstly we can divide the ($N\times1$) matrix X_t into two subgroups, the "fast variables" and the "slow variables", the "fast variables" are the economic variables that can react immediately to the monetary policy shocks, such as the interest rates, stock prices, monetary base, commercial loans and so on. The "slow variables" are the economic variables that react slowly to the monetary policy shocks, or we can say they are the "sticky" variables, such as IP, employment, CPI and so on. The "fast variables" can be observable and most "slow variables" belong to the group of non-observable economic variables, and then we can use the principle components analysis method to get its estimate $\hat{F}_t^s$, and later on, we can also conduct the principle components analysis on X_t, $C_t=(F_t, Y_t)$, we can extract (K+M) principle components from X_t and get the new information group $\hat{C}_t$, and then we will get the equation(6).

$$\hat{C}_t = b^f \hat{F}_t^s + b^y Y_t + e_t \quad (6)$$

In equation(6), we can get the new estimate of the non-observable economic variables, and it is $\hat{C}_t$ - $b^y Y_t$, and now the estimate of the non-observable economic variables is free from the information of Y_t , and it is the pure estimate of the non-observable economic variables. So now we can put the new $\hat{F}_t$ and Y_t into the equation(4), and then we will get the model of equation(7).

$$\Gamma(L)\begin{bmatrix}\hat{F}_t \\ Y_t\end{bmatrix} = v_t \quad (7)$$

$\Gamma(L)$ is the polynomial with lag equal to q, v_t represents the error term with mean of 0 and covariance matrix of Q, then we will further get the impulse response function between $\hat{F}_t$ and Y_t.

$$\begin{bmatrix}\hat{F}_t \\ Y_t\end{bmatrix} = \psi(L)v_t \quad (8)$$

$\Psi(L)$ is the polynomial with lag equal to r, and it fulfill the requirement that $\Psi(L) = \Gamma(L)^{-1}$, Combined with the equation (5), we will get the impulse response function (9).

$$\hat{X}_t' = \left[\hat{\Lambda}^f \;\; \hat{\Lambda}^y\right]\begin{bmatrix}\hat{F}_t' \\ \hat{Y}_t'\end{bmatrix} = \left[\hat{\Lambda}^f \;\; \hat{\Lambda}^y\right]\psi(L)v_t' \quad (9)$$

Now the FAVAR model has been constructed, and it is the model that we are going to use in our empirical analysis.

4.2. Selection of economic variables

Based on the economic variables selected by Bernanke and Boivin(2005), and after considering the completeness and the availability of data, we choose the monthly data of 115 variables from 1959 January to 2014 December, and these variables can be divided into 12 groups：

(1) real outputs and income

Including IP(total), IP(final products), IP(materials products), IP(durable consumption), IP(nondurable consumption), IP (energy), IP(auto) and so on.

(2) employment rate and average working hours

Including employed population(manufacturing industry), nonagricultural employed population, employed population(service industry), employed population(commodity production), employed population(government), employed population(private sector), employed population(durable goods manufacturing), employed population(nondurable goods manufacturing), employed population(energy and extractive industries), employed population(logistics), employed population(educational and medical), employed population(retail), short-term unemployment rate(<27weeks), long-term unemployment rate(>=27weeks), unemployment rate, average working hours in manufacturing and so on.

(3) consumption

Including personal consumption expenditure and personal consumption expenditure (except food and energy expenditure) and so on.

(4) real estate investment

Including the number of new house starts, the number of new house starts in the Midwest, the number of new house starts in the Northeast, the number of new house starts in the South, and the number of new house starts in the West and so on.

(5) inventory and new orders

Including new orders for durable goods manufacturing, new orders for consumer goods and raw materials manufacturing, inventory index, new order index and so on.

(6) stock price

Including S&P 500 index and Dow Jones index.

(7) exchange rate

Including USD currency index and so on.

(8) interest rate

Including Aaa corporate bond yield, Baa corporate bond yield, fed funds rate, three-month Treasury bill yield, six-month Treasury bill yield, 1-year Treasury bond yield, 10-year Treasury bond yield and so on.

(9) average hourly income

Including average hourly income(construction industry) and average hourly income (manufacturing industry).

(10) money supply and total credit

Including commercial and industrial loans, consumer loans, monetary base, M2, depository institution reserves, real estate loans and so on.

(11) price index

Including PPI, PPI(crude oil), PPI(final product), PPI(industrial), PPI(intermediate product), CPI, CPI(excluding food and energy expenditure) and so on.

(12) consumer expectation

Including consumer expectations index.

4.3. The reason for choosing fed fund rates to work as the proxy of monetary policy until September 2008

According to the research of Bernanke and Blinder (1992), Christiano, Eichenbaum and Evans (1994a, b) and other scholars, the fed funds rate, which is the main interest rate in the US interbank trading market, can be viewed as an indicator showing the changes in monetary policies. When the fed funds rate changes in the empirical models, it means that the monetary policy has been changed. The other variables in the model will follow the changes of the monetary policy, in this way, the structural dynamics of each macroeconomic variable following the changes in the monetary policy can be represented by the empirical model.

Bernanke and Mihov (1995) estimated the model of the fed's monetary policy operating procedures and found that during the period before 1979 and during the period from 1988 to 1995, the fed funds rate was a good description of the fed's monetary policy. In the long run, the fed funds rate and the US currency market interest rate have also maintained a high degree of consistency.

The data of this paper is taken from January 1959 to December 2014, and the indicator used by this paper to describe the fed's monetary policy from January 1959 to September 2008 is the fed funds rate, however, we need to note that the data from 1980 to 1988 has been included. During this period, the reason why the fed funds rate couldn't describe the fed's monetary policy well is that since the mid-1960s,the fed had believed in the substitution relationship between inflation rate and unemployment rate proposed by Phelps (1967), that is, the Phillips curve. The model indicated that there is a significant negative correlation between the inflation rate and the unemployment rate in a country. Under this guidance, the monetary policy of the fed began to shift to excessive easing, causing a hidden danger for the hyperinflation.

In 1978, the turmoil in Iran's political landscape and the outbreak of the Iran-Iraq war led to a sharp reduction in the total supply of the crude oil on the international market, which in turn triggered a surge in the international oil prices and led to the second oil crisis, which ultimately caused American economy to fall into a "stagflation" pattern, the Phillips curve began to fail, and the inflation rate exceeded 10% for three consecutive years from 1979 to 1981. The fed chairman Volcker sharply increased interest rates in order to suppress the abnormal and excessive inflation rate. The average lending rate soared from 11.2% in 1979 to 20% in 1981, the base interest rate was as high as 21.5%, and the 10 years Treasury rate reached 17.3%. At the same time, the unemployment rate soared to 1982 due to the excessively tight monetary policy and the sluggish macroeconomic conditions. Generally speaking, during the Volcker period, the main goal was to curb the hyperinflation, which is different from the main objectives of the fed's monetary policy under normal circumstances. The fed tends to maintain a relatively low inflation rate under the normal circumstances. At the same time, the unemployment rate should also be kept low, but during Volcker's period, the main goal had been to suppress the hyperinflation in the first place, and at the same time they suffered from a high unemployment rate.

However, after observing the inflation rate, the fed funds rate and the unemployment rate from 1980 to 1988, we can find that the Volcker's policy had a major impact on the economic data from 1980 to 1982, although the fed funds rate in July 1981 had once exceeded 20%, but after 1983, the fed funds rate had quickly fallen below 10%, and had shown a long-term slow downward trend. At the same time, the inflation rate and the unemployment rate had also been significantly improved after 1983, so it is believed that the fed funds rate, as an indicator describing the central bank's monetary policy, will have problem only from 1980 to 1982, and it has gradually recovered its effectiveness since 1983. Generally speaking, the period from 1980 to 1982 is short, so it will not prevent this paper from using the fed funds rate to describe the fed's monetary policy in the long run.

Figure 4 USA 1975-1988 inflation rate

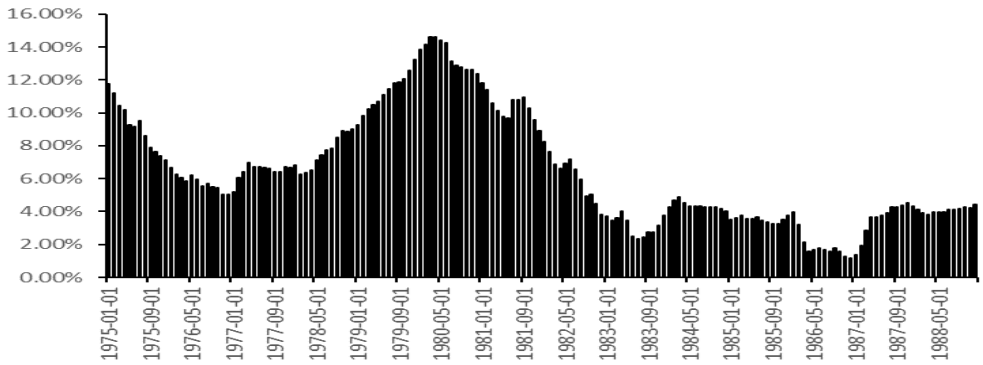
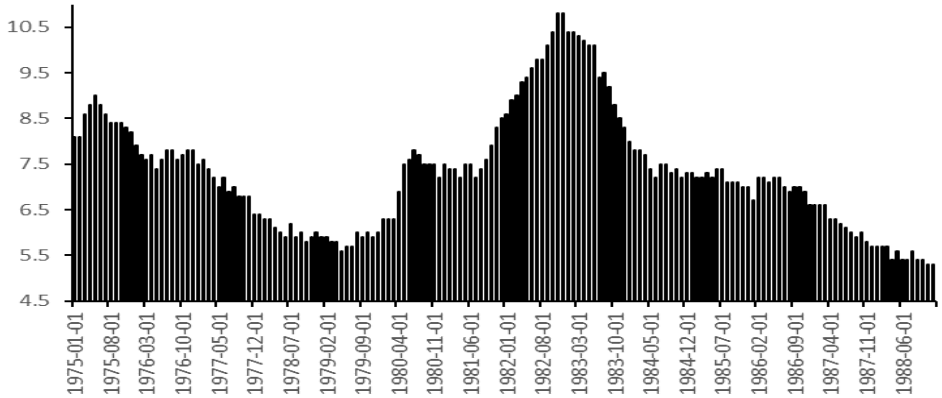


Figure 5 USA 1975-1988 unemployment rate



The economic data contained in this paper also includes the period of the financial crisis since 2008. In response to the financial crisis from 2008 to 2014, Bernanke (1999) pointed out that once the entire market fell into a financial crisis, the normal bank credit channels would be completely destroyed and the banking system would face serious capital shortages. If the initial operating risks of financial institutions are huge, the shrinking of the final asset prices would cause serious harm to the financial institutions' balance sheets. In order to control the spread of risks in the financial system and repair the normal bank credit channels, the fed should perform its function of maintaining financial market stability,

In December 2008, the fed funds rate was lowered to the target range of 0-0.25%, and was maintained at this low level until December 2015, when the fed raised the target rates by 25 basis points for the first time since 2008 crisis. During the period from 2008 to 2015,the fed carried out three rounds of large-scale asset purchase programs to inject the liquidity into the financial system, and at the same time, the fed funds rate was nearly a constant variable.

Due to the particularity of the payment method of the large-scale asset purchase program and the consideration that the large-scale asset purchase program should mainly play the role of the last lender, which is the responsibility of the central bank, from Ben Bernanke's point of view, most of the payment of the large-scale asset purchase program was stored in the fed as the reserve and did not actually participate in currency circulation. The macroeconomic impact of the large-scale asset purchase program can also be well confirmed in the inflation rate data from 2009 to 2016. Through the large-scale asset purchase program, the deflation effect caused by the deleveraging during the recession period can be effectively eliminated without triggering high inflation rate. Also, there is another explanation made by Ray Dalio, even if the money printed by the large-scale asset purchase program really participated in the

currency circulation, as long as it is used to offset the deflation effect caused by the diminishing credit during the crisis, the price effect on the overall price level would be the same (the price effect of one dollar cash and one dollar credit should be the same).

The monetary policy related to the fed funds rate would affect the borrowers and the consumers directly, as we can understand from the bank credit channel and the enterprise balance sheet channel transmission mechanism, but the monetary policy related to the large-scale asset purchase program is different in that it won't affect the borrower and the consumers directly, but instead it would affect the investors and the depositors directly, this special monetary policy tool should be used when the liquidity premium and the risk premium in the financial markets are large in order to make the financial markets and the investment activities to function again. But the limitations of the large-scale asset purchase program are clear. Firstly it will be less powerful when the premium has been minimized. Secondly, since it won't affect the borrower and the consumers directly, and the economic transmission mechanism is not very clear, it should not be used as a normal tool by the central bank.

Therefore, the large-scale asset purchase program is fundamentally different from the fed's normal open market operation, which affects the fed funds rate and therefore changes the money supply of the real economy. Because of the special mechanism of the large-scale asset purchase program and the fact that it has become the main monetary policy tool from October 2008 to December 2014, the fed funds rate which is kept at the level of zero lower bound during this period should not be used as the indicator describing the fed's monetary policy in the FAVAR model. So during the after crisis period the fed funds rate can't work as an effective indicator of the monetary policy in the empirical models, and an alternative variable that can quantitatively reflect the effect of the large-scale asset purchase program should be used as the indicator from October 2008 to December 2014.

Figure 6 composition of the asset side of the federal fund

(**bottom:** other security **middle:** Treasury **upper:** MBS)

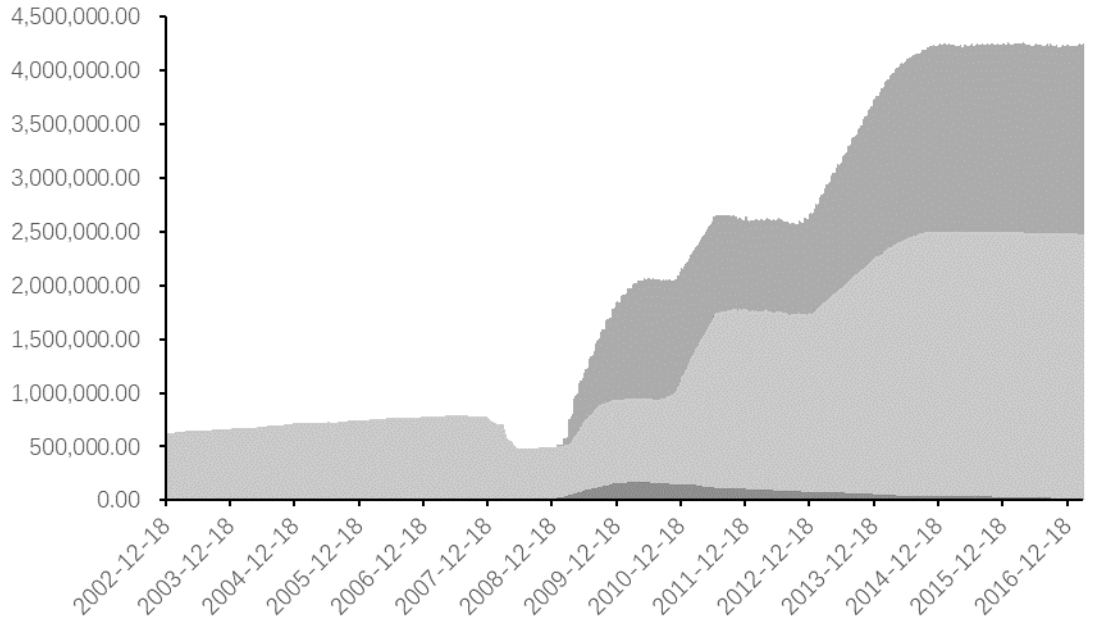


Figure 7 fed funds target rate

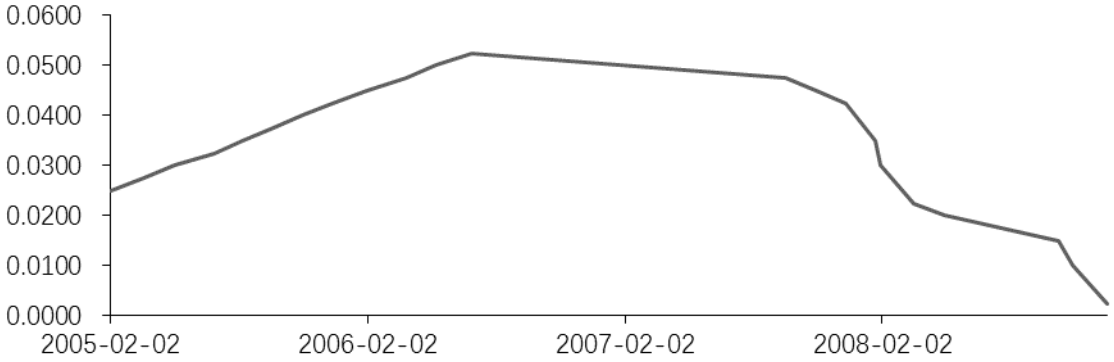


Figure 8 USA CPI before and after the crisis

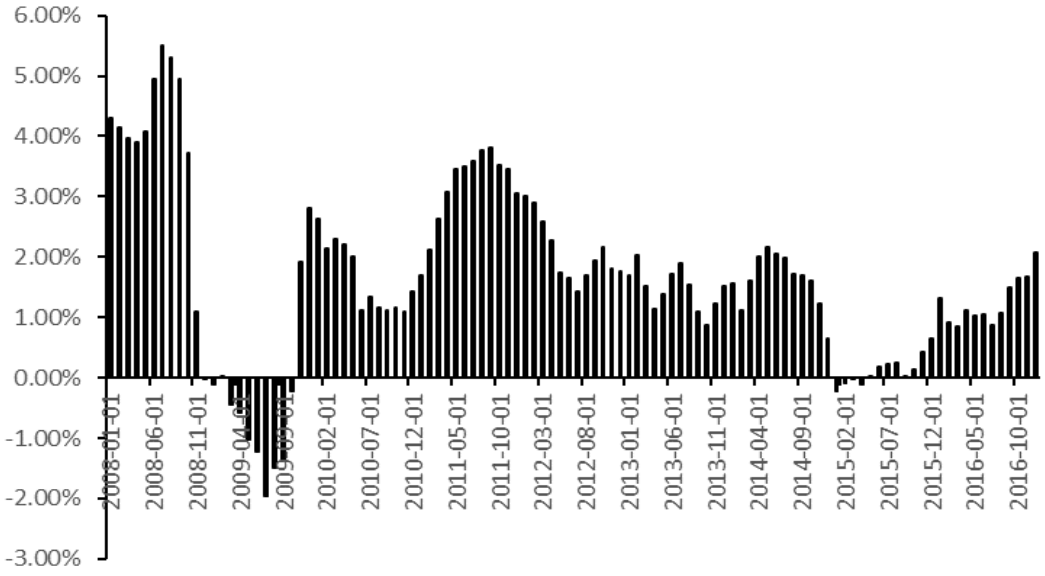
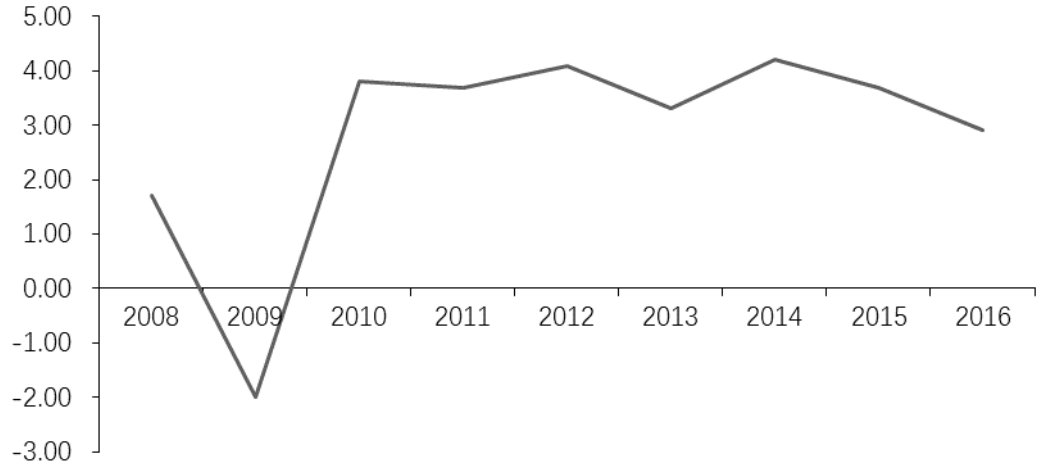


