

# Analysis on the dynamic effects of the aggregate supply, aggregate demand and macroeconomic policies of china based on SVAR model

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Received 1 March 2014, www.tsi.lv

## Abstract

After studying the financial crisis using the AS-AD model and the SVAR model, the paper analyses the dynamic effects of the aggregate supply, aggregate demand and macroeconomic policies of China. Then, combining the real macroeconomic environment of China at present, the paper discusses the Keynesian AD-AS model, gives the constraint conditions of SVAR model according to the economic meaning of China, makes an empirical study based on five selected variables including supply, demand, fiscal expenditure, monetary expenditure and interest rate and their monthly data correspondingly, and lastly analyses the results of empirical study to make recommendations on current macroeconomic policy adjustment of China.

*Keywords:* AD-AS model, SVAR model, impulse response, variance analysis

## 1 Introduction

The financial crisis caused by American sub-prime mortgage crisis in 2007 had different shocks to economies of different countries in different degrees from different channels. During the financial crisis, many scholars, at home or abroad, studied the effects on Chinese economic fluctuations focusing on the effect issue of fiscal policy & monetary policy and exogenous shocks. Main document researches are as follows: Wenfu W [1] studied the dynamic shock effects of government expenditure on total output, social investment and resident consumption using a structural vector auto regression (SVAR) model and came to a conclusion that government expenditure had a positive effect on total output and a complementary effect on social investment and residents' consumption. Qiang D [2] built a dynamic stochastic general equilibrium model based on financial accelerator theory to study external shock effects during economic fluctuations with the quarterly data of China. Numerical simulation results consisted with real economic operation and thus had a strong explanatory power to the fluctuation of output and investment in real economy. He draw such a conclusion that shocks of exchange rate and foreign demand had an obvious dual function: the appreciation of RMB had a greater adverse impact, while the recession in foreign demand was not as terrible as imagined. Chinese economy would rise from the bottom by expanding domestic demand. Within a M-F model framework, Rong L [3] introduced the conclusion of the classic paper of Bernanke & Blinder

[20] to build an economic structure model of China and established a SVAR model under the model to estimate the dynamic adjustment characteristics of economic system. He calculated the overall pulling effect of current round of expansionary monetary policy on economy by impulse response function and then analysed and compared the effects of different channels. In conclusion, most document researches only explored economic fluctuation by focusing on one factor, such as monetary policy, fiscal policy or external shock. Research literatures of domestic and foreign scholars on the dynamic effects of aggregate supply, aggregate demand and macroeconomic policy in Chinese economic fluctuations are few.

American subprime mortgage crisis has inflicted a severe impact on Chinese economy. The fluctuations and instability of Chinese economy require the government to take active measures to adjust economy correspondingly. Under current market economy conditions, the government makes macroeconomic regulations with *The General Theory of Employment, Interest, and Money* of Keynes as the source of theory. Keynes proposed macro-control policies of fiscal policy and monetary policy for market imbalance and economic fluctuation. For either policy, the goal is demand management, which is fixing market imbalance by regulating aggregate supply – aggregate demand. Any regulation & control theory is based on corresponding theory and model describing macroeconomic fluctuations. As to Keynes' theory, its main idea describing macroeconomic fluctuations can be reflected in the famous AS-AD model.

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After studying the financial crisis using an AS-AD model and a SVAR model, the paper analyses the dynamic effects of the aggregate supply, aggregate demand and macroeconomic policy in Chinese economy. AS-AD-model-based SVAR theoretical research literatures are as follows: Min G [5] estimated a SVAR model containing output and price level based on the AS-AD model to reveal the changes of AS-AD forces driving Chinese economic fluctuations during 1996-2005; Jian G [6] built an AS-AD model with Chinese characteristics and estimated & tested the model using quarterly data. Researches show that the macroeconomic model with Keynes characteristics can explain the economic fluctuations in China to some degree. The paper first uses Jian G's [6] AS-AD model with Chinese characteristics and Wenfu W's theoretical analytical framework for reference and then improves the model on this basis. Jian G estimated the equation using Cochrane-Orcutt program and LSM; while the paper makes estimations using a SVAR model and the SVAR model is a structured VAR model. The VAR model is modelling based on the statistical property of data and building the model using each endogenous variable as the function of lagged value of all the endogenous variables in the system, thus extending the single-variable autoregressive model to a vector autoregressive model composed by multivariate time series variables. VAR model does not give the exact form of current correlation among variables, that is, there is no current value of endogenous variables in the right hand of model. Current correlations hide in the related structure of error term and cannot be explained, so the structured VAR model placing the current value of endogenous variable into the right had of model, i.e. the SVAR model, can reduce estimated parameters by imposing constraint conditions to the parameter space. Next, the empirical study of Min G [5] only analysed the shock effects of aggregate supply and aggregate demand in Chinese economic fluctuations. When Wenfu W tested the matching or applicability of Keynesian AD-AS model in China, he only selected four variables of supply, demand, fiscal expenditure and monetary expenditure and used quarterly data as the endogenous variables of SVAR model without regarding the variable of interest rate, in which case the persuasiveness of conclusion was weakened to some degree in the empirical analysis. Facts proved that since 2007 the People's Bank of China (PBOC) has exercised low control and regulation to interest rate. Currently, PBOC controls loan interest rate ceiling & floor, and other market interest rates are almost open, such as the monetary market, constant return interest rate and inter-bank rate, which are all open. In 2007, Shanghai Interbank Offered Rate (SHIBOR) was established as a reference rate. On this basis, when selecting variables, besides four variables of supply, demand, fiscal expenditure and monetary expenditure, the paper also adds interest rate into the endogenous variables of SVAR model; in addition, the literature empirical researches mentioned above all used quarterly

data as the object of study, but the SVAR model in the paper only considers short-term restraints and the characteristics of macroeconomic policy and selected monthly data for empirical analysis. At last, basing on a SVAR theoretical research, the paper discusses Keynesian AD-AS model combining the real macroeconomic environment in China at present, proposes the constraint conditions of SVAR model according to the economic meaning of China, recognizes SVAR structural equation form from VAR simple equation form, and makes an empirical analysis using the monthly data from September of 2008 to February of 2012, thus is of innovation.

The structure of the paper is as follows: the second section discusses Keynesian AD-AS model; the third section analyses the shock effects of supply, demand and macroeconomic policy on Chinese economic fluctuations using the data from September of 2008 to February of 2012 and a modified AS-AD model through the impulse response function and variance decomposition means; the fourth section gives a conclusion and recommendations.

## 2 Discussions on Keynesian AD-AS Model

Within the basic framework of real business cycle theory and using AS-AD model as a major analysis tool, the section discusses traditional AS-AD model combining the real economic background in China currently to make the modified AD-AS model match the real economic background of China currently.