Figure 9 USA GDP growth rate before and after the crisis



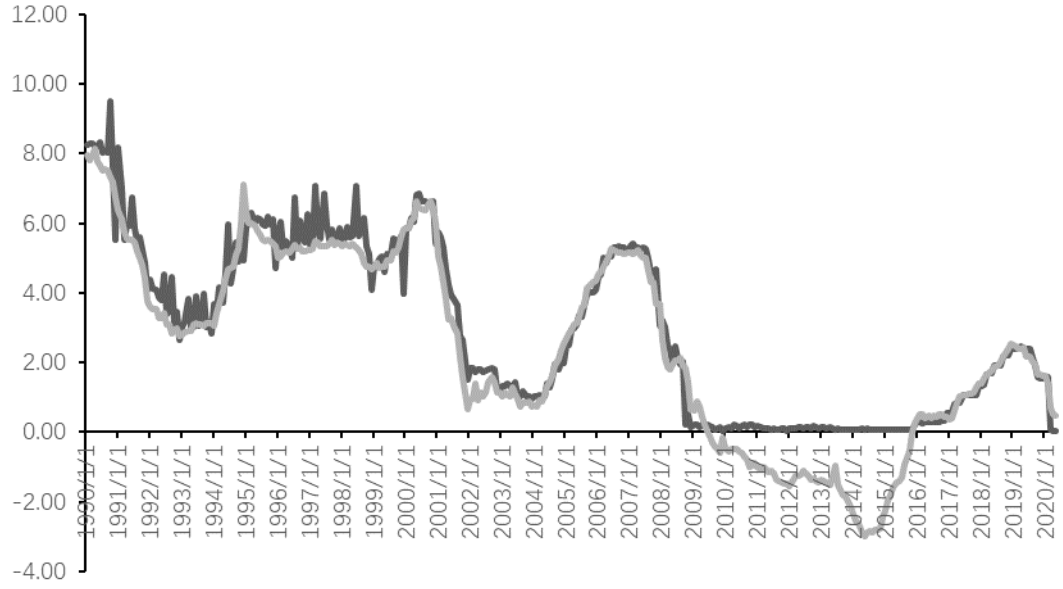
4.4. The reason for choosing Wu-Xia shadow fed funds to work as the proxy of monetary policy after September 2008

Black (1995) proposed the shadow rate term structure model (SRTSM) and argued that there was a shadow interest rate and it was linear in the Gaussian factors. The short term interest rate in the market could be expressed as the maximum value of the lower bound zero and the shadow rate, so it was quite clear that the short term interest rate in the market couldn't be lower than zero and the negative interest rate didn't exist. Based on the foundation of the shadow rate term structure model (SRTSM), which is a one-factor model, Wu and Xia (2016) introduced a multifactor SRTSM, and through the improvement, better approximation could be achieved and the empirical analysis would be more tractable. They calculated the Wu-Xia shadow fed funds rate and showed the relationship between the Wu-Xia shadow fed funds rate and the effective fed funds rate, through the comparison, they found that before the financial crisis, the difference between these two rates is negligible, but when the effective fed funds rate starts to reach the zero lower bound, the difference between these two rates would start to be significant. They believed that when the fed funds rate falls below 25 basis points, the Wu-Xia shadow fed funds rate would turn into the negative territory and we should treat this reaction as the expression of the effect of the large scale asset purchase program carried out by the fed. But when the fed funds rate is above 25 basis points, the Wu-Xia shadow fed funds rate is highly correlated with the effective fed funds rate.

So the Wu-Xia shadow fed funds rate can work as a suitable indicator of the monetary policy from October 2008 to December 2014 in our empirical analysis, by using the Wu-Xia shadow fed funds rate to substitute for the fed funds rate during this period, we would be able to let the indicator of the monetary policy to be changeable again. For example, the Wu-Xia shadow fed funds rate reached -3% in May 2014, and this means that the effect of three rounds of large scale asset purchase program is equal to the effect of lowering the fed funds rate below the zero lower bound by 300 basis points. Also when the fed stopped the large scale asset purchase program, the Wu-Xia shadow fed funds rate rose dramatically by 280 basis points, which would be equal to the effect of raising the fed funds rate. By using the Wu-Xia shadow fed funds rate, the effect of the quantitative easing would be more measurable.

Figure 10 Effective federal funds rate vs Wu-Xia shadow rate

(**black:** effective federal funds rate **grey:** Wu-Xia shadow rate)



4.5. empirical analysis

4.5.1. ADF test on unit root

Firstly, we have to transform the original data (115 variables) in order to make sure they are stationary, and then we run the ADF test on them to check the stationarity.

4.5.2. Extract the principle components and define the lags

According to the definition of the principle components analysis, in practice we usually use it for lowering the dimensionality of the data，and this idea is very important in the FAVAR model.

We use Eviews 10.0 to run the principle components analysis on the non-observable variables (also we can call it the slow variables) and the results are shown as below:

Table 2 Principle components result

Number	Value	Proportion	Cumulative proportion
1	15.130210	0.2564	0.2564
2	4.642209	0.0787	0.3351
3	3.966360	0.0672	0.4024
4	3.167022	0.0537	0.4560
5	2.348443	0.0398	0.4958

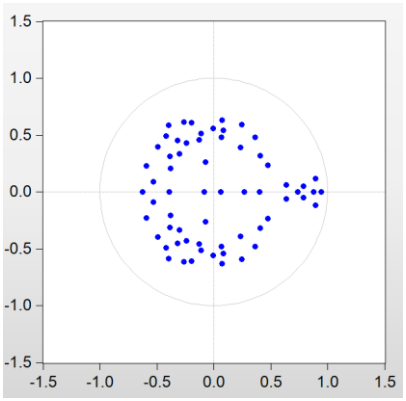
According to the principal components analysis results, the cumulative proportion of the first 5 factors has reached 50%. From Bernanke and Boivin (2005), they concluded that when conducting the two-step FAVAR model, 5 PCAs will generate better result. So we generate 5 principle components from the non-observable variables group, and their name is PC1, PC2, PC3, PC4 and PC5.

After estimating the factor model, we will get $\hat{F}_t$, which doesn't include the effect of the observable variables Y_t, combined with observable variables of interest, we can then construct a VAR model, according to the AIC rules, the lag should be 3.

4.5.3. AR root table test

According to the graph of the inverse roots of AR characteristic polynomial, we can find that all the dots are inside the unit circle, so we can conclude that our VAR model is stable.

Figure 11 Inverse roots of AR characteristic polynomial



4.5.4. Granger causality

We use the Granger causality to test the causality relationship among the policy shock (the fed funds rate or the shadow rate) and variables of interest, and the result is shown below:

Table 3 Granger causality results

Variables	Prob
FFR is not the causality of commercial loans *	0.0030
FFR is not the causality of CPI *	0.0001
FFR is not the causality of durable consumption	0.8602
FFR is not the causality of nonresidential construct	0.2469
FFR is not the causality of inventory	0.7479
FFR is not the causality of monetary base *	0.0039
FFR is not the causality of M2 *	0.0012
FFR is not the causality of non-durable consumption *	0.0747
FFR is not the causality of 10 year treasury bond	0.1885
FFR is not the causality of 3 month treasury bill *	0.0000
FFR is not the causality of unemployment	0.1990
FFR is not the causality of S&P 500	0.4276
FFR is not the causality of PPI	0.4801
FFR is not the causality of IP	0.5512
FFR is not the causality of new orders *	0.0148

From the results of the Granger causality, the changes in the monetary policy shocks are the causes of the changes in commercial loans, CPI, monetary base, M2, non-durable consumption, 3 month treasury bill rate and the new orders.

The proxies of the bank credit channels are more significant and sensitive to the changes in the monetary policy shocks, like commercial loans, monetary base, M2. While the proxies of the enterprise balance sheet channels are not that significant, like inventory and the nonresidential construction spending, but at the same time the impacts on the enterprise income statement proxies like non-durable consumption and new orders are quite significant.

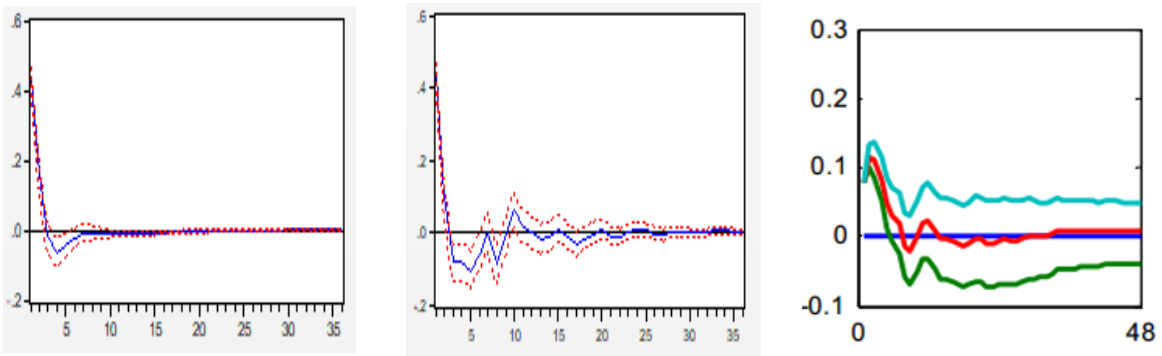
When we look at the traditional factors in Taylor rules, we can find that the changes in the monetary policy shocks are the significant causes of the changes in the CPI, so it is reasonable for the fed to control CPI by using monetary tools like fed funds rate, and it is in accordance with our common sense. At the same time, the changes in the monetary policy shocks are not the significant causes of the changes in the IP, this is in accordance with Ben Bernanke's economic theory. In the long run, the interest rate can't affect the IP growth, the effect of the monetary policy shocks on IP can only exist for a short period of time.

4.5.5. Impulse response function (to the macroeconomic indictors)

(1) impulse response of policy shock to policy shock

Figure 12 impulse response of policy shock to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

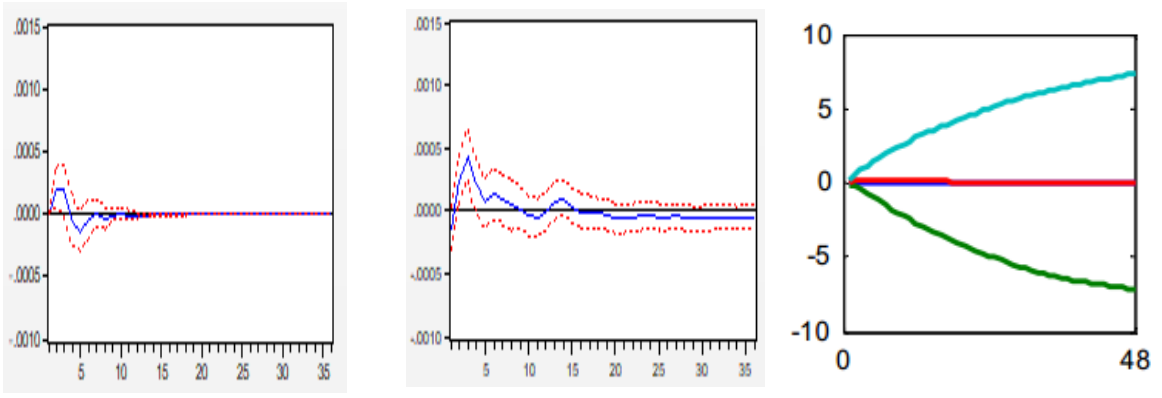


According to the impulse response result of the FAVAR model on the left, the fed funds rate will increase sharply at the beginning of the monetary tightening period, and then fall rapidly, and reach the bottom in the fifth month and then start to rebound until the seventh month when the long-term trend value is reached. The difference between the result on the left and the result in the middle is quite negligible and it is in accordance with the economic theory.

(2) impulse response of CPI to policy shock

Figure 13 impulse response of CPI to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

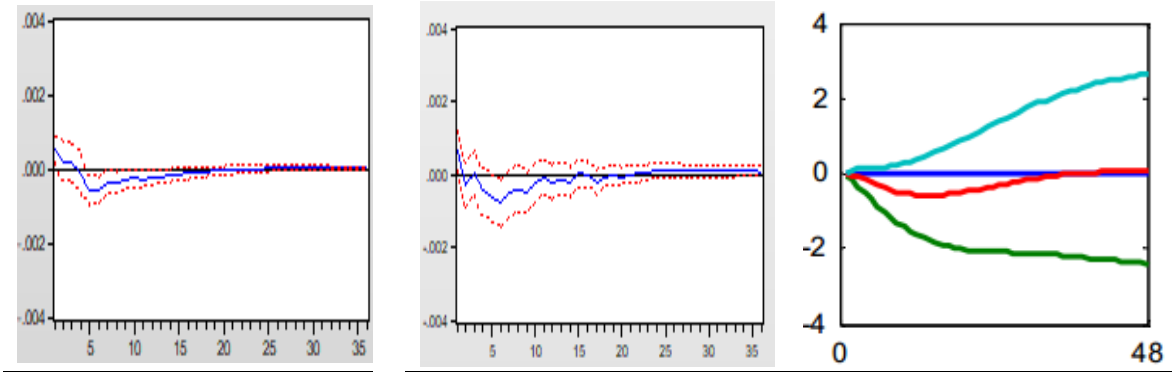


According to the impulse response result of the FAVAR model on the left, the CPI will rise slightly until the second month and then begin to decline, and it will reach the bottom in the fifth month and then start to rebound until the seventh month when the long-term trend value is reached. Compared with the result in the middle, the negative impact of the interest rate increase on CPI is more significant when we include the data from the whole long-term credit circle, and the reason why the CPI still rise slightly at the beginning could be that CPI is a slow indicator and it will react to the short-term shock with time lag. In general, the difference between two results is not very large and the "price puzzle" can still be found.

(3) impulse response of IP to policy shock

Figure 14 impulse response of IP to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

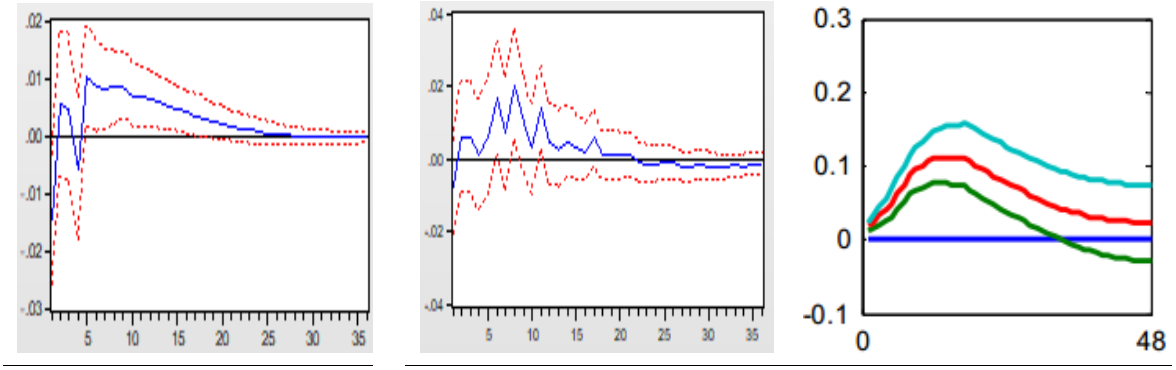


According to the impulse response result of the FAVAR model on the left, the IP will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 22nd month when the long-term trend value is reached. We can also figure out that the negative effect is statistical significant during the period from the fifth month to the 20th month, and it is in accordance with the economic theory that a higher interest rate will depress the economy growth in the short run and the effect will diminish over time. The difference between the result on the left and the result in the middle is quite negligible.

(4) impulse response of unemployment rate to policy shock

Figure 15 impulse response of unemployment rate to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

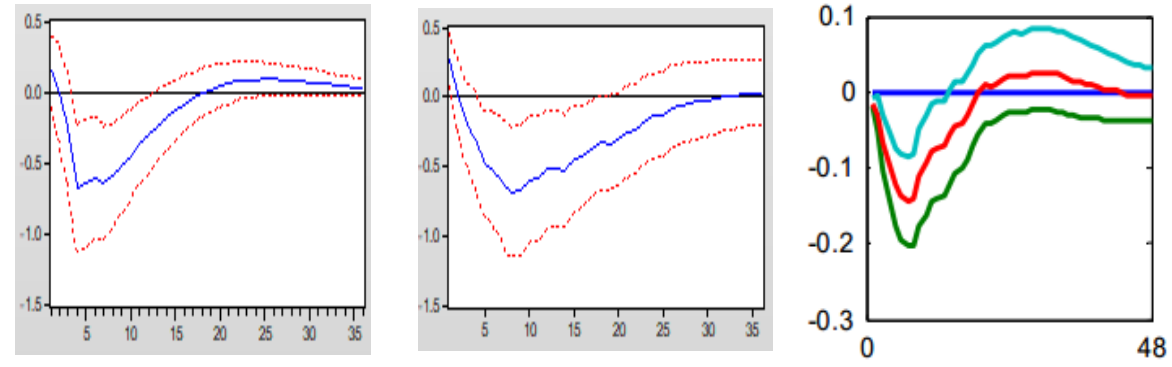


According to the impulse response result of the FAVAR model on the left, the unemployment rate will rise immediately with oscillation until the seventh month when it reaches the top and then start to drop slowly until the 25th month when the long-term trend value is reached. The effect on the unemployment rate is in accordance with the economic theory and the difference between the result on the left and the result in the middle is quite negligible.

(5) impulse response of employment rate to policy shock

Figure 16 impulse response of employment rate to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

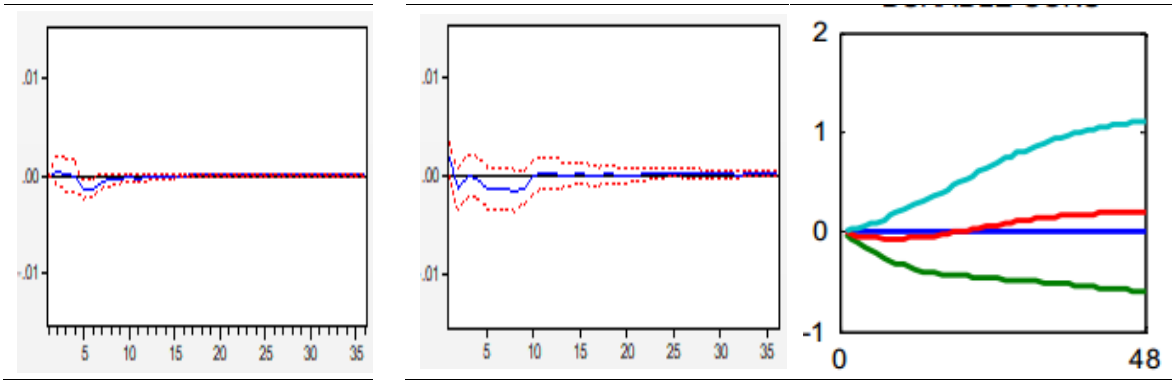


According to the impulse response result of the FAVAR model on the left, the employment rate will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 20th month when the long-term trend value is reached. The effect on the employment rate is in accordance with the economic theory and the difference between the result on the left and the result in the middle is quite negligible.

(6) impulse response of durable consumption to policy shock

Figure 17 impulse response of durable consumption to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

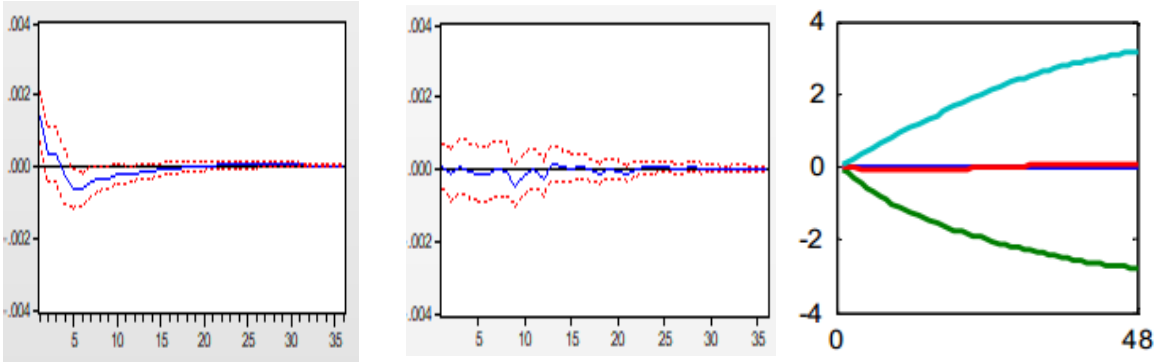


According to the impulse response result of the FAVAR model on the left, the durable goods consumption will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 10th month when the long-term trend value is reached. It is in accordance with the economic theory that a higher interest rate will depress the durable goods consumption. The differen ce between the result on the left and the result in the middle is quite negligible.

(7) impulse response of nondurable consumption to policy shock

Figure 18 impulse response of nondurable consumption to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

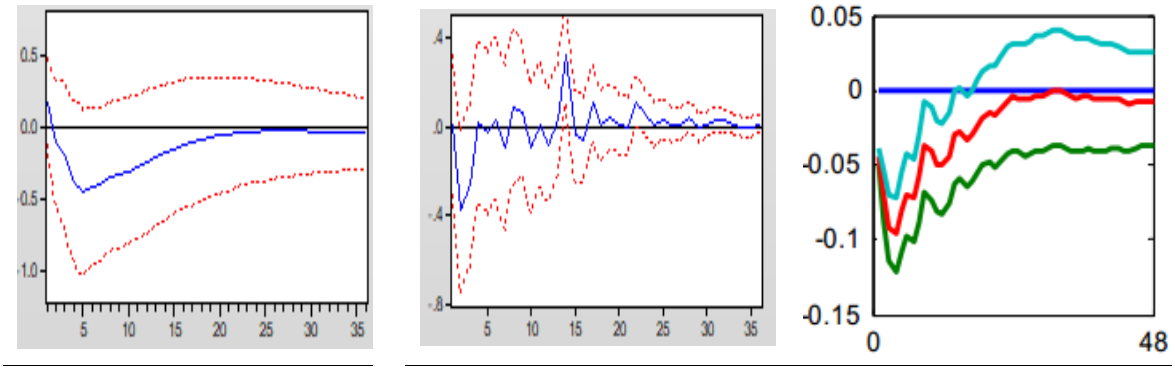


According to the impulse response result of the FAVAR model on the left, the nondurable goods consumption will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 20th month when the long-term trend value is reached, the result is quite similar to that of the durable goods consumption. It is in accordance with the economic theory that a higher interest rate will depress the nondurable goods consumption in the short term. The difference between the result on the left and the result in the middle is quite negligible.

(8) impulse response of consumer expectation to policy shock

Figure 19 impulse response of consumer expectation to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

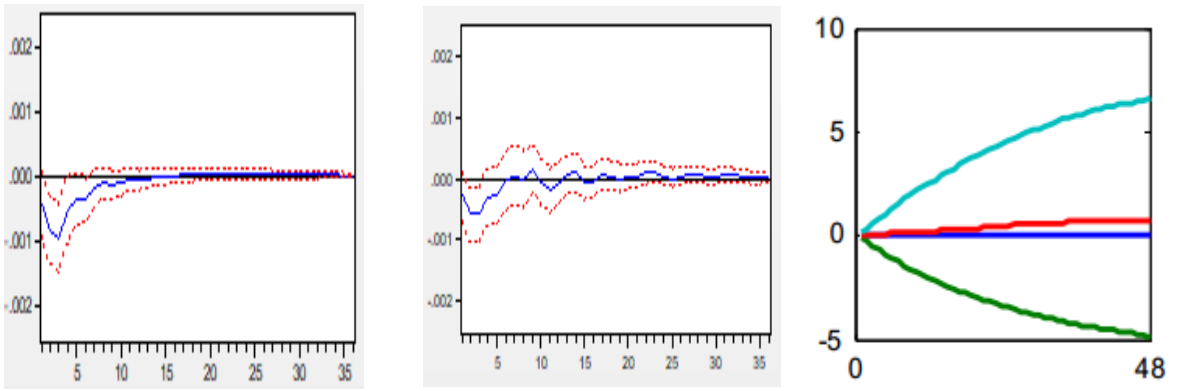


According to the impulse response result of the FAVAR model on the left, the consumer expectation will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 20th month when the long-term trend value is reached, the FAVAR model result on the left is better than the result in the middle in that the negative effect of the monetary policy shocks on the consumer expectation is clearer and more persistent . The result is in accordance with the economic theory that a higher interest rate will depress the consumer expectation for an extended period of time, thus causing the consumption level to decrease accordingly, and finally the decrease in the consumption level would depress the real economy.

(9) impulse response of monetary base to policy shock

Figure 20 impulse response of monetary base to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

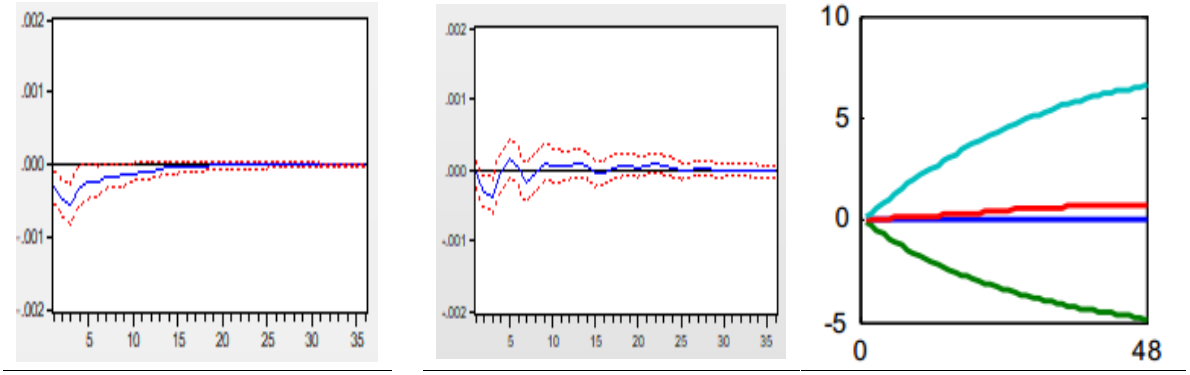


According to the impulse response result of the FAVAR model on the left, the monetary base will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 10th month when the long-term trend value is reached, the negative effect on the monetary base is in accordance with the economic theory. The difference between the result on the left and the result in the middle is quite negligible.

(10) impulse response of M2 to policy shock

Figure 21 impulse response of M2 to policy shock

left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version

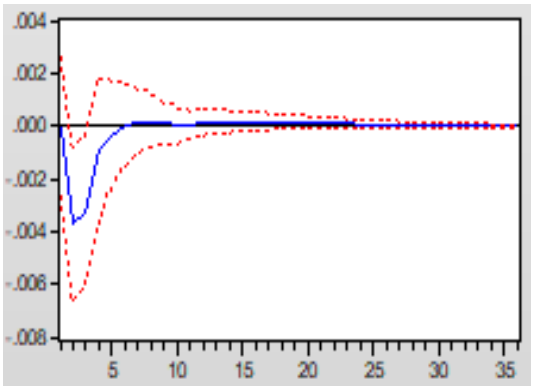


The result of M2 is exactly similar to that of the monetary base and it is in accordance with the economic theory, and the difference between the result on the left and the result in the middle is quite negligible.

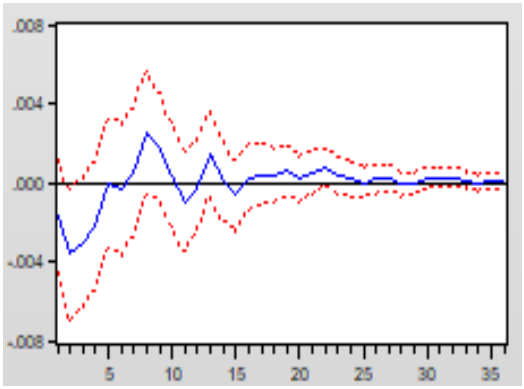
(11) impulse response of S&P500 to policy shock

Figure 22 impulse response of S&P500 to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)

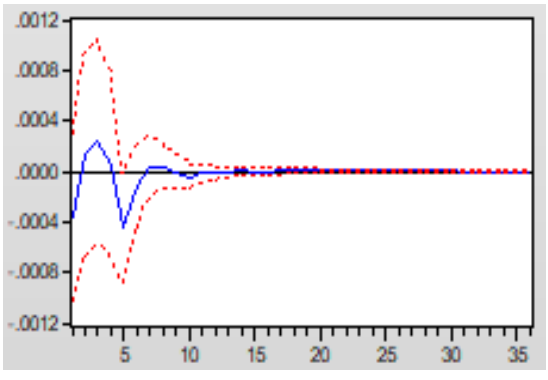


According to the impulse response result of the FAVAR model on the left, the S&P 500 index will drop immediately until the second month when it reaches the bottom and then start to rebound until the seventh month when the long-term trend value is reached, the whole process is short. The negative effect on the stock price is in accordance with the economic theory and it is quite clear that the stock market is efficient, the difference between the two results above is still quite negligible.

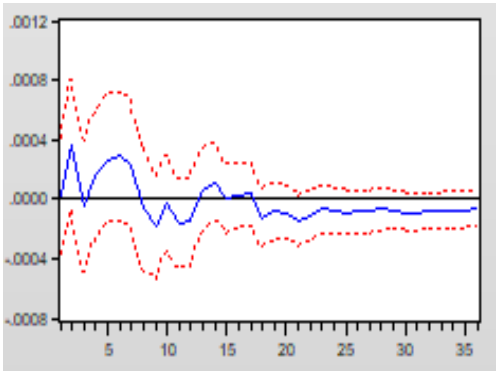
(12) impulse response of PPI to policy shock

Figure 23 impulse response of PPI to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)

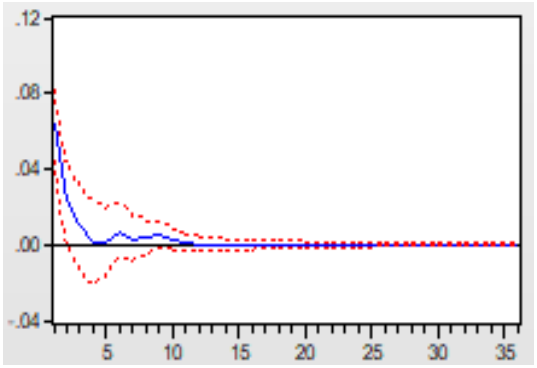


According to the impulse response result of the FAVAR model on the left, the PPI will oscillate mainly in the negative territory until the 10th month when the long-term trend value is reached. The negative effect on PPI is in accordance with the economic theory and the difference between the two results is quite significant as the result on the right side is just the opposite and it can't be explained very well by the economic theory.

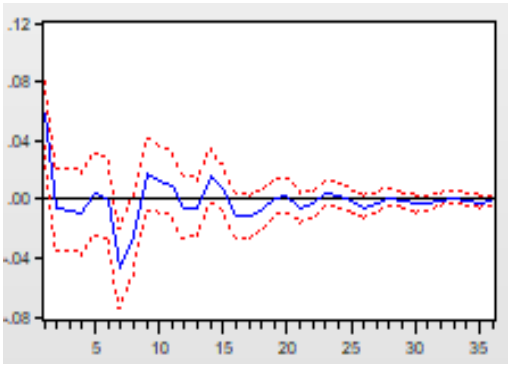
(13) impulse response of 10 year treasury rates to policy shock

Figure 24 impulse response of 10 year treasury rates to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)



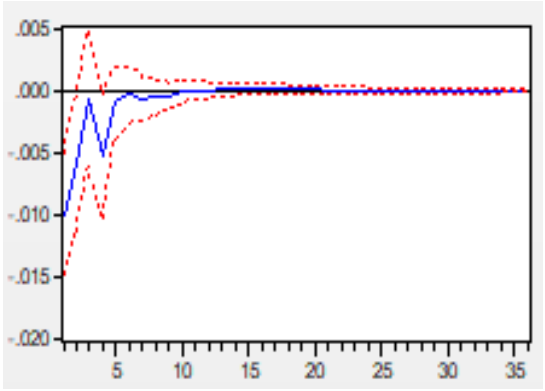
According to the impulse response result of the FAVAR model on the left, the 10 year treasury bond rate will first rise immediately and start to drop until the fifth month when the long-term trend value is reached, the whole process is short. The effect on the treasury bond yield is in accordance with the economic theory and the difference between the two results above is still quite negligible.

4.5.6. Impulse response function (to the balance sheet channel indicators)

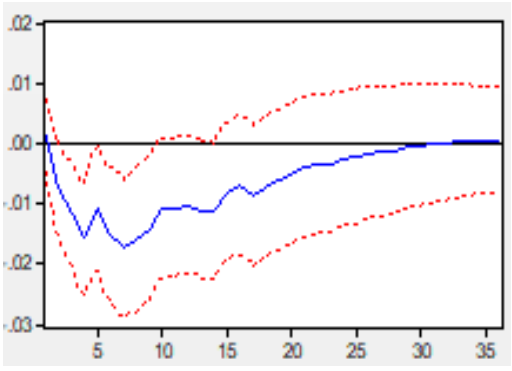
(1) impulse response of nonresidential construction investment to policy shock

Figure 25 impulse response of construction investment to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)



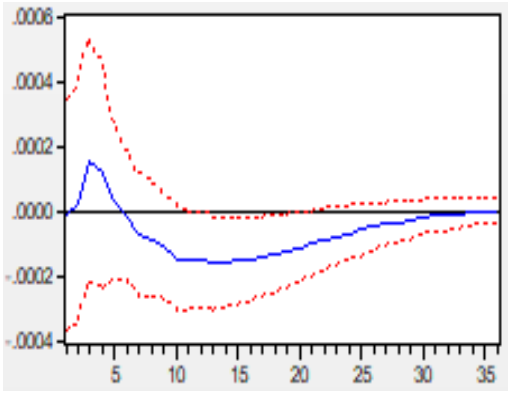
According to the impulse response result of the FAVAR model on the left, the nonresidential construction investment will drop immediately to the bottom at the beginning and then start to rebound slowly until the seventh month when the long-term trend value is reached, the result shows that the nonresidential construction investment is very sensitive to the monetary shocks, we can conclude that the interest rate is very important for enterprises' decision for non-residential construction investment, the reason for this relationship could be that usually the non-residential construction investment is financed by the long-term debt, the increase in the long term debt rate could result in the increase of WACC of the project, thus causing the NPVs of a lot of projects to be lower than 0. Our finding is in accordance with the enterprise

balance sheet channel transmission mechanism theory. Compared with the result on the right side, we can find that the negative shock at the beginning is more significant if we include the data from the whole long-term credit cycle, and the negative effect will last for a shorter period as the enterprise can react accordingly to the negative situation, so we can conclude that the result on the left should be preferred.

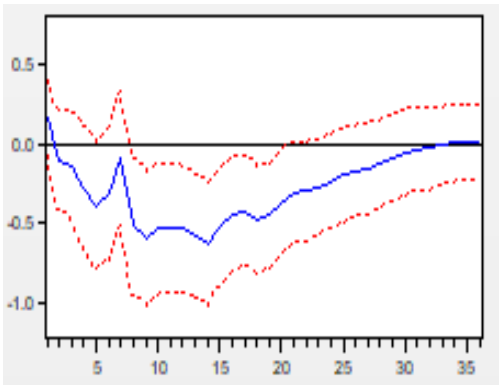
(2) impulse response of inventory to policy shock

Figure 26 impulse response of inventory to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)



According to the impulse response result of the FAVAR model on the left, the inventory index will first rise slightly until the fifth month when it reaches the top and then start to drop until the 15th month when the bottom is reached, and then rebound slowly until the 35th month. The negative effect on the inventory index is slow and persistent.

Usually part of the inventory investment is financed by the cash on balance sheet, unlike the non-residential construction investment, this financing part is interest free from the income statement's perspective and is related to the opportunity costs of the internal funds from the economic perspective, but from both perspectives, the costs related would be much lower than the costs in the external financing.

The enterprise will usually first use these internal funds until they are used up so the enterprise inventory investment will be less sensitive to the interest rate shocks at the beginning because the costs related to the cash on balance sheet is the opportunity costs of internal funds from the economic perspective, but not the costs in external financing. And the enterprise inventory investment will start to be more sensitive to the interest rate shocks when more interest bearing liabilities are needed in later periods. Our finding is in accordance with the enterprise balance sheet channel transmission mechanism theory and the concept of the extra costs in the external financing. Compared with the result on the right side, we can find that if we include the data from the whole long-term credit cycle, the effect of the short-term insensitiveness could be better presented, and this effect is caused by the difference between the opportunity costs of internal funds and the costs in the external financing.

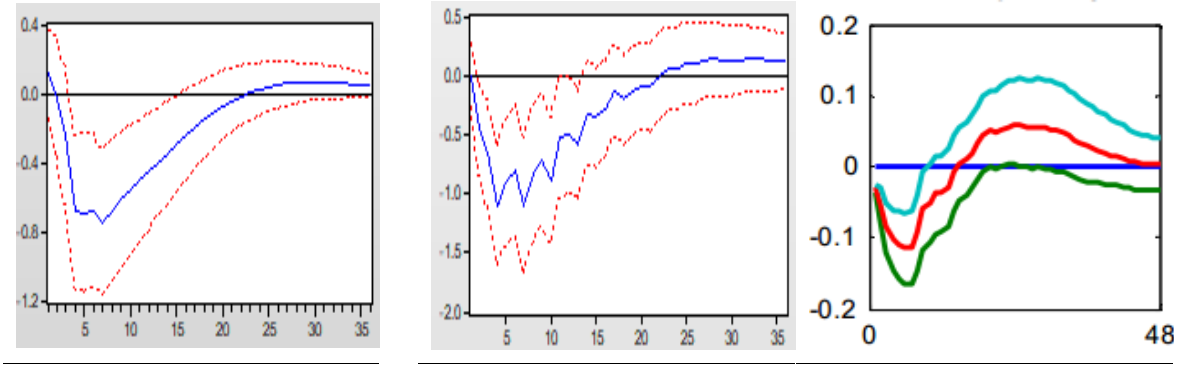
Also the impulse response result of the FAVAR model on the right is quite similar to that of the nonresidential construction spending, the reason could be that the time period from 1959 to 2003 is the debt accumulation phase in the long-term credit cycle. During this period, the overall interest rate level is in the long-term downward trend and the leverage level of the whole economy is increasing, because of the good condition of the credit market, the difference between the opportunity costs of the internal funds and the costs in the external financing is small. A lot of entities would choose to use interest bearing liabilities to support the daily operation as they will be cheaper and cheaper during this stage, thus making even

the inventory investment more sensitive to the interest rate shocks. This phenomenon could be explained by the selection of the data range, and this problem could be solved if we can include the data from the whole long-term credit cycle, not only from the leveraging period.

(3) impulse response of new orders to policy shock

Figure 27 impulse response of new orders to policy shock

Left: FAVAR (1959-2014) middle: FAVAR (1959-2003) right: Bernanke version



According to the impulse response result of the FAVAR model on the left, the new orders will drop immediately until the seventh month when it reaches the bottom and then start to rebound slowly until the 25th month when the long-term trend value is reached, the negative effect on the revenue side of the enterprises is significant and immediate and it is in accordance with the economic theory.

The reason for this significant decrease in new orders could be also explained by the existence of the extra costs in the external financing. The purchase power for the new orders should be made up of cash and credit, the related costs for cash are the opportunity costs of the internal funds and the related costs for credit are the costs in the external financing. Since most of nowadays purchase power is credit, the most related costs should be mainly the costs in the external financing. From the perspective of the financing costs, the new orders variable is quite similar to the non-residential construction investment variable, and the similar costs structure has made their responses to the monetary shocks similar too.

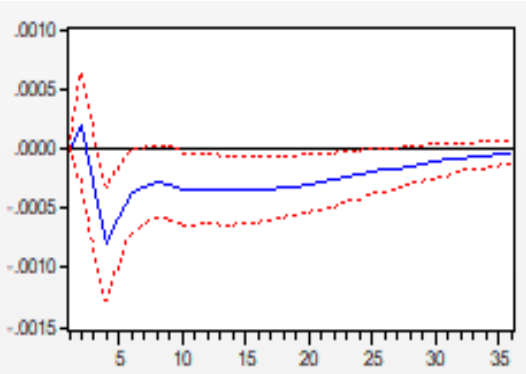
The difference between the result on the left and the result in the middle is quite negligible, so we can also conclude that the balance sheet items are more sensitive to the selection of the data period, but the income statement items are kind of indifferent to the selection of the data period.