### 2.1 CURVE FUNCTION OF AGGREGATE SUPPLY

Generally, the aggregate supply curve is expressed as:

$$p_t = AS(p_{t-1}^e, y_{t-1}), \quad (1)$$

where  $y_t$  represents GDP,  $p_t$  represents the general price level in period  $t$  and subscript  $t$  is time,  $p_{t-1}^e$  represents the expected value of price level of period  $t$  during period  $t-1$ ,  $y_{t-1}$  represents the total output in period  $t-1$  and first derivative  $AS'_p > 0$ ,  $AS'_y > 0$  means price level is decided by output and expected price level and aggregate supply is their increasing function respectively. For the expectation  $p_{t-1}^e$ , many literature researches try to make an explanation using a rational expectation hypothesis, but a lot of empirical researches don't support the hypothesis [15-17]. According to Keynesian adaptive expectation principles, the expectation on price can be identified as  $p_{t-1}^e = f(p_{t-1})$ , and then Chinese aggregate supply function is:

$$p_t = AS(p_{t-1}, y_{t-1}). \quad (2)$$

Make a Taylor series expansion to equation (2), and after a linear approximation it can be expressed as:

$$p_t = \beta_0 + \beta_p p_{t-1} + \beta_y y_{t-1} + \theta_t, \tag{3}$$

where  $\beta_0$  is a constant,  $\beta_p$  and  $\beta_y$  are coefficients and  $\theta_t$  represents the changes of aggregate supply or price.  $\{\theta_t\}_{t=0}^\infty$  is a random walk process, i.e.,  $\theta_t = \theta_{t-1} + u_t^s$ , where  $u_t^s$  is supply shock or price shock, the cost factor shock affecting price, such as the price rise of raw materials of bulk commodity.  $\{u_t^s\}_{t=1}^\infty$  is an independent identically distributed random process where  $u_t^s$  follows normal distribution  $N(0, \sigma_s^2)$ .  $\sigma_s^2$  represents the variance of supply shock.

2.2 CURVE FUNCTION OF AGGREGATE DEMAND

Aggregate demand curve comes from the famous IS-LM model. Traditionally, the model is expressed as:

$$y_t = IS(r_t, d_t), \tag{4}$$

$$\frac{M_t}{p_t} = LM(y_t, r_t). \tag{5}$$

In the equation,  $r_t$  is the interest rate of period  $t$ ,  $d_t$  is fiscal policy variable,  $M_t$  is nominal money supply (in which case  $m_t = M_t / p_t$  is real money supply), and  $IS_r' < 0$ ,  $IS_d' > 0$ ,  $LM_y' > 0$ ,  $LM_r' < 0$ . IS equation decides the equation of output, which is the aggregate social demand decided by consumption demand, investment demand and government expenditure demand, may be adding net export demand. LM equation reflects market equilibrium which means real money supply equals to real currency demand. The aggregate demand curve got by solving Equation (3) and (4) and is as follows:

$$y_t = AD(m_t, d_t), \tag{6}$$

where  $m_t = M_t / p_t$  and  $AD_m' > 0$ ,  $AD_d' > 0$ . In the equation, assume money supply is exogenous, while interest rate is endogenously determined by the balance of currency market. However, in western countries, as the evolution and development of modern financial and banking system, the increase in money supply is more and more decided by the money demand generated from the demand for production and circulation within economic society. That is, PBOC can affect interest rate by monetary policy tool and then affect the cost of money supply, but it cannot control money supply at will.

Therefore, whether from the perspective of the basic model of modern money supply or from the perspective of the development of money supply theory, money supply is significantly endogenous. In the empirical analysis of Jing W [8], the data from quarter 2 of 2001 to quarter 2 of 2011 indicated that Chinese money supply showed more and more endogenous property and the existing compulsory settlement & sales system in China must be reformed to promote interest rate liberalization reform actively.

In addition to the endogeneity of money supply and interest rate, the lagging effect of monetary policy and fiscal policy on economy is also taken into consideration, and together with prior revenue's effect on current demand, so the aggregate demand curve equation of China can be expressed as:

$$y_t = AD(y_{t-1}, m_{t-1}, d_{t-1}), \tag{7}$$

where  $AD_m' > 0$ ,  $AD_d' > 0$ . Make a Taylor series expansion to equation (6) and the expression after linear approximation is:

$$y_t = \lambda_0 + \lambda_m m_{t-1} + \lambda_d d_{t-1} + \lambda_y y_{t-1} + u_t^y. \tag{8}$$

In the expression,  $\lambda_0$  is a constant and constant coefficient  $\lambda_m > 0$ ,  $\lambda_d > 0$ ,  $\lambda_y < 0$ .  $u_t^y$  is the aggregate demand shock in period  $t$ .  $\{u_t^y\}_{t=1}^\infty$  is an independent identically distributed random process.  $u_t^y$  follows normal distribution  $N(0, \sigma_d^2)$ .  $\sigma_d^2$  represents the variance of demand shock.

2.3 POLICY RESPONSE FUNCTION

We first discuss the response function of fiscal policy. The change rule of  $d_t$  can be expressed as:

$$d_t = \delta_0 + \delta_y y_t + \delta_p p_t + \delta_d d_{t-1} + u_t^d. \tag{9}$$

In the equation,  $\delta_0$  is a constant and constant coefficient  $\delta_y < 0$ ,  $\delta_p < 0$ ,  $\delta_d < 0$ .  $u_t^d$  is the government expenditure shock in period  $t$  following normal distribution  $N(0, \sigma_d^2)$ .  $\{u_t^d\}_{t=1}^\infty$  is an independent identically distributed random process.  $\sigma_d^2$  represents the variance of government expenditure shock. The rule indicates that when output or price rises, fiscal policy will be restrained, and vice versa.

The next is the response function of monetary policy. When money supply is endogenous, money aggregate is endogenous in economic operation and decided jointly by the subjects of social economic activities, rather than an

exogenous variable decided and controlled by governmental monetary authority (PBOC). Similar to equation (8), money supply rule has the following form:

$$m_t = \theta_0 + \theta_y y_t + \theta_p p_t + \theta_d d_t + \theta_m m_{t-1} + u_t^m \tag{10}$$

In the equation,  $\theta_0$  is a constant and constant coefficients  $\theta_y < 0$ ,  $\theta_p < 0$ ,  $\theta_d > 0$ ,  $\theta_m < 0$ .  $u_t^m$  is the money supply shock of PBOC in period  $t$ .  $\{u_t^m\}_{t=1}^\infty$  is an independent identically distributed random process.  $u_t^m$  follows normal distribution  $N(0, \sigma_m^2)$ .  $\sigma_m^2$  represents the variance of money supply shock.

Last, we discuss the rule of interest rate. Interest rate is generally endogenous, but when money supply is endogenous, it is difficult for PBOC to realize money supply rule using monetary policy tools (such as open-market operation, discount rate, reserve ratio, etc.). In fact, the central banks of many developed countries currently have given up money supply rule and use the indicator of interest rate as the intermediate target more frequently, and the so called Taylor rule (interest rate rule) is generated there from.

$$r_t - r_{t-1} = \phi_0 + \phi_1 (r_{t-1} - r^*) + \phi_y (y_t - y^*) + \phi_p (p_t - p^*) \tag{11}$$

In the equation,  $\phi_1 < 0$ ,  $\phi_y < 0$ ,  $\phi_p < 0$ .  $r^*$ ,  $y^*$  and  $p^*$  can be interpreted as the targets of interest rate, output and price. The rule indicates that when a target deviates, interest rate will be adjusted [10, 18].

According to equation (11), it is simplified into the following form:

$$r_t = \omega_0 + \omega_r r_{t-1} + \omega_y y_t + \omega_p p_t + u_t^r \tag{12}$$

where the interest rate impact is  $u_t^r$  in period  $t$ ,  $\{u_t^r\}_{t=1}^\infty$  is an independent identically distributed random process,  $u_t^r$  follows normal distribution  $N(0, \sigma_r^2)$  and  $\sigma_r^2$  represents the variance of interest rate shock.

Because China is in a critical period of interest rate rule transition currently, according to the characteristics of transitional economy, either money supply or interest rate can be considered as a policy variable. Therefore, Chinese money policy can be presented as the implementation of both rules that is using money supply rule (10) and interest rate rule (12) simultaneously [11].

To sum up, for Chinese economic fluctuation currently, formula (3) represents aggregate supply curve; formula (8) represents aggregate demand curve; formulas (9), (10) and (12) represents the policy response rules of fiscal policy, monetary policy and interest rate rule.

According to the methods of Blanchard [19], Blanchard & Quah [21] and Gali [14], the following difference equation can be got from Equation (3), (8), (9), (10) and (11):

$$\Delta p_t = \beta_0 + \beta_p p_{t-1} + \beta_y y_{t-1} + \theta_t^p \tag{13}$$

$$\Delta y_t = \lambda_m \Delta m_{t-1} + \lambda_d \Delta d_{t-1} + \lambda_y \Delta y_{t-1} + u_t^y - u_{t-1}^y \tag{14}$$

$$\Delta d_t = \delta_y \Delta y_{t-1} + \delta_p \Delta p_{t-1} + \delta_d \Delta d_{t-1} + u_t^d - u_{t-1}^d \tag{15}$$

$$\Delta m_t = \theta_y \Delta y_{t-1} + \theta_p \Delta p_{t-1} + \theta_d \Delta d_{t-1} + \theta_m \Delta m_{t-1} + u_t^d - u_{t-1}^d \tag{16}$$

$$\Delta r_t = w_r \Delta r_{t-1} + w_y \Delta y_{t-1} + w_p \Delta p_{t-1} + u_t^r - u_{t-1}^r \tag{17}$$

The following equation form can be obtained from formulas (13) ~ (17).

$$\begin{bmatrix} \Delta p_t \\ \Delta y_t \\ \Delta d_t \\ \Delta m_t \\ \Delta r_t \end{bmatrix} = \begin{bmatrix} d_{11}(L) & d_{12}(L) & d_{13}(L) & d_{14}(L) & d_{15}(L) \\ d_{21}(L) & d_{22}(L) & d_{23}(L) & d_{24}(L) & d_{25}(L) \\ d_{31}(L) & d_{32}(L) & d_{33}(L) & d_{34}(L) & d_{35}(L) \\ d_{41}(L) & d_{42}(L) & d_{43}(L) & d_{44}(L) & d_{45}(L) \\ d_{51}(L) & d_{52}(L) & d_{53}(L) & d_{54}(L) & d_{55}(L) \end{bmatrix} \begin{bmatrix} u_t^s \\ u_t^y \\ u_t^d \\ u_t^m \\ u_t^r \end{bmatrix} \tag{18}$$

where  $d_{ij}$  ( $i, j=1, \dots, 5$ ) represents a lagging polynomial. The economic meaning of equation (18) is the theoretical basis of the empirical analysis in the paper and the empirical analysis is made by considering the five variables of  $\Delta p_t$ ,  $\Delta y_t$ ,  $\Delta d_t$ ,  $\Delta m_t$ ,  $\Delta r_t$  as the endogenous variables of SVAR model.

### 3 AD-AS Model Empirical Analysis in Chinese Macroeconomic Fluctuations

#### 3.1 SAMPLE SELECTION AND VARIABLE DEFINITION

The financial crisis can be divided into three stages of development: from sub-prime mortgage crisis to financial crisis, from financial crisis to the spread of substantial economy, and the financial market volatility again since 2010. In the second stage when the financial crisis happened, Chinese government adjusted macroeconomic policy immediately from the tight monetary policy and prudent fiscal policy of 2007 to the macroeconomic economy of keeping stable economic development & controlling price hikes in August of 2008, and to the proactive fiscal policy & moderately loose monetary policy in November of 2008. Because the object of study in the paper is analysing the dynamic effects of aggregate supply, aggregate demand and economic policy when China introduced economic policies successively after the crisis, the second stage's starting point, i.e. September of

2008, is the starting point of the data selected in the paper.

The data selected are monthly data of the following variables from September of 2008 to February of 2012 from the source of RESSET/DB. In the empirical part, five endogenous variables of GDP growth rate, inflation rate, monetary growth rate, fiscal expenditure and interest rate are selected. Because there is no monthly data on GDP growth rate, the paper uses monthly industrial growth rate as the substitution for monthly GDP growth rate  $y_t$ . Inflation rate  $p_t$  is calculated using consumer price indexes (CPIs) with the formula Inflation Rate= (Current CPI-Base CPI)/Base CPI. Monetary growth rate  $m_t$  is a narrow monetary growth rate. Fiscal expenditure variable  $d_t$  can be calculated with the formula (Fiscal Expenditure-Fiscal Revenue)/Aggregate Fiscal Expenditure. Interest rate  $r_t$  is Shanghai interbank offered monthly rate.

### 3.2 QUANTITATIVE TEST OF AS-AD AND MACROECONOMIC POLICY OF CHINESE ECONOMY AFTER FINANCIAL CRISIS

#### 3.2.1 Test of VAR Model Lag Structure

We first inspect the chart of AR root. As shown in Figure 1, the all the inverse roots of estimated VAR model is in the unit circle, i.e. <1, indicating a stable state and meeting the conditions of pulse response analysis and variance analysis.