4.5.7. Impulse response function (to the bank credit channel indicators)

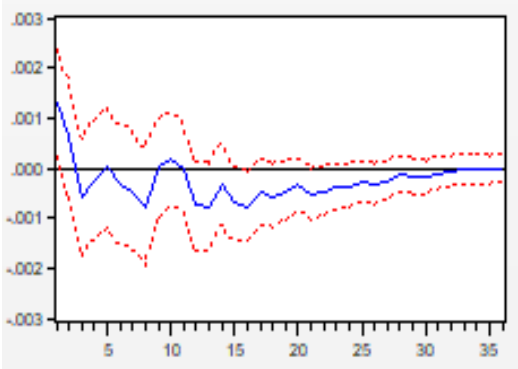
(1) impulse response of commercial loans to policy shock

Figure 28 impulse response of commercial loans to policy shock

left: FAVAR (1959-2014)



right: FAVAR (1959-2003)



According to the impulse response result of the FAVAR model on the left, the commercial loans will drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 40th month when the long-term trend value is reached, the negative effect on the credit is statistically significant and persistent and it is in accordance with the economic theory, when the central bank is conducting a tightening monetary policy, the incremental commercial bank loans will shrink. Compared with the result on the right side, we can find that if we include the data from the whole long-term credit cycle, the negative effect will be more significant, the increase at the beginning on the right side result is hard to explain because when the inter-bank market rate increases, the overall liability cost will increase immediately, and this effect should be transformed to the asset side of the bank and influence new bank loans immediately. Also we can find that the negative effect on the right during the whole process is less statistically significant than the result on the left, so we can conclude that the result on the left should be preferred.

4.5.8. Summary of the empirical analysis result

When we compare the impulse response results of different data ranges, we can find that in general the differences in macroeconomic variables are negligible, so if we only care about the macroeconomic variables' reaction to monetary policy shocks, we don't necessarily have to consider about the long-term credit cycle.

Also from the comparison of the impulse response results, we can conclude that both the enterprise balance sheet channel and the bank credit channel proposed by Ben Bernanke still hold after the expansion of the data input range and the inclusion of the Wu-Xia shadow fed funds rate when the fed funds rate is kept at the zero lower bound, meaning that Ben Bernanke's theory do hold in the long-term credit cycle.

But the differences do exist in the microeconomic variables, especially for the proxy variables for the enterprise balance sheet channel, if we only use the data from the long-term leveraging period and forget about the long-term deleveraging period, we will not figure out the difference between enterprises' inventory investment and the non-residential construction investment. During the long-term leveraging period, the overall leverage level keeps rising, when the leverage growth rate exceeds the revenue growth rate, the entities in the economy

system will start to use the new debts to pay back the old debts and this action would further drive the leverage level to an unsustainable level in the long run, and at this stage, the entities in the economy system would prefer to use debts to support every investment and don't care whether the investment is the inventory investment or the non-residential construction investment, because the long-term downward trend of the interest rate and the good condition of the credit market would make the overall interest rate and the external financing costs cheaper and cheaper. During this stage because of the fact that a lot of entities choose to support even the inventory investment by the interest-bearing liabilities like bonds or bank loans, the costs related in the leveraging stage are mainly the costs in the external financing. This phenomenon would exist during the leveraging period even if it is supposed to be unsustainable in the long run, and at this stage, the whole system would be more sensitive to the extra costs in the external financing.

this financing part is interest free from the income statement's perspective and is related to the opportunity costs of the internal funds from the economic perspective, but from both perspectives, the costs related would be much lower than the costs in the external financing.

During the long-term deleveraging period, when entities finally notice the overall leverage level can't be maintained and the painful deleveraging period can't be avoided, they will cut the non-residential construction investment immediately because the non-residential construction investment can be postponed when the credit environment is not favorable at the moment, and the rising extra costs in the external financing would make a lot of non-residential construction investment projects less attractive through a rising WACC. But they would cut the inventory investment slowly and moderately because the inventory investment is related to the daily operation so that immediate decrease is not possible and usually part of the inventory investment is financed by the cash on the balance sheet, unlike the non-residential construction investment, this financing part is interest free from the income statement's perspective and is related to the opportunity costs of the internal funds from the economic perspective, but from both perspectives, the costs related would be much lower than the costs in the external financing especially during the long-term deleveraging period when the credit market has been seriously deteriorated.

By expanding the data range, we can get a clearer picture on the enterprise balance sheet channel, we can understand better how monetary policy shocks can affect the enterprise inventory investment and non-residential construction investment, how the concept of extra costs in the external financing will make a difference in the enterprises' investment decision. After considering the long-term credit cycle, the enterprise inventory investment and non-residential construction investment do react differently to the monetary policy shocks.

5. Summary

In this paper, the FAVAR model is constructed with 115 sets of economic variables from January 1959 to December 2014, and the unit root test is performed on each set of transformed economic variable to make sure that they would meet the stability requirements of the FAVAR model. Then the two-step principal components analysis method is used to get the estimates of the non-observable economic variables, by combining them with the observable variables of interest, we have constructed a new VAR model. Based on the FAVAR model, we have further conducted the AR root test, Granger causality test and compared the impulse response function results of the FAVAR model using the data that includes both the leveraging period and the deleveraging period with the results of the FAVAR model using the data that only includes the leveraging period. The impulse response function results have been divided into three subgroups: the impulse response function of the macroeconomic indicators, the impulse response function of the enterprise balance sheet channel indicators and the impulse response function of the bank credit channel indicators. Based on the comparison results of different subgroups, we can judge that whether the selection of the data ranges would make a difference in the conclusions of the impulse response function results and whether Ben Bernanke's theory about the credit channel transmission mechanism of monetary policy still holds after expanding the data range. The main conclusions can be shown below:

(1) Generally speaking, from the impulse response function results, both the enterprise balance sheet channel and the bank credit channel proposed by Ben Bernanke still hold after the expansion of the data input range, meaning that Ben Bernanke's theory do hold in the long-term credit cycle. It is in accordance with the conclusions proposed by Bernanke and Gertler (1995), Bernanke and Blinder (1988).

(2) From the comparison of the impulse response results, in general the differences in macroeconomic variables are negligible, but the differences do exist in the microeconomic variables, especially for the impulse response results of the inventory and the nonresidential construction investment to the monetary policy shocks. Before the expansion of the data input range, the enterprise inventory investment and the non-residential construction investment would react similarly to the monetary policy shocks, but after including the data of the deleveraging period, the significant difference would exist.

The reason could be explained by the difference in the related financing resources, the financing costs related to the inventory investment is the opportunity costs of the company's internal funds and the financing costs related to the non-residential construction investment is the costs in the company's external financing. During the leveraging period in the long-term credit cycle, in general, the extra costs in the external financing is not large so that the difference in the costs between the enterprise inventory investment and the non-residential construction investment is also not very large, and because of the over-leveraging nature of the whole economy system during that time, it is very likely that some entities in the system would choose to use the interest bearing liabilities to support the inventory investment and thus making even the inventory investment sensitive to the changes of the extra costs in the external financing. However, during the deleveraging period in the long-term credit cycle, because of the deterioration of the credit markets and the existence of the information asymmetry, the extra costs in the external financing would become no longer negligible and the mismatches between financing resources and the investment would be reduced significantly. Because of the difference in the financing costs and the existence of the information asymmetry in the credit market, the responses of the enterprise inventory investment and the non-residential construction investment to the monetary policy shocks in the long-term credit cycle are different.

The extra costs in the external financing means the difference between the costs in the

company's external financing and the opportunity costs of the company's internal funds. So the difference that we have found through the comparison between the impulse response results of the inventory and the nonresidential construction investment to the monetary policy shocks could work as a sound evidence of the existence of the extra costs in the external financing, and it is in accordance with Bernanke, Gertler and Gilchrist (1994), the frictions and the existence of the information asymmetry in the financial market can cause the difference in the financing costs related to the enterprise inventory investment and non-residential construction investment in the long-term credit cycle, and the existence of the extra costs in the external financing would be more significant during the deleveraging period.

(3) During the deleveraging period in the long-term credit cycle, the Wu-Xia shadow fed funds rate can work as a suitable indicator of the monetary policy so that we would be able to let the indicator of the monetary policy to be changeable again. In our FAVAR model, the effect of three rounds of large scale asset purchase program is equal to the effect of lowering the fed funds rate below the zero lower bound by 300 basis points, the effect of monetizing the debt and the effect of lowering the fed funds rate could be treated as interchangeable. By using the Wu-Xia shadow fed funds rate, the effect of the quantitative easing would be more measurable and the FAVAR model can work again even in the zero interest rate environment.

6. Potential for further improvements

In this paper we have already showed that through the Wu-Xia shadow fed funds rate, the interest rate decreasing effect of the large scale asset purchase program can be represented, and by using the Wu-Xia shadow fed funds rate to work as the proxy of the monetary policy shocks during the after crisis period, we have proved that Ben Bernanke's theory still holds in the long-term credit cycle through the FAVAR model. But an important pre-assumption here is that the country should be able to monetize its debt through the large scale asset purchase program, but this pre-assumption won't hold for all the countries, for example Brazil, Turkey and other countries whose debts are not denominated in its own currency. In these cases, the central bank won't be able to print its domestic currency to purchase the financial assets denominated by another country's currency. Also unlike the situation of deflation in US during the financial crisis, when debts are not denominated in its own currency, the country in trouble would face the pressure of high inflation and capital outflow, and both of these problems will be even worse if the central bank decides to lower the interest rate, and usually these financial crisis would lead to a significant domestic currency depreciation and high inflation.

According to Bernanke, Gertler and Gilchrist (1994), the uncontrollable depreciation of the domestic currency would lead to a certain degree of indirect transfer of the domestic wealth from the domestic debtors to the foreign creditors due to the fact that domestic debt is denominated in foreign currencies. According to the above theoretical views, we can conclude that the collapse of a country's domestic currency would cause the real economy to contract and further cause the economic recession.

So for these countries whose debts are not denominated in its own currency, whether credit channel monetary policy transmission mechanism theory proposed by Ben Bernanke still holds in the long-term credit cycle and what is the appropriate proxy for the monetary policy shocks during the financial crisis could be the interesting topic for further research.

Part 2: Comparison between the FAVAR Model and the VAR model when Testing the Credit Channel Monetary Policy Transmission Mechanism

Abstract

The main shortage of the traditional VAR model introduced by Sims(1980) is that the model can only contain too few variables, thus causing the problem of the lack of necessary economic information in the traditional VAR model. Since the number of economic variables that the monetary policy makers working at the federal funds need to consider when they are formulating the monetary policy is extremely large, Bernanke and Boivin(2005) proposed the FAVAR model to solve the shortcomings of the traditional VAR model, with the inclusion of more necessary economic information, the impulse response results of the FAVAR would provide more useful and correct guidance to the monetary policy makers.

In this paper, based on the FAVAR model created by Ben Bernanke, 115 groups of economic variables' data from January 1959 to December 2014 were selected for the empirical analysis. From January 1959 to August 2008, the fed funds rate was used to work as the indicator of the monetary policy. From September 2008 to December 2014, since the fed funds rate was kept unchanged at the zero lower bound, the Wu-Xia shadow fed funds rate was used to substitute for the fed funds rate so as to let the indicator of the monetary policy to be changeable again.

Based on the comparison of the impulse response results, we can conclude that compare with the traditional VAR model, the FAVAR model is a more efficient and stable model. And the FAVAR model is very useful in providing the guidance when the fed is deciding the monetary policy. By including more variables into the FAVAR with the help of the two-step principal components analysis method, the FAVAR can include the information about the frictions of the credit market and the existence of the information asymmetry in the financial market.

When it comes to the enterprise balance sheet channel indicators, the traditional VAR model can prove the existence of the extra costs in the external financing. Since the financing costs related to the inventory investment are the opportunity costs of the company's internal funds and the financing costs related to the non-residential construction investment are the costs in the external financing, they would react differently to the monetary policy shocks because of the differences in the related financing costs. But when it comes to the bank credit channel indicators, because of the lack of information, through the impulse response result, the traditional VAR model would give the indication that a tightening monetary policy shock would have a positive effect on the commercial loans, and we can conclude that this is totally wrong since it is not in accordance with the economic theory and the reality. However, the FAVAR model can solve this problem quite well and the negative effect of the monetary policy shock on the commercial loans can be presented through the impulse response function result.

Based on the current macroeconomic situation of the United States and Bernanke's related theory of monetary policy transmission mechanism, we would discuss the problem of using the large scale asset purchase program as the main monetary policy tool and give our policy recommendation to the policy maker: the collaboration between the monetary policy and the fiscal policy should be considered in the next recession when the traditional interest rate tools and the quantitative easing tools are less effective.

Key Words： Monetary policy transmission mechanism, enterprise balance sheet channel, bank credit channel, FAVAR model, VAR model

1. Introduction

1.1. Purpose

The traditional VAR model introduced by Sims(1980) can only contain too few variables. Since the number of economic variables that the monetary policy makers working at the federal funds need to consider when they are formulating the monetary policy is extremely large, Bernanke and Boivin(2005) proposed the FAVAR model to solve the shortcomings of the traditional VAR model, and for three variables (FFR, CPI and IP), they compared the impulse response function results of the FAVAR model and the traditional VAR model, and concluded that the results of the FAVAR model were superior.

Based on the comparison results from Bernanke and Boivin(2005), it is an interesting topic to see whether for other variables of interest (such as unemployment rate, PPI, monetary base, M2 and so on), the FAVAR model would still generate superior results. Also the data range included in Bernanke and Boivin(2005) was from January 1959 to August 2001, and from the perspective of the long-term credit cycle, only the data during the leveraging period was included. We would like to further improve the empirical model by expanding the data range and see whether the FAVAR model is still the superior model.

Bernanke and Gertler (1995) pointed out that the credit channel transmission mechanism could be divided into two channels, bank credit channel and enterprise balance sheet channel. Also they showed the dynamic changes of related variables due to the monetary policy shocks through the impulse response function of the traditional VAR model. Bernanke and Boivin(2005) only showed the impulse response function results of the macroeconomic variables through the FAVAR model and the results of the enterprise balance sheet channel indicators and the bank credit channel indicators are not included. However, it is interesting to see the comparison of the impulse response function results between the FAVAR model and the traditional VAR model for the enterprise balance sheet channel indicators and the bank credit channel indicators, and this contribution can work as an improvement to Bernanke and Gertler (1995) where only the VAR model results were included for the enterprise balance sheet channel indicators and the bank credit channel indicators.

The empirical model used in this part is the two-step principal components FAVAR model proposed by Bernanke and Boivin(2005), and the theoretical foundation is the credit channel monetary policy transmission mechanism theory. The time period of the data would be from 1959 January to 2014 December and 115 sets of economic variables would be included in the FAVAR model.

Through the comparison of the impulse response function results between the FAVAR model and the traditional VAR model, we can test if the use the FAVAR model would make an improvement in testing the credit channel monetary policy transmission mechanism theory proposed by Ben Bernanke.

Furthermore, we should not only care about the macroeconomic indicators, but also care about the enterprise balance sheet channel indicators and the bank credit channel indicators. By dividing the impulse response function results into three subgroups (the impulse response function results of the macroeconomic indicators, the impulse response function results of the enterprise balance sheet channel indicators and the impulse response function results of the bank credit channel indicators), we would further know in which specific area would the improvement made by the FAVAR model be the most significant.

Also we want to test if the traditional VAR model alone can make the indication correctly and how could the improvement made by the FAVAR model be explained based on the theoretical foundation proposed by Ben Bernanke.

1.2. Contribution

(1) The traditional VAR model is not able to include many variables, and this shortage has made the VAR model not very relevant to the actual situation when the fed is deciding the monetary policy. In this paper, the FAVAR model was used to solve the problem of the traditional VAR model.

By making the comparison of the impulse response function results between the FAVAR model and the traditional VAR model, we can conclude that with the inclusion of much richer economic information, the FAVAR model is in general a more efficient model with much fewer meaningless volatilities and the indication made by the FAVAR model would be more in accordance with the reality.

The reason of the difference of the impulse response function results between the FAVAR model and the traditional VAR model could be explained by the frictions of the credit market and the existence of the information asymmetry in the financial market. Because of the limitation of the number of variables, information about the frictions of the credit market and the existence of the information asymmetry can't be included in the traditional VAR model, and the incompleteness of the empirical model would make incorrect indication through the impulse response function results.

(2) Bernanke (2005) mainly focused on testing and comparing the impulse response function results of the macroeconomic indicators, while in this paper, the impulse response function results of the enterprise balance sheet channel indicators and the bank credit channel indicators have been shown in the form of comparison between the FAVAR model and the traditional VAR model. Also we have expanded the data range so as to include both the leveraging period and the deleveraging period in the long-term credit cycle.

From the impulse response function results of the enterprise balance sheet channel indicators, we can conclude that on one hand, the FAVAR model is a better model in making the indication for the enterprise balance sheet channel indicators such as the inventory, the non-residential construction investment and the new orders. On the other hand, even if we only use the traditional VAR model, the existence of the extra costs in the external financing could still be proved from the impulse response function results just like what I have done in the part 1 chapter 4.

From the impulse response function results of the bank credit channel indicators, for the commercial loans, the indication made by the traditional VAR model would not be in accordance with the reality at all since the traditional VAR model can't include information about the frictions of the credit market and the existence of the information asymmetry in the empirical model. In contrast, with the help of the two-step principal components analysis method, the indication made by the FAVAR model would be in accordance with the reality and the bank credit channel monetary policy transmission mechanism theory.

(3) Bernanke (2005) included the economic variables from January 1959 to August 2001, since during that period the fed funds rate has never approached the zero lower bound for an extended period of time, the single indicator of the fed funds rate can work as the suitable indicator of the monetary policy.

In this paper, the time period of the economic variables would be from 1959 January to 2014 December, and it includes the period from October 2008 to December 2014 when the traditional indicator fed funds rate is kept at the zero lower bound and become no longer changeable. During this after crisis period, this paper uses the Wu-Xia shadow fed funds rate to substitute for the fed funds rate so as to let the indicator of the monetary policy to be

changeable again and make the monetary policy effect of three rounds of large scale asset purchase program more measurable. And during the time period from 1959 January to September 2008, the fed funds rate is still used to work as the indicator of the monetary policy shocks. In general, the series of the monetary policy shock used in the empirical model is the combined variable made up of two parts.

By using the combined variable to work as the indicator of the monetary policy shocks, we could get the conclusion that the credit channel transmission mechanism still holds in the long-term credit cycle and the FAVAR model is still a better model when the adjustment on the indicator of the monetary policy shocks has been made.

1.3. Outline

The part 2 is mainly divided into five sections:

The first section is an introduction section that includes the purpose and the main contributions of this paper.

The second section is a brief review of the Wu-Xia shadow fed funds rate and the economic theory of the credit channel transmission mechanism, which includes two subchannels: the enterprise balance sheet channel and the bank credit channel.

The third section is a brief introduction about the FAVAR model.

The fourth section is the empirical analysis section, we use 115 sets of economic variables from 1959 January to 2014 December, and construct the FAVAR model through the two-step principal components method.

Through the comparison of the impulse response function results between the FAVAR model and the traditional VAR model, we can test if the FAVAR model is a better model in testing the credit channel monetary policy transmission mechanism theory and if through the impulse response function results, the FAVAR model could provide the indication that is more in accordance with the reality.

The fifth section is the summary and the policy recommendations section, based on the empirical analysis results of the FAVAR model, combined with the current economic situation, we can provide reasonable recommendations to the policy makers in the near future.

2. Literature review for credit channel monetary policy transmission mechanism & the Wu-Xia shadow fed funds rate

2.1. Review of credit channel transmission mechanism

Bernanke (1983), Bernanke and James (1991), Bernanke and Lown (1992) re-focused on the impact of credit market conditions on the macroeconomics, the debt burden of domestic companies and the banking system. Bernanke and Blinder (1988), Bernanke and Gertler (1995) introduced the concept of the credit channel transmission mechanism based on the theory of the information asymmetry, and pointed out that the direct impact of the monetary policy on the interest rates is amplified by the extra costs in the external financing. The traditional cost of capital theory ignored the change of the extra costs in the external financing. Because of the existence of the extra costs in the external financing, the impact of the monetary policy on the real expenditures and the real economy would be amplified. The extra costs in the external financing means the difference between the costs in the external financing and the opportunity costs of the company's internal funds.