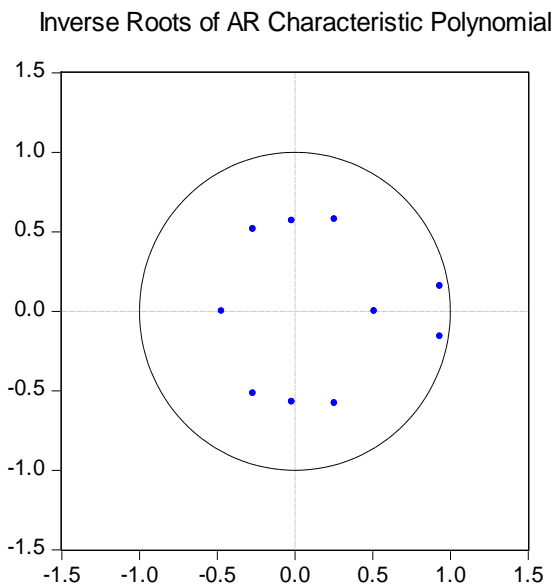


FIGURE 1 VAR Model Stationary Inspection

Next, the paper uses ADF (Augmented Dickey-Fuller) method to make a stationary test to each sequence and corresponding first difference sequence. Test results are shown in table 1. In the ADF test of original sequence,  $d_t$ 's simple-root statistic -6.982528 is less than -2.935001, ADF critical value with a significance level of 5%, so variable  $d_t$  passes the test. Similarly,  $m_t$  also passes the

test. Other variables fail the ADF test. Then we make the first-difference test. As in table 2 all the variables pass the ADF test, indicating the first difference is stationary.

TABLE 1 ADF Test of Sequence and Its First Difference Sequence

Variable	ADF Test				Result
	1% level	5% level	t-Statistic	Prob*	
$d_t$	-3.600987	-2.935001	-6.982528	0.0000	Stationary
$m_t$	-3.600987	-2.935001	-6.849287	0.0000	Stationary
$p_t$	-3.600987	-2.935001	-1.831882	0.3603	Non-stationary
$r_t$	-3.600987	-2.935001	-0.452598	0.8901	Non-stationary
$y_t$	-3.600987	-2.935001	-3.513982	0.0125	Non-stationary
$Dd_t$	-3.632900	-2.948404	-5.653387	0.0000	Stationary
$Dm_t$	-3.610453	-2.938987	-10.84507	0.0000	Stationary
$Dp_t$	-3.605593	-2.936942	-5.556035	0.0000	Stationary
$Dr_t$	-3.610453	-2.938987	-4.001337	0.0000	Stationary
$Dy_t$	-3.615588	-2.941145	-5.763493	0.0000	Stationary

Table 1 shows that each sequence is first-difference stationary, which means each sequence is a first-difference single integration sequence. Therefore, there is a need to make a co-integration test to the variables contained in the model. We use Johansen co-integration test to check if the model has a co-integration relationship. The result shows that 5 co-integration equations exist under the significance levels of 1%~5% and the endogenous variables in the model have a co-integration relationship.

At last, we determine lag order. VAR equation is tested and the result shows that the optimal lag order k is selected according to AIC criteria, SC criteria and LR criteria. Results show that the optimal orders from two information criteria are different. AIC rules suggest selecting lag period 4; SC information criteria suggest selecting period 1; LR test suggests period 4. Because AIC and LR rules both select lag period 4, we finally selected the form of lag period 4, i.e.  $p=4$ .

#### 3.2.2 SVAR Model Recognition Constraint Condition

On the theoretical basis of AD-AS model analysis, we select five endogenous variables of the measurement models in the paper. The five variables are industrial growth rate  $y_t$ , which is a substitution for monthly GDP growth rate, inflation rate  $p_t$ , monetary growth rate  $m_t$ , fiscal policy variable  $d_t$  and interest rate  $r_t$ .

The short-term constraints of structured VAR are generally based on AB-type SVAR model. It means A & B are 5x5 invertible matrices and satisfy:

$$A\varepsilon_t = B\mu_t, t=1,2,\dots,T. \tag{19}$$

The recognition conditions are parameters that can estimate the structural formula model only when imposing  $k(k-1)/2=10$  constraint conditions. The constraint conditions are either in the same period (short-term) or long-term [12].



About the constraint conditions of SVAR model in the paper, we give the following five assumptions according to Equation (13) - (17) and their economic meaning. 1) Current GDP growth rate, current fiscal expenditure, current monetary growth rate and current interest rate have no effect on current inflation rate. 2) The changes of current inflation rate affect the changes of current GDP growth rate. Fiscal policy and monetary policy have a time lag, so the changes of government expenditure and monetary growth rate do not affect GDP growth rate in current period. In the short run, interest rate does not affect GDP growth rate. 3) Current fiscal expenditure is only affected by current inflation rate, current GDP growth rate and self shock but not monetary policy and interest rate. 4) Monetary policy is affected by current inflation rate, current GDP growth rate, current government expenditure changes and the self shock of current monetary growth rate but not current interest rate. 5) Current interest rate is affected by the shocks of current inflation rate, current GDP growth rate and interest rate changes.

3.2.3 Estimate Structure Factors

Basing on the recognition model of equation (19), the paper selects SVAR model's endogenous vector  $\mu_t = [\Delta p_t, \Delta y_t, \Delta d_t, \Delta m_t, \Delta r_t]$ , where the first difference sequence of monthly  $p_t, y_t, d_t, m_t$  and  $r_t$  represents the time series corresponding to  $\Delta p_t, \Delta y_t, \Delta d_t, \Delta m_t$  and  $\Delta r_t$ . The disturbing term  $\varepsilon_t$  of simple equation is a five-dimensional vector  $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t}]$ , of which each component is the linear combination of  $u_t^s, u_t^y, u_t^d, u_t^m, u_t^r$ . Therefore,  $\varepsilon_t$  represents a composite shock, and the matrices A & B got are as follows:

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.13 & 1 & 0 & 0 & 0 \\ 0.41 & -1.56 & 1 & 0 & 0 \\ -0.05 & 0.23 & -0.07 & 1 & 0 \\ 0.07 & 0.20 & -0.03 & 0.17 & 1 \end{bmatrix}, \tag{20}$$

$$B = \begin{bmatrix} 1.45 & 0 & 0 & 0 & 0 \\ 0 & 0.26 & 0 & 0 & 0 \\ 0 & 0 & 2.56 & 0 & 0 \\ 0 & 0 & 0 & 0.48 & 0 \\ 0 & 0 & 0 & 0 & 0.27 \end{bmatrix}. \tag{21}$$

Then, according to the recognition principles of SVAR model, we get a structural equation and the results of impulse response function (IRF) and variance decomposition necessary for analysis.

3.2.4 Response Analysis of Impulse Function

IFR describes the effects on endogenous variables' current & future values when adding a one-off shock to a disturbing term.

1) Dynamic Effects of Supply Shock

Figure 2 shows the dynamic response process of output, price level, money supply, interest rate and government expenditure when the aggregate supply has a 1% positive shock. First, we explore price level's response to supply shock. In current period of shock, price level rose immediately by a big margin and then declined continuously and reached the lowest in 5 months. After that, it rose slowly and kept on a stable level in the 26<sup>th</sup> month or so. The final accumulative shock effect is increased. It means the positive shock of supply may cause the rise in price level [26]. Next, we explore output's response to supply shock. Output rose continuously in current period and then declined slowly after the 3<sup>rd</sup> month. It finally reached the lowest in the 5<sup>th</sup> month or so. After that, it rose slightly and reached a stable state in the 20<sup>th</sup> month. The final accumulative shock effect is increased. Then, we explore the dynamic response process of fiscal policy and monetary policy to supply shock. After the supply shock, the accumulative shock effect on government expenditure approximated to zero, an invariant state. Money supply rose slowly in early period and began to decline in the 5<sup>th</sup> month. Then it rose and declined again and reached a stable value after the 12<sup>th</sup> month or so. The final accumulative shock effect is increased. Finally, we explore supply shock effect on interest rate. Interest rate was unchanged in current period and began to decline slowly in the 6<sup>th</sup> month and reached the lowest in the 15<sup>th</sup> month. Then, it reached a stable state. The final accumulative shock effect of supply on interest rate is decreased.

The following conclusion can be drawn from the analysis above: 1) after the financial crisis, aggregate supply has a positive accumulative shock effect on price level, output and money supply; 2) after the financial crisis, the accumulative shock effect of supply on government expenditure approximates to 0, i.e. nearly no supply shock; supply has a negative accumulative shock effect on interest rate. After the financial crisis, America took a quantitative easing policy causing the rise of bulk commodity in international market. China has a high dependency on bulk commodity, such as oil, in world market. The rise in foreign commodity price may cause the increase in Chinese commodity export, thus increasing the export demand of foreign trade in China. On the other hand, the rise in foreign commodity price may reduce Chinese residents' consumption of import commodity and increase the consumption of domestic commodity. In this case, it may result in an increase in the aggregate demand of the whole society. Because of the rise in foreign commodity price, Chinese foreign trade may face large surplus, which may increase the

foreign exchange reserves of China greatly. In a pegged exchange rate system, large foreign exchange reserves may cause a great increase in domestic money supply and then cause the decline of interest rate and the increase in investment and finally result in a demand-pull inflation.

2) *Dynamic Effects of Demand Shock*

When aggregate demand has a positive shock of 1%, output, price level, money supply, interest rate and government expenditure have a dynamic response process to it. First, we explore the demand shock effect on price level. Current price dropped to a value immediately. Then the accumulative response effect of price level rose slowly and continuously. It declined slowly in the 5<sup>th</sup> month or so and began to rise in the 8<sup>th</sup>

month with small fluctuations. It fluctuated during the 8<sup>th</sup> -24<sup>th</sup> month and stabilized after the 24<sup>th</sup> month. It indicates the positive demand shock promotes the rise in price level. Next, we explore output's dynamic response to demand shock. Output rose to a level in current period suffering the demand shock, and then declined continuously. It dropped to the lowest accumulative decline value in the 1<sup>st</sup> month and then rose slowly with fluctuations. It reached the highest in the 5<sup>th</sup> month, dropped slightly and then rose again. It kept stable and constant in the 27<sup>th</sup> month. It means demand shock may help output increase. Then, we explore the responses of government expenditure and money supply to demand shock. Government expenditure rose continuously in current period and reached the top in the 1<sup>st</sup> month or so.