Bernanke and Gertler (1995) pointed out that the credit channel transmission mechanism could be divided into two channels, bank credit channel and enterprise balance sheet channel. And the brief transmission mechanism can be shown below:

The bank credit channel:

Fed funds rate decreases $\Longrightarrow$ Money supply increases $\Longrightarrow$ Loanable funds increase $\Longrightarrow$ Market interest rate decreases, the extra costs in external financing decrease $\Longrightarrow$ The loans to the enterprises increase, the production investments increase $\Longrightarrow$ Overall outputs increase

The enterprise balance sheet channel:

Fed funds rate decreases $\Longrightarrow$ Interest expenses decrease , collateral value increases $\Longrightarrow$ Borrower net asset value increases, the extra costs in external financing decrease $\Longrightarrow$ The loans to the enterprises increase, the production investments increase $\Longrightarrow$ Overall outputs increase

2.2. Review of the Wu-Xia shadow fed funds rate

Black (1995) proposed the shadow rate term structure model (SRTSM) and argued that there was a shadow interest rate and it was linear in the Gaussian factors. The short term interest rate in the market could be expressed as the maximum value of the lower bound zero and the shadow rate, so it was quite clear that the short term interest rate in the market couldn't be lower than zero and the negative interest rate didn't exist.

Based on the foundation of the shadow rate term structure model (SRTSM) proposed by Black (1995), which is a one-factor model, Wu and Xia (2016) introduced a multifactor SRTSM. They calculated the Wu-Xia shadow fed funds rate and showed the relationship between the Wu-Xia shadow fed funds rate and the effective fed funds rate. When the fed funds rate falls below 25 basis points, the Wu-Xia shadow fed funds rate would turn into the negative territory and we should treat this reaction as the expression of the effect of the large scale asset purchase program carried out by the fed. So the Wu-Xia shadow fed funds rate can work as a suitable indicator of the monetary policy from October 2008 to December 2014 when the traditional indicator fed funds rate is kept at the zero lower bound. By using the Wu-Xia shadow fed funds rate, the effect of the quantitative easing would be more measurable.

3. FAVAR model description

Based on the dynamic factor model proposed by Stock and Watson (2002) and the VAR model proposed by Sims (1980), Bernanke and Boivin (2005) combined the factor analysis method with the traditional standard VAR model and established the FAVAR model, thereby solving the standard VAR model's shortcomings of being only able to contain too few economic variables. Also the FAVAR model would be more relevant to the actual situation when the fed is deciding the monetary policy and the FAVAR model is better than the standard VAR model in describing the transmission mechanism of the central bank's monetary policy.

In FAVAR model， firstly we need to identify an (M×1) matrix Y_t to represent the observable economic variables, at the same time, we need to identify a (K×1) matrix F_t to represent the non-observable economic variables. Basically, F_t is used to represent the economic variables that are not included in Y_t, but they are still important in our empirical model.

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

In the equation (1), B(L) represents the polynomial with lag p, ε_t represents the error term with mean of 0 and covariance matrix of Q. The above equation (1) looks exactly like the model proposed by Sims in 1980, but the difference is that here F_t is the non-observable economic variables, so the whole equation can't be estimated directly. To estimate the matrix F_t,we can now introduce an (N×1) matrix X_t to represent the overall group of the economic variables, and N is the number of economic variables in the matrix X_t, and it should fulfill the requirement that N≫K+M, now we also suppose X_t can be linearly expressed by the observable variables Y_t (M×1) and the non-observable variables F_t (K×1), then we can get the equation (2).

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

In the equation (2), the Λ^f is the (N×K) factor loading matrix, Λ^y is the (N×M) factor loading matrix, ε_t represents the error term with mean of 0 and covariance matrix of Q. This equation (2) is the standard orthogonal factor model, and now we can use $\widehat{F}_t$ to estimate F_t, and we replace F_t by $\hat{F}_t$ in the equation (1) to realize the combination between the traditional VAR model and the factor model.

We will estimate $\hat{F}_t$ by using two-step principle components analysis, the principle components analysis method was introduced by Hotelling (1936). It is a multivariate statistical method used to discover the correlation between multiple variables, and it can fully reflect the idea of dimensionality reduction. By extracting a few main components from a large number of original variables, the internal structure between the original variables can be revealed and the original data information can be maintained.

The reason for selecting the two-step principal component analysis in this paper is that based on the dynamic factor model proposed by Stock and Watson (2002), Bernanke and Boivin (2005) use the two-step principal component analysis method, Gibbs sampling method and iterative method to extract the factors of the FAVAR model, Boivin (2009) used the Gibbs sampling method to test the effectiveness of the monetary policy, Gupta, Marius and Kabundi (2010) found that the effect of Gibbs sampling is the poorest, and Hwang (2009) proved that the two-step principal component analysis method is the best, so this paper will choose to use

the two-step principal component analysis method for factors extraction.

In the two-step principal component analysis, firstly we can divide the (N×1) matrix X_t into two subgroups, the "fast variables" and the "slow variables", the "fast variables" are the economic variables that can react immediately to the monetary policy shocks, such as the interest rates, stock prices, monetary base, commercial loans and so on. The "slow variables" are the economic variables that react slowly to the monetary policy shocks, or we can say they are the "sticky" variables, such as IP, employment, CPI and so on. The "fast variables" can be observable and most "slow variables" belong to the group of non-observable economic variables, and then we can use the principle components analysis method to get its estimate $\hat{F}_t^S$, and later on, we can also conduct the principle components analysis on X_t, $C_t=(F_t, Y_t)$, we can extract (K+M) principle components from X_t and get the new information group $\hat{C}_t$, and then we will get the equation(3).

$$\hat{C}_t = b^f \hat{F}_t^S + b^y Y_t + e_t \quad (3)$$

In equation(3), we can get the new estimate of the non-observable economic variables, and it is $\hat{C}_t$ - $b^y Y_t$, and now the estimate of the non-observable economic variables is free from the information of Y_t , and it is the pure estimate of the non-observable economic variables. So now we can put the new $\hat{F}_t$ and Y_t into the equation(1), and then we will get the model of equation(4).

$$\Gamma(L)\begin{bmatrix}\hat{F}_t \\ Y_t\end{bmatrix} = v_t \quad (4)$$

$\Gamma(L)$ is the polynomial with lag equal to q, v_t represents the error term with mean of 0 and covariance matrix of Q, then we will further get the impulse response function between $\hat{F}_t$ and Y_t.

$$\begin{bmatrix}\hat{F}_t \\ Y_t\end{bmatrix} = \psi(L)v_t \quad (5)$$

$\Psi(L)$ is the polynomial with lag equal to r, and it fulfill the requirement that $\Psi(L) = \Gamma(L)^{-1}$, Combined with the equation (2), we will get the impulse response function (6).

$$\hat{X}_t' = \begin{bmatrix}\hat{\Lambda}^f & \hat{\Lambda}^y\end{bmatrix}\begin{bmatrix}\hat{F}_t' \\ \hat{Y}_t'\end{bmatrix} = \begin{bmatrix}\hat{\Lambda}^f & \hat{\Lambda}^y\end{bmatrix}\psi(L)v_t' \quad (6)$$

Now the FAVAR model has been constructed, and it is the model that we are going to use in our empirical analysis.

4. Effectiveness test of the credit channels of the monetary policy—comparison between FAVAR & VAR model

4.1. Selection of economic variables

Based on the economic variables selected by Bernanke and Boivin (2005), and after considering the completeness and the availability of data, we choose the monthly data of 115 variables from 1959 January to 2014 December, and these variables can be divided into 12 groups shown in the appendix. The fed funds rate would be used as the proxy of the monetary policy shocks from 1959 January to 2008 September, and the Wu-Xia shadow fed funds rate would be used as the proxy of the monetary policy shocks from 2008 October to 2014 December so as to let the proxy of the monetary policy shocks to be changeable again.

4.2. Empirical analysis(comparison between FAVAR & VAR model)

Just like the classification method at the part 1 chapter 4, the comparison of the impulse response function results would be divided into three subgroups: the impulse response function results of the macroeconomic indicators, the impulse response function results of the enterprise balance sheet channel indicators and the impulse response function results of the bank credit channel indicators.

For the subgroup of the enterprise balance sheet channel indicators, two variables: the inventory and the non-residential construction investment would be of great importance. While for the subgroup of the bank credit channel indicators, the commercial loans would be of great importance.

Furthermore, the inventory index could be extended further in its economic meaning through the following simplified calculation formula to work as a suitable indicator of the enterprises' working capital investment.

By definition the enterprise working capital is the amount of highly liquid capital that the enterprise can readily use for the daily operations. The calculation formula is: Working capital = Current assets (excluding the excess cash and the cash equivalents) – Current liabilities (including the current portion of the long-term liabilities), and in order to ignore the disturbance from the enterprise specific items, we can simplify the calculation formula to be: Working capital = Account receivables + Inventory – Account payable. Furthermore, the account receivable can be viewed as the enterprise's financing service to its customer and the account payable can be viewed as the enterprise's financing resources from its supplier. From the macroeconomic point of view, since one party's account receivable is another party's account payable, suppose we don't care about the international trade, and the account receivable and the account payable in the whole country can offset each other in one economy system, so if we want to test the dynamics of the overall working capital investment changes to the shocks of the monetary policy, the inventory index would be the most suitable indicator of the enterprises' working capital investment from the macroeconomic point of view.

4.2.1. Impulse response function (to the macroeconomic indictors)

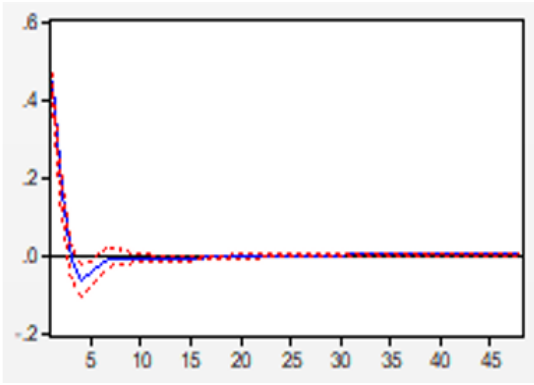
In this section, 11 groups of macroeconomics variables are selected, and these variables are the most common variables that the policy makers and the financial market participants care about. Among them, five variables (monetary policy shock, S&P 500, 10 year treasury rates, monetary base and M2) are the so called "fast variables" that are supposed to react quickly enough to the monetary policy shocks, while the other six variables are the so called "slow variables" that are supposed to react slowly to the monetary policy shocks and the effect of the monetary policy shocks on these so called "slow variables" would be considered as more persistent.

The comparison of impulse response results between the FAVAR model and the VAR model can be shown below:

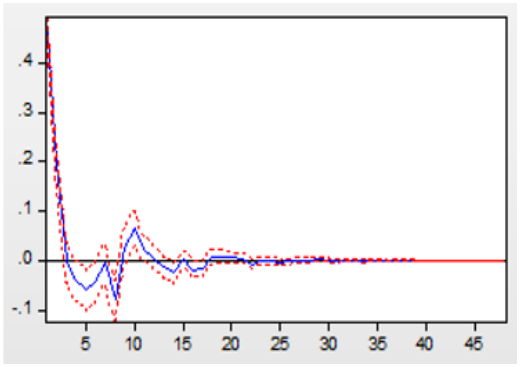
(1) impulse response of policy shock to policy shock

Figure 1 impulse response of policy shock to policy shock

left: FAVAR (1959-2014)



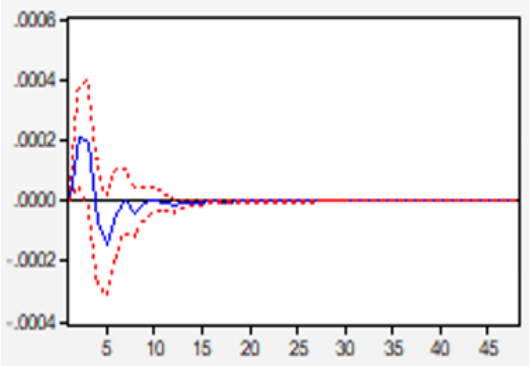
right: VAR (1959-2014)



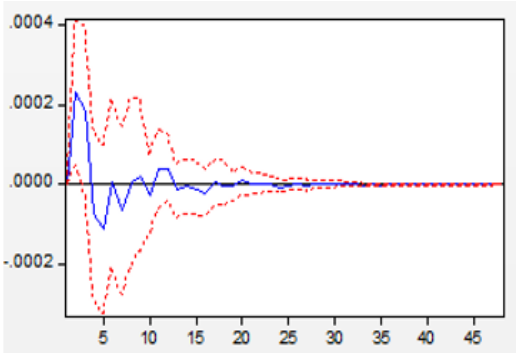
(2) impulse response of CPI to policy shock

Figure 2 impulse response of CPI to policy shock

left: FAVAR (1959-2014)



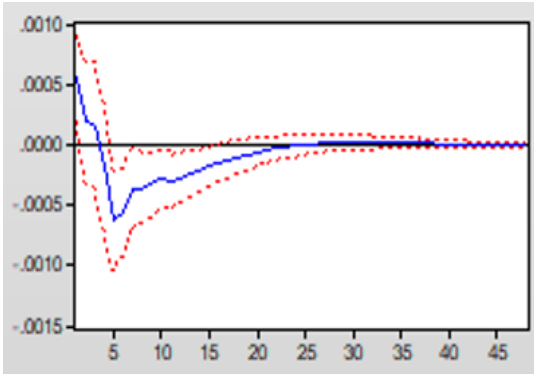
right: VAR (1959-2014)



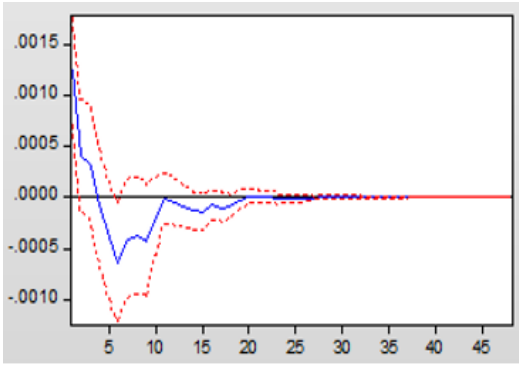
(3) impulse response of IP to policy shock

Figure 3 impulse response of IP to policy shock

left: FAVAR (1959-2014)



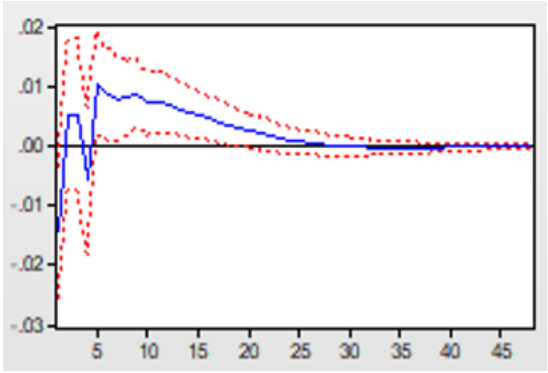
right: VAR (1959-2014)



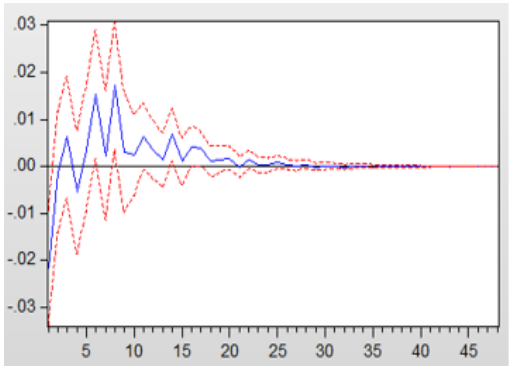
(4) impulse response of unemployment rate to policy shock

Figure 4 impulse response of unemployment rate to policy shock

left: FAVAR (1959-2014)



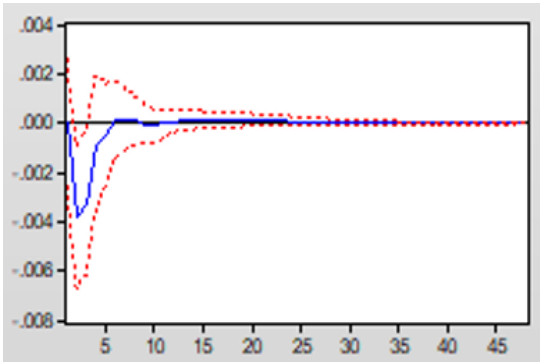
right: VAR (1959-2014)



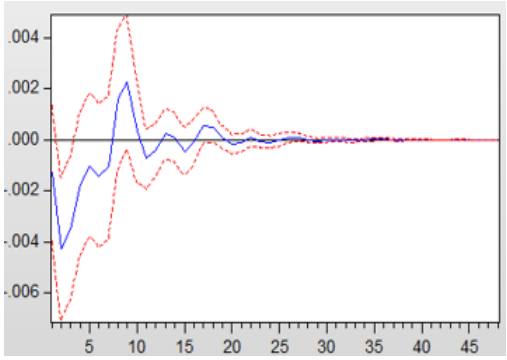
(5) impulse response of S&P500 to policy shock

Figure 5 impulse response of S&P500 to policy shock

left: FAVAR (1959-2014)



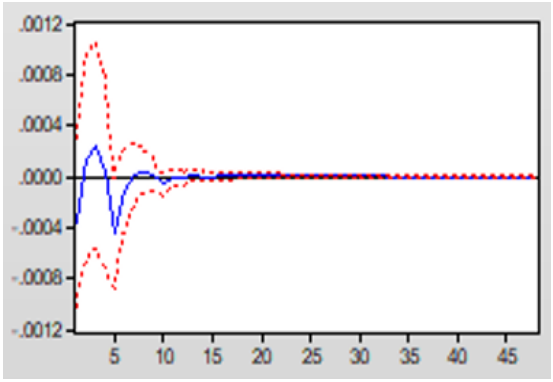
right: VAR (1959-2014)



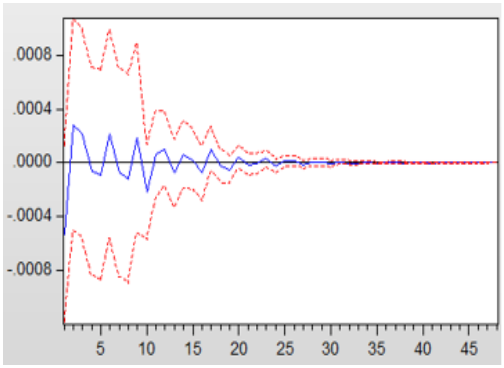
(6) impulse response of PPI to policy shock

Figure 6 impulse response of PPI to policy shock

left: FAVAR (1959-2014)



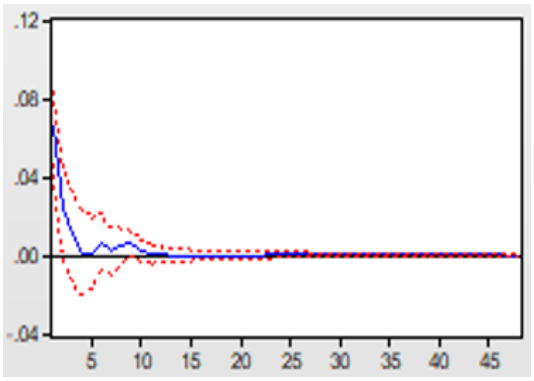
right: VAR (1959-2014)



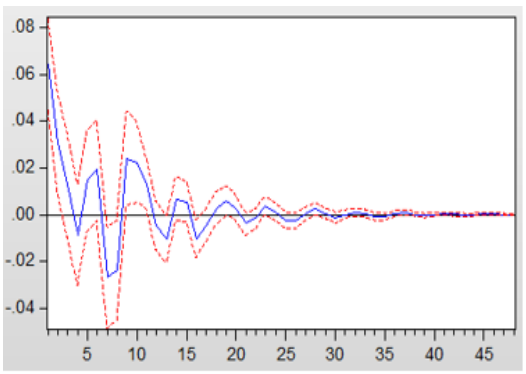
(7) impulse response of 10 year treasury rates to policy shock

Figure 7 impulse response of 10 year treasury rates to policy shock

left: FAVAR (1959-2014)



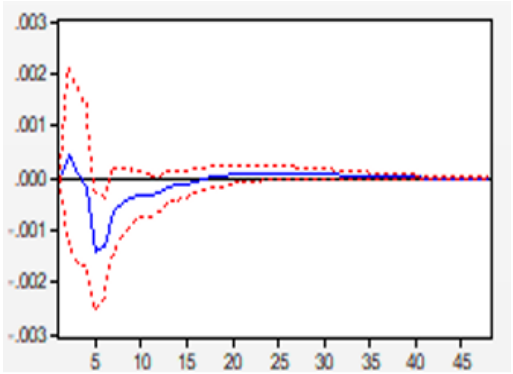
right: VAR (1959-2014)



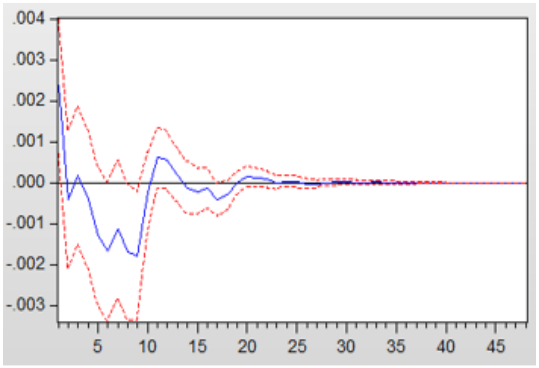
(8) impulse response of durable consumption to policy shock

Figure 8 impulse response of durable consumption to policy shock

left: FAVAR (1959-2014)



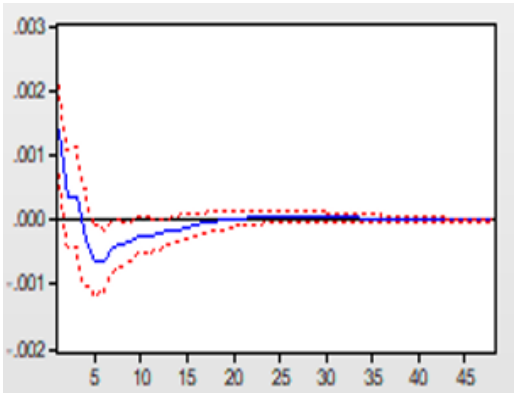
right: VAR (1959-2014)



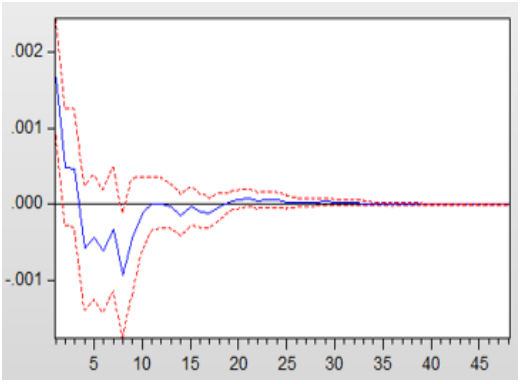
(9) impulse response of nondurable consumption to policy shock

Figure 9 impulse response of nondurable consumption to policy shock

left: FAVAR (1959-2014)



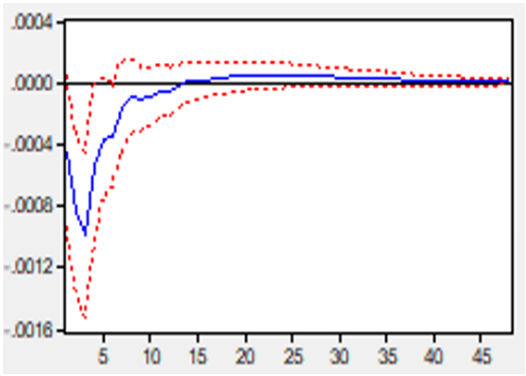
right: VAR (1959-2014)



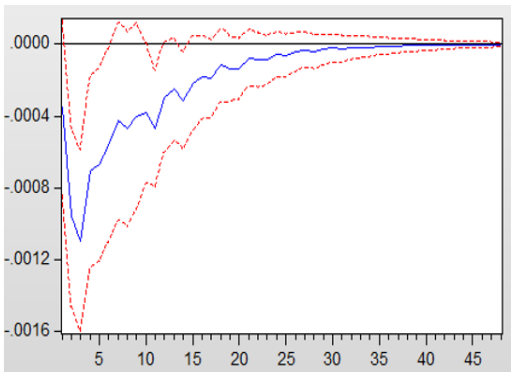
(10) impulse response of monetary base to policy shock

Figure 10 impulse response of monetary base to policy shock

left: FAVAR (1959-2014)



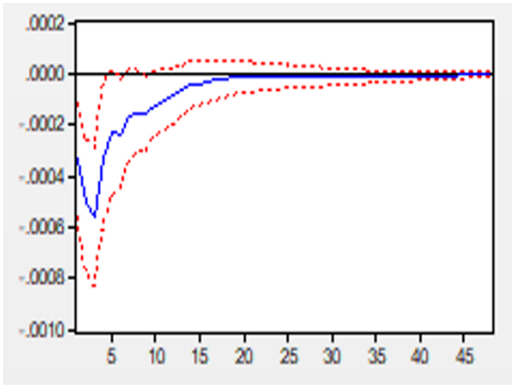
right: VAR (1959-2014)



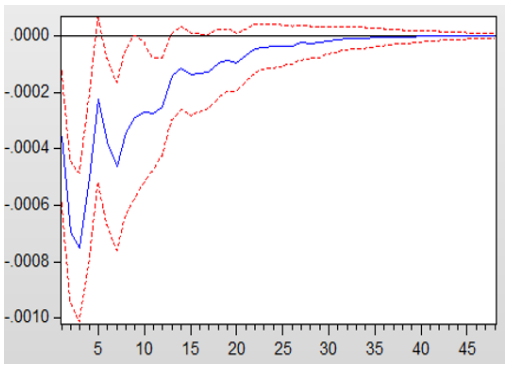
(11) impulse response of M2 to policy shock

Figure 11 impulse response of M2 to policy shock

left: FAVAR (1959-2014)



right: VAR (1959-2014)



According to the comparison of impulse response results between the FAVAR model on the left and the VAR model on the right, we have found that in general, the impulse response results of the FAVAR model would be less volatile and they would return to the long-term mean much faster than the impulse response results of the VAR model. The differences are very significant for the unemployment rate, S&P500, PPI and the 10 year treasury rates.

Especially for the two variables: S&P500 and 10 year treasury rates, they are assumed to be very fast variables as the US market for the stocks and the treasury bonds are highly efficient. From the impulse response results of the FAVAR model, the duration of the effect of monetary policy shocks on S&P500 and 10 year treasury rates would be all less than 10 months, and the adjustments in the treasury bonds market could be even faster. This results should be very in accordance with the reality as the market with high liquidity would price in the monetary policy shocks in a timely manner.

However, when we look at the impulse response results of the VAR model for the two variables: S&P500 and 10 year treasury rates, after the 10^{th} month, there would still be a lot of meaningless volatilities around the long-term mean value, and it would be hard to find the reason why the market can't price in the monetary policy shocks in a timely manner. The meaningless volatilities won't have any effective indication and that would be clearly the main shortage of the traditional VAR model.

When it comes to the impulse response results of the FAVAR model for the unemployment rate, it will rise with oscillation until the seventh month when it reaches the top and then start to drop slowly until the 25^{th} month when the long-term trend value is reached. The overall effect of the monetary policy shocks on the unemployment rate is very persistent and clearly it would take much longer time for the effect to be fully digested, unlike what we can see from the impulse response results of S&P500 and 10 year treasury rates. However, when we look at the impulse response results of the VAR model for the unemployment rate, we will find a lot of meaningless volatilities that can't be explained by the economic theory.

When it comes to the impulse response results of the FAVAR model for the PPI, it will oscillate mainly in the negative territory until the 10^{th} month when the long-term trend value is reached and this is in accordance with the economic theory where a tightening monetary policy would depress the PPI for an extended period of time. However, when we look at the impulse response results of the VAR model for the PPI, we will find a lot of meaningless volatilities that can't be explained by the economic theory and the negative effect of the tightening monetary policy shocks on the PPI is not very clear.

When it comes to the impulse response results of the FAVAR model and the VAR model for the two variables: the durable consumption and the nondurable consumption, both models could present good indications and the negative effect of the tightening monetary policy shocks on the consumption is in accordance with the economic theory.

When it comes to the impulse response results of the FAVAR model and the VAR model for the two variables: monetary base and M2, both models could present good indications and the negative effect of the tightening monetary policy shocks on the overall money supply amount is in accordance with the economic theory.

Through the comparison of the impulse response results between the FAVAR model and the traditional VAR model within the subgroup of macroeconomic indicators, we can conclude that the FAVAR model would provide much clearer indication when it comes to the macroeconomic variables since it can include more useful economic information than the traditional VAR, and the result of the traditional VAR can't present the reality of the monetary policy shocks effect in a lot of cases.

4.2.2. Impulse response function (to the balance sheet channel indicators)

In this section, three variables: the nonresidential construction investment, inventory and new order are selected. By definition, the inventory is the short-term balance sheet item, the nonresidential construction investment is the long-term balance sheet item and the new order is the income statement item.

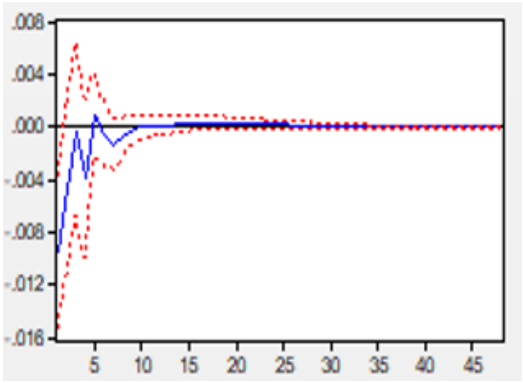
The financing costs related to the inventory investment are the opportunity costs of the company's internal funds and the financing costs related to the non-residential construction investment and the new order are the costs in the external financing.

The comparison of impulse response results between the FAVAR model and the VAR model can be shown below:

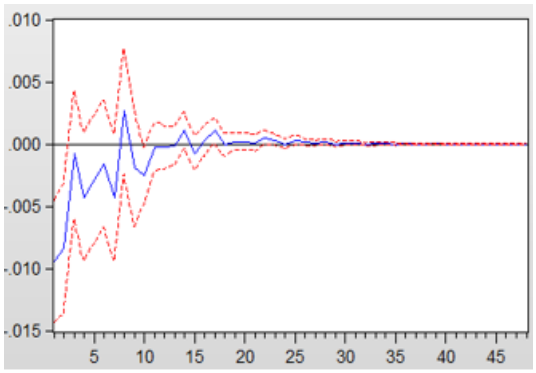
(1) impulse response of nonresidential construction spending to policy shock

Figure 12 impulse response of construction spending to policy shock

left: FAVAR (1959-2014)



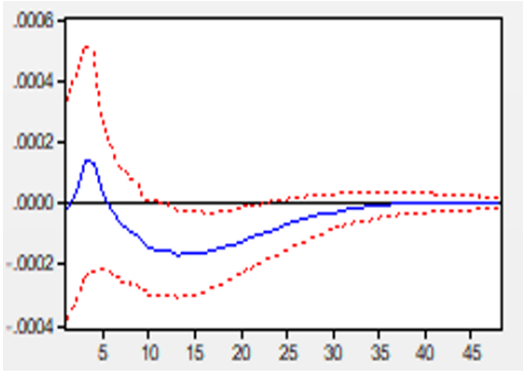
right: VAR (1959-2014)



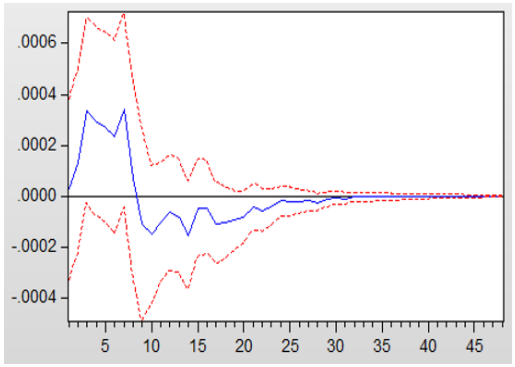
(2) impulse response of inventory to policy shock

Figure 13 impulse response of inventory to policy shock

left: FAVAR (1959-2014)



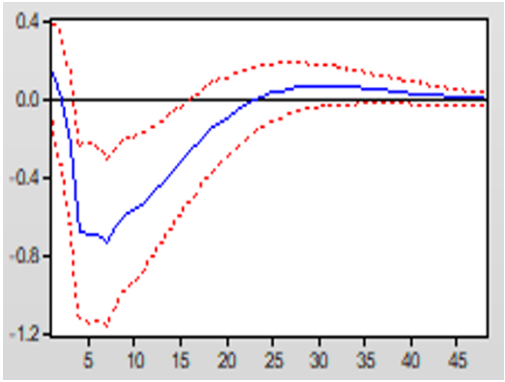
right: VAR (1959-2014)



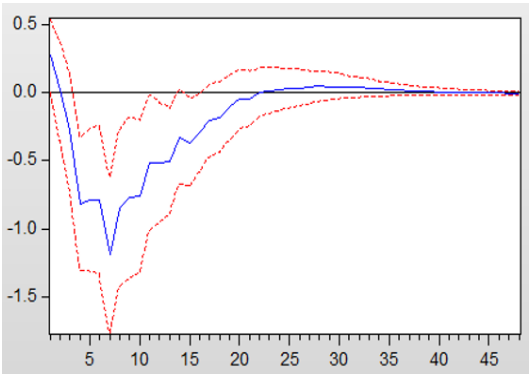
(3) impulse response of new orders to policy shock

Figure 14 impulse response of new orders to policy shock

left: FAVAR (1959-2014)



right: VAR (1959-2014)



According to the comparison of impulse response results between the FAVAR model on the left and the VAR model on the right, just like what we have found within the subgroup of macroeconomic indicators, in general, the traditional VAR model is less efficient and tends to volatile a lot.

On the other hand, even if we only use the traditional VAR model, the existence of the extra costs in the external financing could still be proved just like what we have done at the part 1 chapter 4. If we only focus on the results generated from the traditional VAR model on the right, there is significant difference between the impulse response results of the inventory investment and the non-residential construction investment.

When there is a tightening monetary policy shock, the non-residential construction investment would drop immediately while the inventory investment would be less sensitive to the tightening monetary policy shocks at the beginning period.

The financing costs related to the inventory investment are the opportunity costs of the company's internal funds and the financing costs related to the non-residential construction investment are the costs in the external financing.

When there is a tightening monetary policy shock, enterprises would cut the non-residential construction investment immediately because usually the non-residential construction investment is treated as part of the enterprises' long-term capital expenditures, and normally the long-term capital expenditures would take a few years to build and these projects can be postponed when the credit environment is not favorable at the moment, and the rising costs in the external financing would make a lot of long-term capital expenditures projects less attractive through a rising WACC and a negative NPV.

But enterprises would cut the inventory investment slowly and moderately because the inventory investment is related to the enterprises' daily operation. As we have discussed through the simplified calculation formula, the inventory index would be the most suitable indicator of the enterprises' working capital investment from the macroeconomic point of view because of the offsetting nature of the account receivable and the account payable in aggregation in the whole economy system.

So for the enterprises, the immediate decrease in the working capital investment is not possible and usually part of the working capital investment is financed by the cash on the balance sheet, unlike the long-term capital expenditures, this financing part is interest free

from the income statement's perspective and is related to the opportunity costs of the internal funds from the economic perspective, but from both perspectives, the costs related would be much lower than the costs in the external financing. Unlike the costs in the external financing, the opportunity costs of the internal funds would not rise significantly with the tightening monetary policy, and that is the reason why the inventory investment would be less sensitive to the tightening monetary policy shocks at the beginning period.

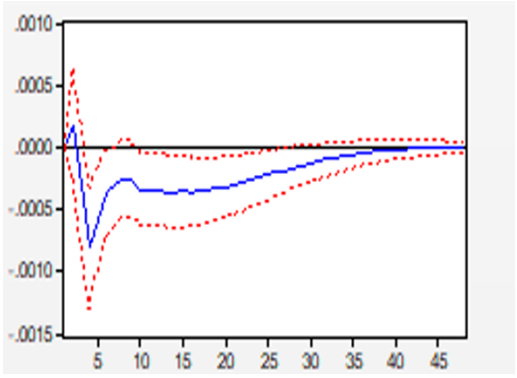
4.2.3. Impulse response function (to the bank credit channel indicators)

In this section, one variable: the commercial loans is selected. And the comparison of impulse response results between the FAVAR model and the VAR model can be shown below:

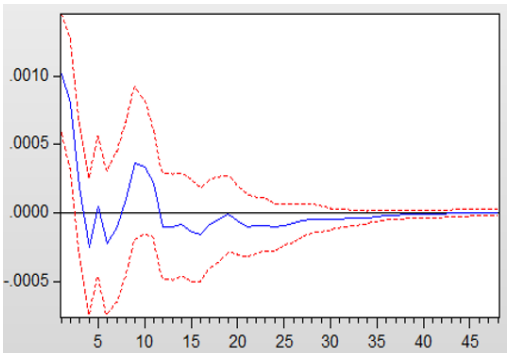
(1) impulse response of commercial loans to policy shock

Figure 15 impulse response of commercial loans to policy shock

left: FAVAR (1959-2014)



right: VAR (1959-2014)



According to the comparison of impulse response results of the commercial loans to the monetary policy shocks, the indication made by the VAR model is not in accordance with the reality in that when there is a tightening monetary policy shock, the impulse response function of the VAR model shows that the commercial loans would mainly stay in the positive territory for the first 12 months, and clearly that should not be correct since it would be hard to explain why the tightening monetary policy shock would result in a positive effect on the commercial loans. Since the VAR model can only include limited number of variables, the reason for this mistake could be explained by the fact that the positive effect on the commercial loans is not caused by the tightening monetary policy shock itself, but it is caused by some variable shocks that are not included in the traditional VAR model, it is the shortage of the traditional VAR model that prevents it from indicating the right impulse response function.

In contrast, the indication made by the FAVAR model is in accordance with the reality in that when there is a tightening monetary policy shock, the impulse response function of FAVAR shows that the commercial loans would drop immediately until the fifth month when it reaches the bottom and then start to rebound slowly until the 40th month when the long-term trend value is reached, the negative effect on the new loans is statistically significant and persistent. The reason why the FAVAR can generate the correct indication is that the FAVAR model has solved the problem of the traditional VAR model and much more economic information could be included in the empirical model.

4.2.4. Summary of the empirical analysis result

When we compare the impulse response function results between the FAVAR model and the VAR model, we can find that in general the FAVAR model is a more efficient and smoother model in that the effect of the monetary policy shocks would exist for a shorter period of time and there would be much fewer meaningless volatilities so that the monetary policy shocks' impact could be presented more clearly. When the fed is deciding the monetary policy, the FAVAR model could give more useful guidance than the traditional VAR model. It would be easier for us to understand the effect of the monetary policy shocks on the economic variables that we care about from the FAVAR model. Also the reason could be explained by the fact that the FAVAR model has included much more information than the traditional VAR model, and the results that we get through the impulse response function would be much closer to the reality than what we would get through the traditional VAR model. Because of the existence of the market expectation, the effect of the monetary policy shocks should be reflected quickly and be digested by the market in a short period of time, especially when it comes to the so-called fast variables.

When it comes to the comparison between the FAVAR model and the VAR model for the macroeconomic variables and the enterprise balance sheet channel variables, the differences mainly come from the efficiency of the model as we have already discussed.

But when it comes to the comparison between the FAVAR model and the VAR model for the bank credit channel variables. The most significant difference would exist for the commercial loans, when we use the FAVAR model, the negative effect would be very significant and persistent. However, when it comes to the impulse response results of the traditional VAR model, there is no negative effect.

From the theory of the bank credit channel monetary policy transmission mechanism, since the bank's asset and liability structure can't be adjusted quickly enough to avoid the impact of the fed's monetary policy, the size of the bank's loanable funds would be subject to the fed's monetary policy. A tightening monetary policy shock would cause the size of the loanable funds in the banking system to decrease, and this would further lead to a decrease in the total supply of the bank loans. From the impulse response results of the FAVAR model, the theory has been well presented, however, the VAR model results seem to be poor at presenting this theory. And the shortage of the VAR model results could be caused by the lack of necessary information.

Generally speaking, using the FAVAR model would improve the impulse response results of bank credit channel indicators to the monetary policy shocks significantly. By including more information that may be necessary, the frictions of the credit market and the existence of the information asymmetry in the financial market can be well presented in the empirical model.