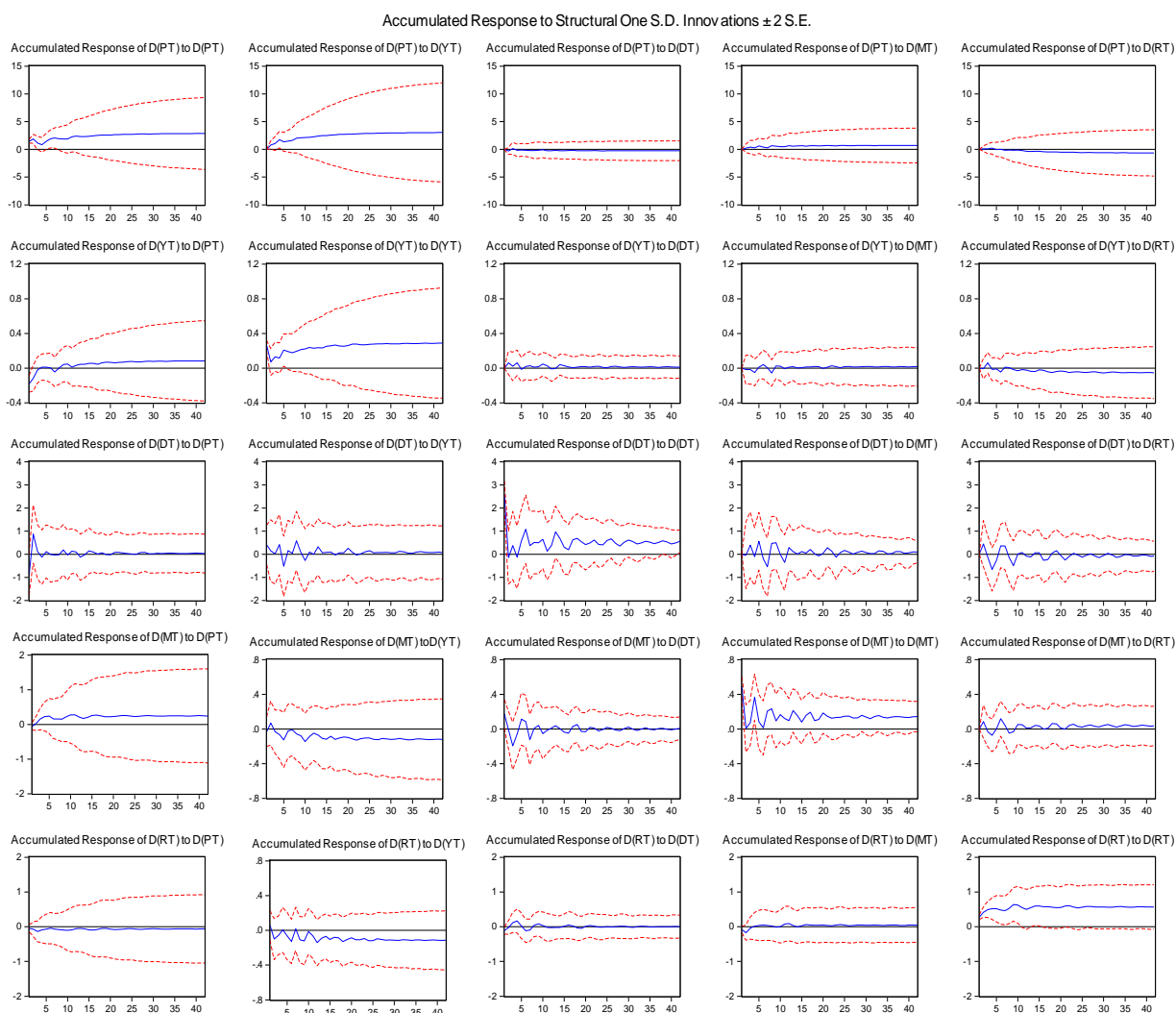


FIGURE 2 Dynamic Effects of Accumulative Shocks among Variables  
(Full line represents impulse response function; dotted line represents  $\pm 2$ -times standard deviation)

Then, it declined continuously and rose slightly. It fluctuated during the 5<sup>th</sup> -27<sup>th</sup> months and reached a stable state in the 27<sup>th</sup> month. Its final accumulative shock effect approximates to 0. Money supply did not change at first in current period. In the 3<sup>rd</sup> month, it declined slightly and

then rose. It reached a stable state approximating to 0 in the 23<sup>rd</sup> month. After the demand shock, interest rate rose slightly in early days, reached the maximum in the 3<sup>rd</sup> month, and then fell. It suffered small fluctuations during the 3<sup>rd</sup>-23<sup>rd</sup> months and reached a stable state after the

23<sup>rd</sup> month. The accumulative shock effect was negative, indicating demand shock may cause interest rate decline. The following conclusion can be drawn from the analysis above: 1) after the financial crisis, demand has positive accumulative shock effects on price level and output; 2) after financial crisis, demand has a negative accumulative shock effect on interest rate and nearly no shock on government expenditure and money supply. The first conclusion consists with AD-AS model's economic meaning that demand increase results in the rise in output and price level, and it consists with the conclusion of Blanchard [19]. When adopting deflation policy after demand shock, demand has slight negative shocks to government expenditure and money supply in a short term but nearly no shock in the long run. The conclusion consists with the economic connotation of Keynesian macro demand management policy. Meanwhile, from table 2 we can see that the contribution of demand shock to output fluctuations is about 50.83%, significantly bigger than the contributions of other four shocks. It consists with Keynesian view that output fluctuations mainly come from the demand shock. Aggregate demand contains investment demand and consumption demand. The fundamental approach to increase effective demand is increasing residents' income steadily, so residents' income can be increased by approaches such as reducing tax or cutting interest rate. Therefore, positive demand shock may cause interest rate decline.

### 3) *Dynamic Effects of Government Expenditure Shock*

This section discusses the dynamic response process of output, price level, money supply, interest rate and government expenditure when government expenditure has a positive shock of 1%. First, we explore level price's response to government expenditure shock. When price level suffered a government expenditure shock of 1%, it rose sharply in current period and reached the highest in the 1.5<sup>th</sup> month or so. Then it dropped continuously and reached the lowest in the 4<sup>th</sup> month. After that, it rose again and suffered fluctuations during the 5<sup>th</sup>-27<sup>th</sup> months. In the 27<sup>th</sup> month, it reached a stable state. The final accumulative shock effect is positive. It indicates that government expenditure may cause the rise in price level. Next, we explore output's dynamic response to government expenditure. After a government expenditure shock of 1%, output rose slightly in current period. Then it dropped slowly continuously, rose slowly and dropped slowly again. It reached the lowest in the 5<sup>th</sup> month and then rose with a small range continuously. It suffered small fluctuations during the 6<sup>th</sup>-38<sup>th</sup> months and reached a stable value in the 38<sup>th</sup> month. The final accumulative shock effect is positive. Then, we explore the dynamic responses of government expenditure and money supply under government expenditure shock. Government expenditure is government's expenditure for random events, such as the external financial crisis of economy and natural hazards like flood or earthquake. In the case of 1% government expenditure shock, government

expenditure rose greatly to a level in current period and then the accumulative effect dropped sharply to the lowest in the 1<sup>st</sup> month. After that, it rose continuously to the highest in the 3<sup>rd</sup> month and then dropped. It suffered small fluctuations during the 4<sup>th</sup> - 42<sup>nd</sup> months and gradually stabilized in the 42<sup>nd</sup> month. As to the dynamic response of money supply, after the government expenditure shock of 1%, money supply rose slightly, dropped and rose again. It suffered small fluctuations during the 2<sup>nd</sup> - 42<sup>nd</sup> months and reaches a stable state after 42 months. It indicates that when suffering a government expenditure shock, government expenditure and money supply will both increase to eliminate the adverse effects in economy. Last, we explore the dynamic response of interest rate to government expenditure shock. When suffering the government shock of 1%, interest rate rose slightly at the beginning. It began to drop slowly in the 2<sup>nd</sup> month and reached the lowest in the 4<sup>th</sup> month. After that, it rose again. It had small fluctuations during the 7<sup>th</sup>-25<sup>th</sup> months and reached a stable state after the 25<sup>th</sup> month. The final accumulative shock effect approximates to 0.

The following conclusion can be drawn from the analysis above: 1) after the financial crisis, government expenditure has positive accumulative shock effects on price level, output, government expenditure and money supply; 2) after the financial crisis, government expenditure has a negative accumulative shock effect on interest rate. To cope with Chinese economic downturn under the impact of international financial crisis, Chinese government began to implement positive fiscal policy in November of 2008, mainly appearing as Chinese government planned to use ¥ 4 trillion government expenditure in advance for railway construction, rural infrastructure construction, social security expenditure, increasing export rebate rate, promotion of fuel oil tax, etc. Government expenditure increased in a short time, i.e. in the first 25 months (09/2008-09/2010), resulting in the increase in aggregate output. Output increase caused the increase in money demand and money market rate (i.e. the rise in capital cost). In this case, marginal cost of production rose and then caused rising prices. As the rise in output and price level, benchmark interest rate began to rise, and money supply began to rise. After 25 months, the effects on aggregate supply and interest rate disappeared and the effects on other economic variables tended to be stable. Keynesianism believes that government expenditure may increase aggregate demand and promote aggregate demand curve to move, thus causing the rise in price level; government expenditure also promotes the increase in output in a short time, which consisting with AD-AS model's economic meaning that government expenditure helps output increase.