5. Summary and policy recommendations

5.1. Summary

In this part, based on the 115 sets of economic variables from January 1959 to December 2014, we used the two-step principal components analysis method to construct the FAVAR model. Then we have further compared the impulse response function results between the FAVAR model and the traditional VAR model and analyzed the results separately based on three subgroups (the impulse response function of the macroeconomic indicators, the impulse response function of the enterprise balance sheet channel indicators and the impulse response function of the bank credit channel indicators).

The main conclusions can be shown below:

(1) Generally speaking, from the impulse response function results of the FAVAR model alone, the indications made are all in accordance with the reality and have proven that Ben Bernanke's theory about the credit channel transmission mechanism of monetary policy would still hold in the long-term credit cycle. Also this conclusion is in accordance with the conclusion made in part 1 chapter 4.

(2) Based on the comparison of the impulse response results between the FAVAR model and the traditional VAR model, in general, the FAVAR model is a more efficient and stable model, thus making it very useful to provide the guidance to the fed when deciding the monetary policy. By including more variables into the FAVAR with the help of the two-step principal components analysis method, the FAVAR model can include the information about the frictions of the credit market and the existence of the information asymmetry in the financial market into the model.

In contrast, because of the lack of necessary information, the indications made by the traditional VAR model always have a lot of meaningless volatilities and the reactions of the so-called fast variables to the monetary policy shocks are always extremely slow, meaning simply the traditional VAR model alone is not good enough for the policy maker to get informative guidance when deciding the monetary policy.

(3) Although the VAR model could be potentially problematic, when testing the enterprise balance sheet channel indicators, even the impulse response results generated by the traditional VAR model can prove the existence of the extra costs in the external financing and this is in accordance with what I have concluded in part 1 chapter 4.

(4) When it comes to the comparison between the FAVAR model and the VAR model for the bank credit channel variables, the FAVAR model would give the indication that is in accordance with the theory of the bank credit channel monetary policy transmission mechanism. However, the traditional VAR model would give totally wrong indication because of the lack of necessary information. The information about the frictions in the credit market and the existence of the information asymmetry in the financial market is included through the two-step principal components analysis method when we construct the FAVAR model.

5.2. Economic status analysis

Because of the COVID-19 shocks to the economy, the IMF has estimated that the US GDP growth rate would be -5.9% in 2020, and the main driving force would be the over 40% decrease in the consumer spending in the second quarter of 2020. But with the in time interest rate cutting to the zero lower bound, the massive asset purchase program implemented by the fed and the aggressive expansionary fiscal policy implemented by the treasury, the short-term

financial market turmoil has already been controlled and both the stock markets and the macroeconomic indicators like PMI and the unemployment rate have shown positive signals recently.

Figure 16 USA PMI

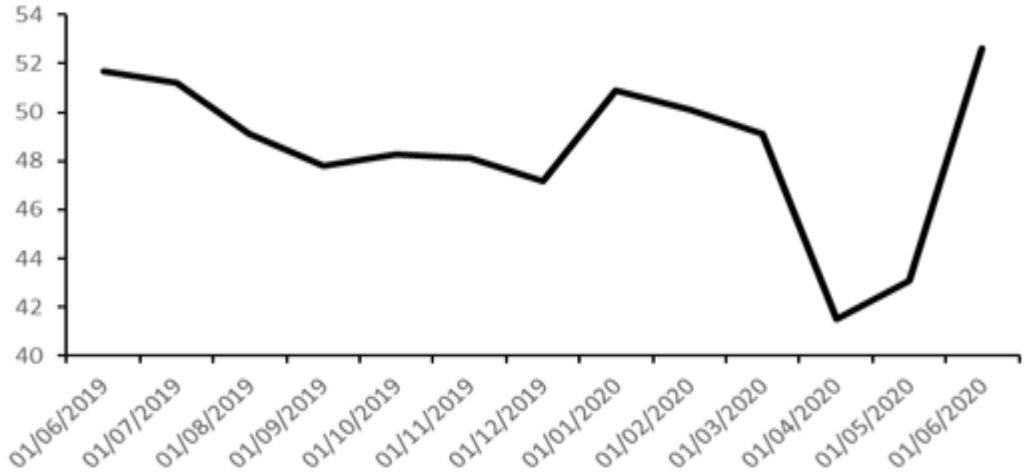
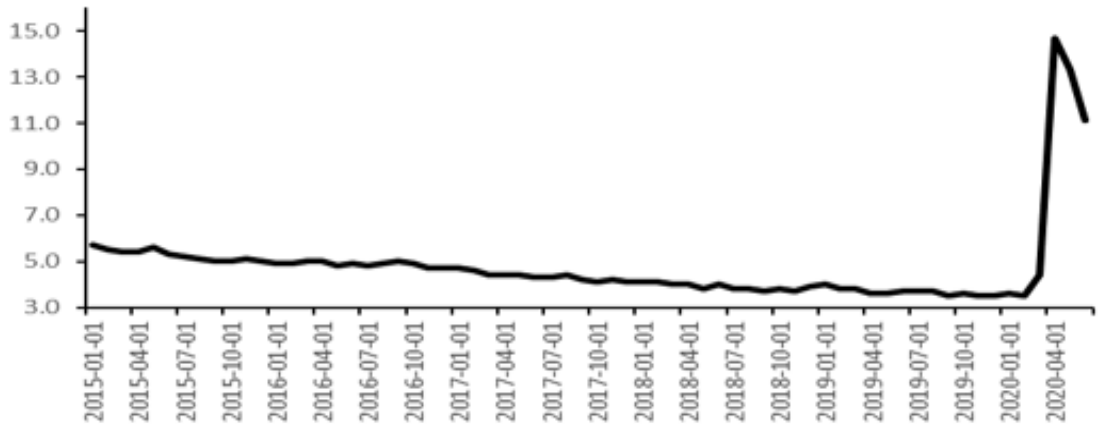


Figure 17 S&P 500

Figure 18 USA unemployment rate



Until now the COVID-19 turmoil has been controlled to a large extent, even if the macroeconomic indicators are still experiencing the recovery process, the equity market has already returned to the bullish market situation, but we still need to keep in mind that for the incoming next recession, whether it is caused by this COVID-19 emergency or another situation in the near future, the monetary policy tools that we are familiar with nowadays may not be that useful in the next recession. Currently the fed funds rate is already near the zero lower bound, even the negative nominal rate is allowed, the potential space for further interest rate decrease is very limited. Also the quantitative easing program would not be as useful as it used to be in the future, as nowadays the risk and the liquidity premiums are already very low, the expected returns for most assets in US markets would be low in the future. If we take the market anticipation into account, the effect of the future large scale asset purchase program would be weaker. And since the quantitative easing program would affect the parties who hold the financial assets directly, but not the parties who would spend these amount to stimulate the economy growth, the stimulus effect on the real economy would be much weaker than the stimulus effect on the financial assets, the financial asset bubbles and the wealth gap would become a potential problem. Although through the Wu-Xia shadow fed funds rate, we can figure out the interest rate decreasing effect of the quantitative easing program during last recession, this flexible monetary policy tool would still experience the limitation and lose the flexibility to a large extent in the next recession.

5.3. Promblem with the large scale asset purchase program

Based on the FAVAR model results, we have concluded that the effect of the monetary shock caused by the changes of the fed funds rate on the real economy variables would be the same as the effect of the monetary shock caused by the changes of the Wu-Xia shadow fed funds rate on the real economy variables as long as the changing amount of the monetary shock is the same. For example, a 100 basis points decrease in the Wu-Xia shadow fed funds rate after 2008 would have the same effect as a 100 basis points decrease in the fed funds rate before 2008 when the interest rate environment is normal.

However, we still need to notice the important difference between the Wu-Xia shadow fed funds rate and the fed funds rate. By definition, the fed funds rate can be directly controlled by the fed through the open market operations. The fed funds rate is the target rate of the open market operations, in the interbank lending market, the fed, as the largest participant, will first sell the short term treasury bills in the open market if it wants to raise the fed funds rate. As the demand for the short term treasury bills declines significantly, the price would fall, and the corresponding interest rate would increase, thus causing the cost of inter-bank lending to rise accordingly, and eventually the central bank would achieve the goal of simultaneously increasing the inter-bank lending rate and the fed funds rate. Also if the fed wants to lower the fed funds rate, it will first lower the fed's lending rate to the commercial banks, then since the interest rate cost of borrowing from the fed is lower than the inter-bank lending rate, commercial banks would choose to borrow from the fed, thus causing the inter-bank lending rate to decrease accordingly, and eventually the central bank would achieve the goal of simultaneously lowering the inter-bank lending rate and the fed funds rate. Normally the fed's monetary policy is mainly based on the open market operations, and the adjustment of the monetary base in the market is flexible and rapid.

In contrast, the Wu-Xia shadow fed funds rate can’t be controlled directly through the open market operations and the Wu-Xia shadow fed funds rate can’t work as the target rate since there is no clear linear relationship between the amount of the large scale asset purchase program and the interest lowering effect. Wu and Xia(2016) explained that one important reason why the effect of QE2 is much smaller than the effect of QE1 is that the market participants have the forward-looking nature and the market anticipation has weakened the effect of the large scale asset purchase program. Because of the existence of the market anticipation, the effect of the certain amount of the large scale asset purchase program on the

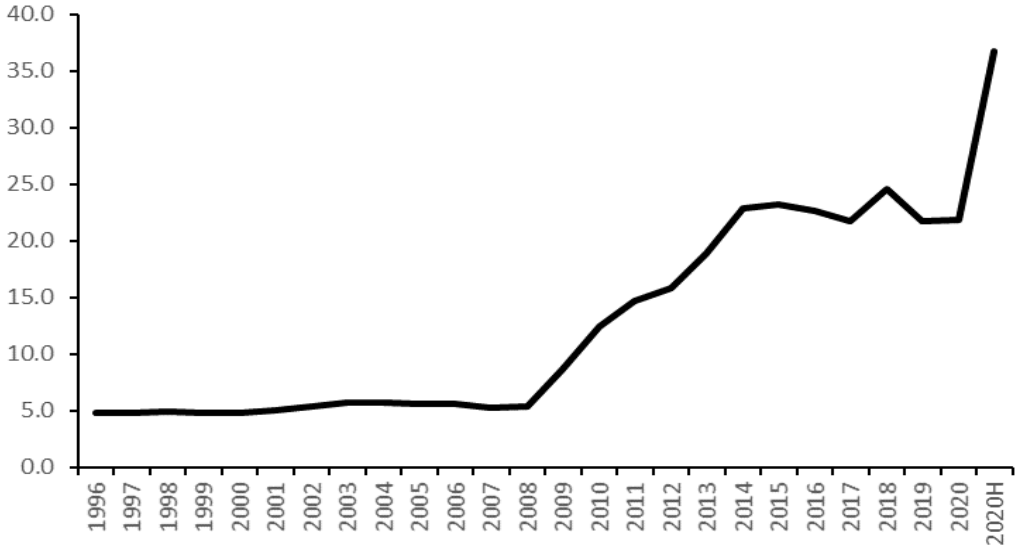
Wu-Xia shadow fed funds rate can't be known precisely in advance by the policy maker, thus making the Wu-Xia shadow fed funds rate unable to work as the controllable tool to the policy maker. In general, unlike the fed funds rate, the Wu-Xia shadow fed funds rate is only the proxy variable to measure the interest rate lowering effect of the large scale asset purchase program and it can show the variation of the monetary policy shocks when the real fed funds rate is kept at the zero lower bound.

Since the Wu-Xia shadow fed funds rate is not controllable and not a reliable monetary policy tool, with the existence of the market anticipation and the prior adjustments, in order to achieve the same interest rate lowering effect in the future, it would be reasonable to expect that larger amount of asset purchase should be required, or even the inclusion of more asset classes should be required when the next recession comes.

Before the financial crisis in 2008, the total asset of the federal reserve always accounted for around 5% of GDP and didn't change a lot over years. However, since the financial crisis in 2008, this ratio has risen dramatically to over 30% in June 2020, and because of the COVID-19 turmoil's negative effect on the US economy, in the near future, we can't see the end of this upward trend. The reason for this upward trend is the large scale asset purchase program implemented by the fed and this monetary policy tool has been used as the main monetary policy tool since 2008.

To the policy maker, the problem is that the interest rate lowering effect of the large scale asset purchase program has been weakened over time, and the strategy of keeping increasing the ratio (total asset of the federal reserve / GDP) may not be sustainable in the long run.

Figure 19 Balance sheet of federal reserve (% GDP)



To the commercial banks, the problem is that their willingness to take the risks would be low in nowadays extremely low interest rate environment. The traditional commercial banks' business model has been destroyed in this environment.

On the liability side, the interest rate of the deposits can be lowered at most to zero, since usually a considerable percentage of the commercial banks' deposits are the interest-free demand deposits, and the commercial banks are only obliged to pay interests to the term deposits, only the term deposits part can benefit from the interest lowering effect. The costs of the deposits can't benefit any more from the interest lowering effect when the Wu-Xia shadow fed funds rate approaches the negative territory because the commercial banks can't ask for the negative interest rate to the depositors. Although the interbank lending liabilities can further benefit from the interest lowering effect when the Wu-Xia shadow fed funds rate

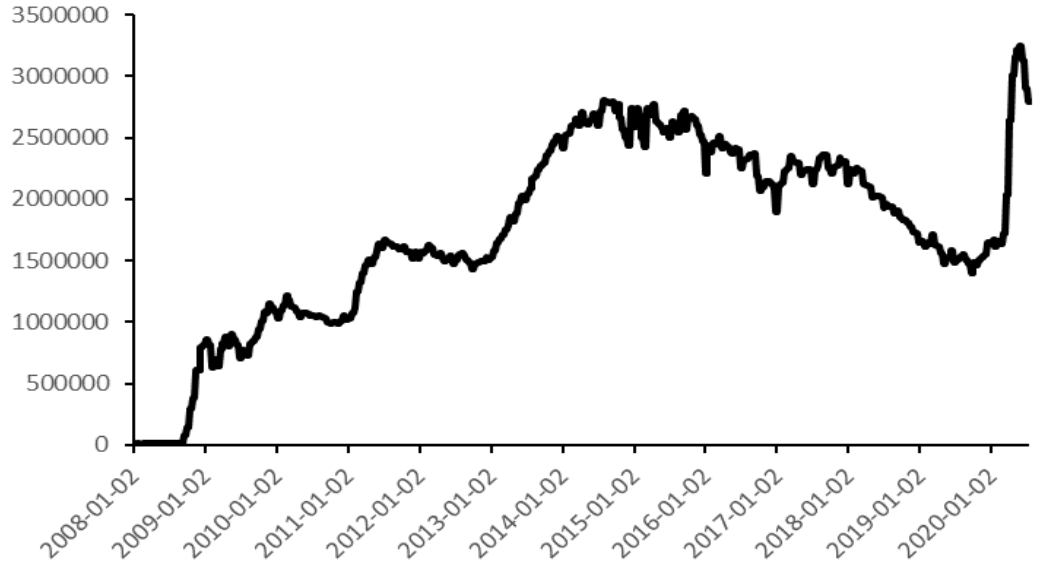
approaches the negative territory, because of the net stable funding ratio regulation of BASEL III that potentially prevent the commercial banks from over relying on the interbank lending liabilities which are considered as instable funding liabilities by the regulators, the overall costs of the liabilities can't be improved that much and the costs of the deposits are always the most important costs to be considered for most of the commercial banks.

On the asset side, a large part of the interest-generating assets are repriced annually or quarterly, and the interest income could be further affected when the Wu-Xia shadow fed funds rate approaches the negative territory. The high quality loans and the high quality fixed-income investment held for maturity would be influenced significantly by the negative Wu-Xia shadow fed funds rate, thus making the interest revenue losses on the asset side much greater than the interest costs benefits on the liability side. Because of the asset-liability structure of the commercial banks, nowadays extremely low interest rate environment would hurt their net interest margins significantly.

For the commercial banks, net income=net interest margins – credit loss costs – taxes, as we have already concluded that the extremely low interest rate environment would cause significant negative impact on the net interest margins, in order to generate enough profits for surviving and fulfill the regulatory capital adequacy ratio, most of the commercial banks would shift to higher quality customers so as to control the credit loss costs. In general, lowering the risk tolerance should be treated as a sensible strategy given the consideration that even the risky customers can negotiate a relatively low interest rate in nowadays extremely low interest rate environment.

Most of the US commercial banks are not controlled by the government directly and they are responsible for their own profits or losses, their low willingness to take the risks would cause their reserve balances maintained with the fed to increase dramatically when the fed is implementing the large scale asset purchase program. Although this result may not be preferred by the central bank and the commercial banks' low willingness to take the risks would weaken the monetary easing effect of the large scale asset purchase program, the fed would never be able to force the commercial banks to raise their risk tolerance, and clearly this conflict of interest between the fed and the commercial banks is another very significant problem of the large scale asset purchase program.

Figure 20 Total US reserve balances maintained with federal reserve banks



5.4. Policy recommendations

When the fed funds rate is not zero, the first monetary policy to be taken into consideration by the fed should be the adjustment of the fed funds rate through the open market operations as it is flexible enough. Then after lowering the fed funds rate to the zero lower bound during the financial crisis, the second monetary policy to be taken into consideration is the large scale asset purchase program to inject the liquidity into the financial system and make the interest lowering influence through the Wu-Xia shadow fed funds rate. With the elimination of the risk and the liquidity premiums of the financial assets, the potential solution in the next stage is the collaboration between the monetary policy and the fiscal policy.

Through the collaboration between the monetary policy and the fiscal policy, the future fed funds rate would be fixed at the zero lower bound and instead the fiscal policies would become more flexible in stimulating the economy, in other words, the deficits could be used as a flexible tool and the government debts following the deficits would be monetized by the fed. The constraint of this collaboration would be the targeted inflation rate.

Compared with the large scale asset purchase program where the fed purchase the financial assets from the parties who hold the financial assets, and then these parties would use this amount of money to purchase other financial assets in the financial market but not spend this amount of money in a way to stimulate the real production. The potential benefit of the collaboration between the monetary policy and the fiscal policy is that we can make sure that the money printed by the fed could be targeted to the specific uses that would stimulate the real production effectively.

Through monetizing the deficits when the fed funds rate is kept at the zero lower bound, the interest lowering effect could still be described by the Wu-Xia shadow fed funds rate, and the deficits monetization is just equal to lowering the Wu-Xia shadow fed funds rate to the negative territory like what we have already seen from the three rounds of large scale asset purchase program during the financial crisis. Also the credit channel monetary policy transmission mechanism would still hold when the fed and the treasury collaborate with each other. What is really different this time is that the decision power would mainly lay on the treasury but not on the fed, through the collaboration, the fed would lose the independence in implementing the monetary policy, but instead, they should follow the mandates from the treasury in order to fulfill the deficits monetization responsibility.

The forms of the collaboration between the monetary policy and the fiscal policy could be quite different, for example the fed could print money and give it directly to the government, or the fed could be less direct by carrying out the large scale asset purchase program and at the same time, the debts purchased are retired, or the fed can target the private sector instead of the public sector by carrying out the helicopter money to the households. So in general, the collaboration between two parties will have enough flexibility in both the targets and the forms.

By reviewing the history of US monetary policy in the late 1930s, the situation at that time is quite similar to what we are experiencing nowadays, For example, from 1938 to 1940, the increase in the total money supply could only cause the commercial banks' reserves to increase since the commercial banks' willingness to issue new loans was low and the loan issuers were super risk averse. In this environment, even if the fed was printing more and more money, most of the new money supply won't flow into the real economy and stimulate the production. The monetary policy alone during this stage is not very effective, even with the large scale asset purchase program.

The final solution was the collaboration between the monetary policy and the fiscal policy during the World War II. During that period of time, the government spending implemented by the treasury increased dramatically, and the money supply implemented by the central

bank also increased accordingly to a nearly doubled level. The central bank managed to monetize the government spending by setting both a cap of 2.5% on the long term treasury bond interest rate and a cap of 0.375% on the short term interest rate and the central bank would participate actively in the markets when these two caps are reached.

Although the background of the collaboration is the World War II last time, and also the main purpose of the collaboration at that time was to finance the production for the war and the military requirements, this functioning mechanism of the collaboration can let us see the picture for solving the next recession more clearly. By changing the targeted aeras for the government spending and monetizing the deficits at the same time, the basic structure could be constructed in order to deal with the next recession.

Through the collaboration between the monetary policy and the fiscal policy, we can at least solve two problems that we have discussed before.

Firstly, monetizing the government deficits in a more direct way can avoid the situation that money printed by the large scale asset purchase program just mainly sits on the balance sheet of the commercial banks in the form of the reserve balances maintained with the fed, and because of the commercial banks' low willingness to hold high risk loans, the real stimulus effect could be quite limited. In contrast, the government don't have to tradeoff between the net interest margin and the credit losses costs and don't care that much about the net profits of the investment and the ROE like the commercial banks owned by the private shareholders, so the investment could be made in the specific aeras that may not generate satisfactory returns but are important in stimulating the real economy. In other words, through the collaboration between the monetary policy and the fiscal policy, the action of monetizing debts could lower the Wu-Xia shadow fed funds rate more effectively, and further cause the stimulus effect on the real economy in the way like what we can see from the FAVAR model's impulse response function results.

Secondly, the large scale asset purchase program that the fed used to implement would benefit only the parties who originally hold the financial assets, and it may cause more capitals to flow into the financial markets and finally cause the asset price bubbles. The money printed may not be spent in a way to stimulate the real production, to create new jobs and so on, and by nature, monetary policy like the large scale asset purchase program would further enlarge the wealth gap. Through the collaboration between the monetary policy and the fiscal policy, the government can spend the money printed by the central bank in a more proper way and invest more efficiently so as to stimulate the real economy.

References

[1] Aoki, K., Ptoudman, J. and Vlieghe, G. House Price, Consumption and Monetary Policy: A Financial Accelerator Approach, Journal of Financial Intermediation,2004(13)：114-435.

[2] Bernanke, B., Boivin, J., and Eliasz, P. Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) approach. Quarterly Journal of Economics, 2005,v120:387-422.

[3] Bernanke, B. Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression , American Economic Review,1983,73:257-276.

[4] Bernanke, B. and Blinder, A. Credit, Money, and Aggregate Demand , American Economic Review,1988,78:435-439.

[5] Bernanke, B. and Gertler, M. Agency Costs, Net Worth and Business Fluctuations , American Economic Review ,1989,79:14-31.

[6] Bernanke, B. and James, H. The Gold Standard, Deflation, and Financial Crisis in the Great Depression: An International Comparison, in R.G. Hubbard, ed., Financial Markets and Financial Crises, Chicago: U. of Chicago Press for NBER, 1991.

[7] Bernanke, B. and Cara, S.L. The Credit Crunch, Brookings Papers on Economic Activity, 1992，2:205-239.

[8] Bernanke, B. and Blinder, A. The Federal Funds Rate and the Channels of Monetary Transmission , American Economic Review ,1992, 92: 901-921.

[9] Bernanke, B., Gertler, M. and Gilchrist, S. The Financial Accelerator and the Flight to Quality, NBER working paper 4789, Review of Economics and Statistics, forthcoming,1994.

[10] Bernanke, B. and Gertler, M. Inside the Black Box: The Credit Channel of Monetary Transmission , Journal of Economics Perspectives,1995,9:27-48.

[11] Bernanke, B. and Mihov, I. Measuring Monetary Policy, mimeo, Princeton University ,1995.

[12] Bernanke, B., Gertler, M. and Gilchrist, S. The Financial Accelerator in a Quantitative Business Cycle Framework, in J.B. Taylor, and M. Woodford, eds. ,Handbook of Macroeconomics, Amsterdam: North-Holland, forthcoming.

[13] Bernanke, B. and Gertler, M. Monetary Policy and Asset Price Volatility , Economic Review,1999,84(4):17-52.

[14] Boivin, J., Giannoni, M. P. and Mihov, I. Sticky Prices and Monetary Policy: Evidence from Disaggregated U.S. data, American economic review,2009,99(1):350-384.

[15] Christiano, L., Eichenbaum, M. and Evans, C. The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds, mimeo, Northwestern University, 1994a.

[16] Christiano, L., Eichenbaum, M. and Evans, C. Identification and the Effects of Monetary Policy Shocks, Federal Reserve Bank of Chicago, working paper WP-94-7, 1994b.

[17] Christiano, L., Eichenbaum, M. and Evans, C. Monetary Policy Shocks: What Have We Learned and to What End?, in J. Taylor and M.Woodford, eds., Handbook of Macroeconomics, Amsterdam: North-Holland 2000.

[18] Fischer, S. Long Term Contracts, Rational Expectations, and the Optimal Money Supply Rule ,Journal of Political Economy ,1977,85:191-205.

[19] Fisher, I. The Debt-Deflation Theory of Great Depression, Econometrican, 1933, 1:337-357.

[20] Garima, V. and Philipp, M. The impact of the global business cycle on small open economies: A FAVAR approach for Canada, North American Journal of Economics and Finance,2013,24.

[21] Gupta, R.and Kabundi, A.The Effect of Monetary Policy on House Price Inflation: A Factor Augmented Vector Autoregression(FAVAR) Approach, Working paper, 2009,No.1-11.

[22] Gupta, R., Marius, J. and Kabundi, A. The Effect of Monetary Policy on Real House Price Growth in South Africa: A factor-augmented Vector Autoregression （FAVAR） Approach ,

Economic Modeling,2010,27:315-323.
[23] Hwang, H. Two-step Estimation of a Factor Model in the Presence of Observable Factors, Economics Letters,2009,105(9):247-249.
[24] Haroon,M. and Paolo,S. The Transmission of International Shocks： A Factor Augmented VAR Approach. Bank of England Working Paper,2007.
[25] Haroon, M.,Zabczyk, P. and Ellis, C. What lies beneath：what can disaggregated data tell us about the behavior of prices? Bank of England Working Paper,2009,364.
[26] Hasen, A. Monetary Theory and Fiscal Policy ,New York: McGraw-Hill,1949.
[27] Hotelling, H. Relations between Two Sets of Variables, Biometrika, 1936, 28: 321-377.
[28] Hicks, J.R. Mr. Keynes and the "classics" .In Critical Essays in Monetary Theory ,Oxford: Clarendon,1967.
[29] John, M. K. The General Theory of Employment , Interest and Money , Macmillian and Co., Ltd,1936.
[30] Leeper, E., Sims, C. and Zha, T. What Does Monetary Policy Do?, Brookings Papers on Economic Activity 1996,2:1-63.
[31] Lucas, R. Expectation and the neutrality of money ,Journal of Economic Theory,1972,4:103-124.
[32] Masahiko, S. An Analysis of Monetary Policy Shocks in Japan: A Factor Augmented Vector Autoregressive Approach ,2007,58(4):484-503.
[33] Massimo, G. The Role of House Price in the Monetary Transmission Mechanism Across European Countries ,Scottish Journal of Political Economy, 2005,52(4):519-543.
[34] Matteo, I. and Raoul, M. The Credit Channel of Monetary Policy: Evidence from the Housing Market , Journal of Macroeconomics,2008,30:69-96.
[35] Meltzer, A.H. Monetary, Credit and (Other) Transmission Processes: A Monetarist Perspective, Journal of Economic Perspectives,1995, 9(4):49-72.
[36] Friedman, M. and Schwartz, A. A Monetary History of the United States, 1867-1960,Princeton University Press for National Bureau of Economic Research,1963.
[37] Modigliani, F. and Miller, M. The cost of Capital, Corporation Finance, and the Theory of Investment , American Economics Review,1958,48: 261-297.
[38] Modigliani, F. Monetary Policy and Consumption ,Consumer Spending and Monetary Policy: The Linkages ,Boston: Federal Reserve Bank of Boston,1971.
[39] Muth, J.F. Rational Expectations and the Theory of Price Movements, Econometrica,1961,29:315-335.
[40] Obstfeld, M. and Rogoff, K. The Mirage of Fixed Exchange Rate , Journal of Economic Perspective,1995,9:73-96.
[41] Phelps, S. Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time , Economica,1967, 34(135): 254-281.
[42] Phelps, E.S. and Taylor, J. Stabilizing Powers of Monetary Policy with Rational Expectations , Journal of Political Economy, 1977,85:163-190.
[43]Liu, P.,Haroon, M. and Angeliki, T. International transmission of shocks ： a time-varying factor-augmented VAR approach to the open economy. Bank of England Working Paper,2011,425.
[44] HE, Q.,LEUNG, P. and CHONG, T. Factor-augmented VAR analysis of the monetary policy in China , China Economic Review,2013:88-104.
[45] Sargent, T.J. Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment. Brookings Papers on Economic Activity,1973,2:429-472.
[46] Sargent, T.J. and Wallace, N. Rational Expectations, the Optimal Monetary Instrument and the Optimal Money Supply Rule ,Journal of Political Economy ,1975,83: 241-254.
[47] Sims, C. Macroeconomics and Reality ,Econometrica ,1980,48:1-48.
[48] Sims, C. Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy, European Economic Review ,1992,36:975-1000.
[49] Stock, J. and Watson, M. Macroeconomics Forecasting Using Diffusion Indexes, Journal of Business and Economic Statistics,2002,20(2):147-162.

[50] Fujii, T., Hiraga, K. and Kozuka, M. Effects of public investment on sectoral private investment: A factor augmented VAR approach, Japanese Int. Economies, 2013, 27:35-47.
[51] Taylor, J.B. The Monetary Transmission Mechanism: An Empirical Framework, The Journal of Economic Perspectives,1995,9:37-47.
[52] Tobin, J. A General Equilibrium Approach to Monetary Theory , Journal of Money, Credit and Banking, 1969,1:15-29.
[53] Vargas-Silva, C. The Effect of Monetary Policy on Housing: A Factor Augmented Vector Autoregression(FAVAR) Approach, Applied Economics Letters, 2008, 15(10):749-752.
[54] Black, Fischer. (1995)"Interest Rates as Options." Journal of Finance, 50, 1371-1376.
[55] Wu, J C. and Xia, F D. Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound, Journal of Money, Credit, and Banking, 2016, 48(2-3), 253-291.

Appendix

The codes for transformation are listed as below: 1 means that no transformation is needed; 2 means that the first difference is needed; 4 means that the logarithm is needed; 5 means that the first difference of the logarithm is needed.

When the variables are noted as *, then it means that they are the slow variables.

Num	Variables	Time period	Trans	Full name
Real outputs and income				
1	INDPRO*	1959:01-2014:12	5	IP: Total index
2	IPFINAL*	1959:01-2014:12	5	Industrial Production: Final Products
3	IPCONGD*	1959:01-2014:12	5	IP: Consumer goods
4	IPMAT*	1959:01-2014:12	5	Industrial Production: Materials
5	IPDMAT*	1959:01-2014:12	5	Industrial Production: Durable Materials
6	IPNMAT*	1959:01-2014:12	5	Industrial Production: Nondurable Materials
7	IPDCONGD*	1959:01-2014:12	5	Industrial Production: Durable Goods
8	IP.B51110.S*	1959:01-2014:12	5	IP: Automotive products
9	IPNCONGD*	1959:01-2014:12	5	Industrial Production: Nondurable Goods
10	IP.B52000.S*	1959:01-2014:12	5	Industrial Production: Business Equipment
11	IP.B51220.S*	1959:01-2014:12	5	IP: Consumer Energy Products
Employment and hours				
12	MANEMP*	1959:01-2014:12	5	All Employees: Manufacturing
13	PAYEMS*	1959:01-2014:12	5	Total Nonfarm Payrolls: All Employees
14	SRVPRD*	1959:01-2014:12	5	All Employees: Service-Providing Industries
15	USGOOD*	1959:01-2014:12	5	All Employees: Goods-Producing Industries
16	USGOVT*	1959:01-2014:12	5	All Employees: Government
17	USPRIV*	1959:01-2014:12	5	All Employees: Total Private Industries
18	CES909101*	1959:01-2014:12	5	Employment Federal Government
19	CES909201*	1959:01-2014:12	5	Employment State government
20	CES909301*	1959:01-2014:12	5	Employment Local government
21	DMANEMP*	1959:01-2014:12	5	All Employees: Durable Goods Manufacturing
22	NDMANEMP*	1959:01-2014:12	5	All Employees: Nondurable Goods
23	USCONS*	1959:01-2014:12	5	All Employees: Construction
24	USEHS*	1959:01-2014:12	5	All Employees: Education & Health Services
25	USFIRE*	1959:01-2014:12	5	All Employees: Financial Activities
26	USINFO*	1959:01-2014:12	5	All Employees: Information Services
27	USLAH*	1959:01-2014:12	5	All Employees: Leisure & Hospitality
28	USMINE*	1959:01-2014:12	5	All Employees: Natural Resources & Mining
29	USPBS*	1959:01-2014:12	5	All Employees: Professional & Business
30	USSERV*	1959:01-2014:12	5	All Employees: Other Services
31	USTPU*	1959:01-2014:12	5	All Employees: Transportation & Utilities
32	USTRADE*	1959:01-2014:12	5	All Employees: Retail Trade
33	USWTRADE*	1959:01-2014:12	5	All Employees: Wholesale Trade
34	CE160V*	1959:01-2014:12	5	Employees Total (Household Survey)
35	CLF16OV*	1959:01-2014:12	5	Civilian Labor Force
36	LNS1130000*	1959:01-2014:12	2	Labor Force Participation Rate (16 Over)
37	LNS1400000*	1959:01-2014:12	2	Urate
38	URATE_ST*	1959:01-2014:12	2	Urate Short Term (< 27 weeks)
39	URATE_LT*	1959:01-2014:12	2	Urate Long Term (>= 27 weeks)
40	LNS1400012*	1959:01-2014:12	2	Unemployment Rate - 16-19 yrs
41	LNS1400025*	1959:01-2014:12	2	Unemployment Rate - 20 yrs. & over Men
42	LNS1400026*	1959:01-2014:12	2	Unemployment Rate - 20 yrs. & over Women
43	LNS1300839*	1959:01-2014:12	5	Number Unemployed for Less than 5 Weeks
44	LNS1308756*	1959:01-2014:12	5	Number Unemployed for 5-14 Weeks
45	UEMP15T26*	1959:01-2014:12	5	Civilians Unemployed for 15-26 Weeks
46	LNS1308516*	1959:01-2014:12	0	Number Unemployed for 15 Weeks & over
47	LNS1308636*	1959:01-2014:12	5	Number Unemployed for 27 Weeks & over
48	LNS1203219*	1959:01-2014:12	5	Employment Level - Part-Time
49	AWHMAN*	1959:01-2014:12	1	Average Weekly Hours: Manufacturing
50	AWOTMAN*	1959:01-2014:12	2	Average Weekly Hours Overtime Manufacturing

51	A0M046*	1959:01-2014:12	1	Index of Help-Wanted Advertising
Housing starts and sales				
52	HOUST	1959:01-2014:12	5	Housing Starts: New Privately Owned Housing Started
53	NONRESIDC	1959:01-2014:12	5	Nonresidential construction spending
54	HOUSTMW	1959:01-2014:12	5	Housing Starts in Midwest Census Region
55	HOUSTNE	1959:01-2014:12	5	Housing Starts in Northeast Census Region
56	HOUSTS	1959:01-2014:12	5	Housing Starts in South Census Region
57	HOUSTW	1959:01-2014:12	5	Housing Starts in West Census Region
Real inventories ,orders and unfilled orders				
58	A0M007	1959:01-2014:12	5	Mfrs' new orders durable goods industries
59	A0M008	1959:01-2014:12	5	Mfrs' new orders consumer goods and materials
60	A1M092	1959:01-2014:12	5	Mfrs' unfilled orders durable goods
61	NAPMSDI	1959:01-2014:12	1	ISM Manufacturing: Supplier Deliveries Index
62	A0M027	1959:01-2014:12	5	Mfrs' new orders nondefense capital goods
63	A0M070	1959:01-2014:12	5	Manufacturing and trade inventories
64	NAPMII	1959:01-2014:12	1	ISM Manufacturing: Inventories Index
65	MTESTUS1	1959:01-2014:12	5	U.S. Ending Stocks excluding SPR of Crude Oil and Petroleum Products
66	MTESTUS1_SA	1959:01-2014:12	5	U.S. Ending Stocks excluding SPR of Crude Oil and Petroleum Products
67	NAPMNOI	1959:01-2014:12	1	ISM Manufacturing: New Orders Index
68	A0M057	1959:01-2014:12	5	Manufacturing and trade sales
69	A0M059	1959:01-2014:12	5	Sales of retail stores
Consumption				
70	PCEPI*	1959:01-2014:12	5	Personal Consumption Expenditures: Chain-type Price Index
71	PCEPILFE*	1959:01-2014:12	5	Personal Consumption Expenditures: Less Food and Energy
Price index				
72	PPIACO	1959:01-2014:12	5	Producer Price Index: All commodities
73	WPU0561*	1959:01-2014:12	5	PPI: Crude Petroleum
74	CPIGAS	1959:01-2014:12	5	CPI Gasoline
75	PPIFGS*	1959:01-2014:12	5	Producer Price Index: Finished Goods
76	PPIFCF*	1959:01-2014:12	5	Producer Price Index: Finished Consumer Foods
77	PPIFCG*	1959:01-2014:12	5	Producer Price Index: Finished Consumer Goods
78	PPIIDC*	1959:01-2014:12	5	Producer Price Index: Industrial Commodities
79	PPIITM*	1959:01-2014:12	5	Producer Price Index: Intermediate Materials: Supplies & Components
80	A0M099*	1959:01-2014:12	5	Index of Sensitive Materials Prices (Discontinued)
81	PSCCOM *	1959:01-2014:12	5	Spot Market Price Index: BLS & CRB: All Commodities
82	NAPMPRI*	1959:01-2014:12	1	ISM Manufacturing: Prices Paid Index
83	CPIAUCSL*	1959:01-2014:12	5	Consumer Price Index For All Urban Consumers: All Items
84	CPILFESL*	1959:01-2014:12	5	Consumer Price Index for All Urban Consumers: Less Food & Energy
Average hourly earnings				
85	LEHCC*	1959:01-2014:12	5	Average Hourly Earnings: Construction
86	LEHM*	1959:01-2014:12	5	Average Hourly Earnings: Manufacturing
Interest rates				
87	AAA	1959:01-2014:12	2	Moody's Seasoned Aaa Corporate Bond Yield
88	BAA	1959:01-2014:12	2	Moody's Seasoned Baa Corporate Bond Yield
89	FEDFUNDS	1959:01-2014:12	2	Effective Federal Funds Rate
90	CPF3M	1959:01-2014:12	2	3-Month AA Financial Commercial Paper Rate post 1997
91	CP90_Tbill	1959:01-2014:12	1	CP3FM-TB3MS
92	GS1	1959:01-2014:12	2	1-Year Treasury Constant Maturity Rate
93	GS10	1959:01-2014:12	2	10-Year Treasury Constant Maturity Rate
94	TB3MS	1959:01-2014:12	2	3-Month Treasury Bill Rate
95	TB6MS	1959:01-2014:12	2	6-Month Treasury Bill Rate
96	AAA_GS10	1959:01-2014:12	1	Aaa-GS10 Spread
97	BAA_GS10	1959:01-2014:12	1	Baa-GS10 Spread
98	tb6m_tb3m	1959:01-2014:12	1	tb6m-tb3m
99	GS1_tb3m	1959:01-2014:12	1	GS1_Tb3m
100	GS10_tb3m	1959:01-2014:12	1	GS10_Tb3m
Money and credit quantity aggregates				
101	BUSLOANS	1959:01-2014:12	5	Commercial and Industrial Loans
102	CONSUMER	1959:01-2014:12	5	Consumer (Individual) Loans
103	AMBSL	1959:01-2014:12	5	St. Louis Adjusted Monetary Base;
104	M1SL	1959:01-2014:12	5	M1 Money Stock

105	M2SL	1959:01-2014:12	5	M2 Money Stock
106	MZMSL	1959:01-2014:12	5	MZM Money Stock
107	NONBORRES	1959:01-2014:12	5	Reserves Of Depository Institutions Non-borrowed
108	NONREVSL	1959:01-2014:12	5	Total Non-revolving Credit Outstanding
109	REALLN	1959:01-2014:12	5	Real Estate Loans at All Commercial Banks
110	TOTRESNS	1959:01-2014:12	5	Total Reserves of Depository Institutions
111	TOTALSL	1959:01-2014:12	5	Total Consumer Credit Outstanding
Stock prices				
112	FSPCOM	1959:01-2014:12	5	S&P Common Stock Price Index: Composite
113	FSDJ	1959:01-2014:12	5	Common Stock Prices: Dow Jones Industrial
Exchange rate				
114	TWEXMMTH	1959:01-2014:12	5	FRB Nominal Major Currencies Dollar Index
Consumer Expectation				
115	U0M083	1959:01-2014:12	1	Consumer expectations NSA