### 4) *Dynamic Effects of Money Supply Shock*

The section focuses on the dynamic response process of output, price level, money supply, interest rate and



government expenditure after a 1% positive shock of money supply. First, we discuss price level's dynamic response to money supply shock. After the 1% money supply shock, the accumulative dynamic effect of price level rose slowly at first and then dropped slowly and rose slowly again. It reached a stable state in the 17<sup>th</sup> month or so. The final accumulative shock effect is positive. Then we explore the dynamic response of output to money supply shock. Output dropped with a small range immediately in current period and then rose slightly. It rose to the highest in the 2<sup>nd</sup> month and then dropped slowly. In the 42<sup>nd</sup> month, it reached a stable value. The final accumulative shock effect is negative. The next is the dynamic responses of government expenditure and money supply to money supply shock. When suffering a money supply shock, current money supply rose greatly immediately and then its accumulative effect dropped sharply and reached the minimum in the 1.5<sup>th</sup> month or so. After that, it rose continuously to the maximum in the 5<sup>th</sup> month and then dropped again. It suffered small fluctuations in the 7<sup>th</sup> - 42<sup>nd</sup> months. The final accumulative shock effect is positive. As to the dynamic effects of money supply on government expenditure, government expenditure rose in current period when suffering the shock, and then it dropped continuously and reached the lowest point in the 3<sup>rd</sup> month or so. After that, it rose continuously and began to drop continuously in the 5<sup>th</sup> month. It had small fluctuations during the 7<sup>th</sup> - 24<sup>th</sup> months and finally stabilized in the 24<sup>th</sup> month. The final accumulative shock effect is negative but small. Last, we explore the dynamic response of interest rate to money supply shock. When suffering the money supply shock, interest rate rose slightly and then began to drop in the 2<sup>nd</sup> month and rose again with small fluctuations. It reached a stable state in the 40<sup>th</sup> month. The final accumulative shock effect is positive but small.

The following conclusion can be drawn from the analysis: 1) after the financial crisis, money supply has positive accumulative shock effects on price level, money supply and interest rate; 2) after the financial crisis, money supply has negative accumulative shock effects on output and government expenditure, but the effects are so small that can be neglected. After the financial crisis, to curb Chinese economic decline, PBOC lowered deposit reserve ratio four times from the 17.5% in June of 2008 to the 14.5% in the end of the year, adjusted deposit interest rate in August of 2008 three times from 4.14% falling to 2.25%, and regulated loan interest rate four times from 7.47% falling to 5.31%. According to model estimation, we can see monetary policy has more limited effects on interest rate and government expenditure. That is, in the first eight months, money supply can affect output, but later the effect is very small, and positive monetary policy has a negative shock to output. It indicates monetary policy has limited effects on economy, consisting with AD-AS model's economic meaning. The reason is unobvious effect of monetary policy, and some scholars share the same view [3]. The

effects of money supply on price level are much bigger than on output. The effects of money supply on various variables can be analysed through variance decomposition. As shown in the table, after the 20<sup>th</sup> month, money supply is driving contribution to price level accounts for 8.79% but to output is only 4.46%. The former nearly doubles the latter. It indicates the changes of price almost completely depend on money in the long term. It accords with the principles of economics and can be confirmed by practice. After China adopted easy monetary policies in 2008, economic decline was curbed in a short period, but in the next year of 2011, a serious inflation occurred and money supply shock seemed more act on price level rather than output, causing more difficulties for realizing the multiple objects of monetary policy simultaneously.

##### 5) *Dynamic Effects of Interest Rate Shock*

This section discusses the dynamic response process of output, price level, money supply, interest rate and government expenditure when interest rate has a 1% positive shock. First, let us see the dynamic response of price level to interest rate shock. After the money supply shock of 1%, price level dropped slightly in current period and had small fluctuations during the 0-18<sup>th</sup> months. It reached a stable state in the 18<sup>th</sup> month or so. The final accumulative shock effect is negative. It indicates the positive shock of interest rate may cause the small decline of price level. Second, the dynamic response of output to interest rate shock. Output rose slightly and immediately in current period and then dropped slowly. It had small fluctuations during the 2<sup>nd</sup> - 26<sup>th</sup> months or so and reached a stable value after the 26<sup>th</sup> month. The final accumulative shock effect is negative. It indicates the positive shock of interest rate may cause output decline, consisting with the views of some scholars [3]. Then, the dynamic responses of government expenditure and money supply to interest rate shock. When suffering the interest rate shock, government expenditure declined slightly in current period and then rose slightly. It had small fluctuations during the 3<sup>rd</sup> - 8<sup>th</sup> months. In the 8<sup>th</sup> month, its accumulative effect stayed in a stable value. Its final accumulative shock effect approximates to zero, indicating government expenditure has nearly no change under the positive shock of interest rate. As to the dynamic effects of interest rate on money supply, money supply reduced in current period when suffering the shock and then rose. It reached a stable state in the 3<sup>rd</sup> month. The final accumulative shock effect approximates to zero, indicating that money supply has nearly no change under the positive shock of interest rate. Last, the dynamic responses of market interest rate to interest rate shock. When suffering the interest rate shock, market interest rate rose greatly in current period and then rose slowly. It reached a stable state in the 25<sup>th</sup> month or so, indicating the interest rate shock may cause a sharp increase in the actual interest rate in market.

The following conclusion can be drawn from the analysis above: 1) after the financial crisis, interest rate has negative accumulative shock effects on price level and output; 3) after the financial crisis, the positive shock of interest rate only affects government expenditure for eight months and the effect approximates to 0 later; it only affects money supply for three months and the effect approximates to 0 later; it has a positive accumulative shock effect on interest rate. The reason is the positive interest rate shock (i.e., deflation monetary policy) has negative effects on price level and economy. In case of rate hike, financial institutions may increase the excess reserves depositing in PBOC, and banks' funds for lending decrease, which equalling to reducing money supply. Therefore, there are influences in a short time (i.e., in three months), but no influence in a long time. Interest rate generally does not affect government expenditure, consisting with relevant economic theory.

### 3.2.5 Analysis on the Relative Importance of Shock

Variance decomposition further evaluates the importance of different structural shocks by analysing the contribution of each structural shock to endogenous variable changes (generally measured by variance). Therefore, variance decomposition gives the information on relative importance of each random disturbance affecting the variables in VAR model. Table 2 shows the contribution rate of shocks among variables.

TABLE 2 Variance Decomposition of the Prediction Errors among Variables

Period	Price Level	Output Shock	Government Expenditure	Money Supply	Interest Rate
Aggregate Supply					
Month 1	100.00	0.00	0.00	0.00	0.00
Month 10	58.75	25.11	6.83	7.56	1.75
Month 20	58.38	24.38	7.15	7.89	2.20
Month 30	58.12	24.35	7.22	8.00	2.26
Month 42	58.15	24.34	7.23	8.01	2.27
Aggregate Demand					
Month 1	33.30	66.70	0.00	0.00	0.00
Month 10	25.02	53.36	6.64	7.92	7.07
Month 20	24.92	51.27	8.13	8.33	7.35
Month 30	24.76	50.90	8.31	8.60	7.42
Month 42	24.72	50.83	8.35	8.65	7.46
Fiscal Expenditure					
Month 1	10.39	2.17	87.44	0.00	0.00
Month 10	16.78	8.82	56.88	10.38	7.15
Month 20	15.78	9.29	55.64	11.75	7.54
Month 30	15.54	9.32	55.13	12.22	7.79
Month 42	15.47	9.32	55.03	12.29	7.89
Money Supply					
Month 1	1.18	0.41	11.28	87.15	0.00
Month 10	8.08	3.94	19.42	62.98	5.58
Month 20	8.78	4.40	19.35	61.61	5.85
Month 30	8.81	4.45	19.58	61.08	6.08
Month 42	8.79	4.46	19.64	60.96	6.16
Interest Rate					
Month 1	2.345	3.60	12.82	7.00	74.22
Month 10	3.64	15.10	11.20	11.08	58.99
Month 20	4.12	15.72	9.82	13.16	57.18
Month 30	4.14	15.64	9.64	13.36	57.22
Month 42	4.13	15.59	9.72	13.38	57.18

1) *After the financial crisis, expanding domestic demand became an important means to keep the economic growth of China.*

Table 2 shows, that aggregate supply has an accumulative contribution rate of 58.14% to the deep shock of price level and an accumulative contribution rate of 24.34% to output shock; aggregate demand has an accumulative contribution rate of 24.71% to price level shock and an accumulative contribution level of 50.82 to output shock. Overall, the contribution rate of aggregate demand shock to output is more than twice of aggregate supply's contribution to output. Therefore, after the financial crisis, to improve economic growth, the government must consider expanding domestic demand as a main instrument.

2) *After the financial crisis, proactive fiscal policy curbed the economic decline of China effectively, while easy money policy backfired as to its adjustment to macro economy.*

In table 2, fiscal expenditure has an accumulative contribution rate of 15.47% to price level shock and an accumulative contribution rate of 9.32% to output shock. It indicates that proactive fiscal policy curbed the economic decline of China effectively, but the effect was limited. Positive money supply has an accumulative rate of 8.79% to price level shock and an accumulative rate of 4.45% to output shock. It means in the long term expansionary money policy's shock to price level is twice of that to output (see Figure 2), and positive money supply has a negative shock to output. Therefore, taking expansionary money policy to curb economic decline is just the opposite of the wish and may bring a huge negative effect, i.e., the inflation. Therefore, it is more difficult to achieve economic goals through monetary policy.

3) *During the financial crisis, the reduction of interest rate had limited regulation effects on economy.*

As shown in table 2, interest rate has an accumulative contribution rate of 4.13% to price level shock, an accumulative contribution rate of 15.59% to output shock, an accumulative contribution rate of 9.72% to fiscal expenditure shock, an accumulative contribution rate of 13.38% to money supply and an accumulative contribution rate of 57.18% to interest rate itself. It indicates that interest rate has limited effects on price level and certain effects on output. After the financial crisis, China took policies of interest & interest rate reduction, which curbed economic decline to some extent with limited effects. The conclusion consists with Marxist interest rate's macro policy effect, and PBOC's interest rate policy has a certain asymmetry in its effect. In a period of economic prosperity, because there is a great investment demand and a relative shortage of money, PBOC's interest rate policy has a relative effective regulation result; in a period of economic recession, because there is an insufficient effective demand on

consumption, desired investment declines naturally and enterprise' demand on funds falls with it. Because of investment risk, banks' loan to enterprises also declines and money in the market is sufficient relatively. In this case, it is difficult for PBOC's interest rate policy to work [13]. Therefore, PBOC's interest rate policy should be used in asymmetric operations corresponding to different stages of economic cycle. In an inflation period with overheated economy, the regulation & control should be dominated by interest rate policy instrument; while in a deflation period with economic recession, interest rate policy should be used in conjunction with many policy instruments, such as money supply, credit scale and fiscal policy.

#### 4 Conclusion and recommendations

On the theoretical analysis basis of AS-AD model and using the SVAR model, the paper reveals the dynamic effects of aggregate supply, aggregate demand and macroeconomic policies of China from September of 2008 to February of 2012 under the background of financial crisis.

The paper first analyses the shocks among the variables of aggregate supply, aggregate demand, government expenditure, money supply and interest rate after the financial crisis according to impulse function response, and then draws the following conclusions for analysis: 1) the aggregate supply has positive accumulative shock effects on price level and output; 2) the demand has positive accumulative shock effects on price level and output; 3) the government expenditure has positive accumulative shock effects on output, government expenditure and money supply, and it has negative accumulative shock effects on interest rate, but every shock effect is limited; 4) the money supply has positive accumulative shock effects on price level and negative accumulative shock effects on output; 5) the interest rate has negative accumulative shock effects on output.

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Next, basing on the variance decomposition analysis, the paper makes recommendations on Chinese macroeconomic policy adjustment after the financial crisis. Main conclusions are as follows: 1) expanding domestic demand should be used as an important approach to keep Chinese economic growth currently; 2) the proactive fiscal policies can effectively curb Chinese economic decline, while easy monetary policy may have opposite effects on macro-economic adjustment; 3) interest rate reduction has limited effects on economic regulation & control. Therefore, in the post-crisis era, the proactive fiscal policy adopted by Chinese government plays an important role in keeping sustained and stable economic growth. However, the effects of monetary policies are still controversial among scholars. According to the empirical study in the paper, currently Chinese government should focus on the stability and continuity of fiscal policies and use monetary policies and interest rate adjustment policies flexibly as supplementary tools.

The follow-up study of the empirical analysis in the paper should be improved in three aspects. First, the paper only selects five variables of price level, output, government expenditure, money supply and interest rate as the endogenous variables of SVAR model, but does not take other macroeconomic variables, such as credit, revenue and labour employment into consideration. Second, the paper uses monthly data for the empirical analysis, but Chinese macroeconomic data are only quarterly and some variables even do not have monthly data, which affected the empirical analysis results to some extent, so the selection of monthly-data variables should be further discussed in later period. Third, the modification of AD-AS model under Chinese economic environment should be further studied.

#### Acknowledgements

In the process of writing paper, thanks for the help and guidance of my colleagues and supervisor.

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