THE ANALYSIS ABOUT THE SOURCE OF THE IMPACT ON CHINESE MACROECONOMIC VOLATILITY——
BASED ON DYNAMIC STOCHASTIC GENERAL EQUILIBRIUM MODEL

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ABSTRACT. This paper analyses the main source of Chinese macroeconomic volatility from the two aspects of supply and demand. Upon the new Keynesian theory, the author constructed the dynamic stochastic general equilibrium model with technology shocks, markup shocks, government spending shocks, consumer preferences shocks, interest rate shocks. The main results are as follows. Firstly, the supply shocks are the main reason, explaining economic fluctuation better than the demand shocks. Secondly, the fluctuation of output gap is mainly from demand shocks, while the volatility of output growth is primarily from supply shocks. Thirdly, government consumption has a little influence on economic fluctuation. Then, with some fiscal policy reforms, our industrial structure will have a great development, while economic fluctuations will just change little.

Keywords: Economic Fluctuation; Supply Shocks; Demand Shocks; the Dynamic Stochastic General Equilibrium Model

1. Introduction. Since 1978, for China, there has been great economic volatility with broad scope. At the same time, we can easily find that economic cyclicity exists, just as Figure 1 shows to us. Figure 1 is plotted with the volatility data that is transformed from the statistics between 1978 and 2011 by the way of the logarithmic difference and the HP filter. By constructing varieties of macroeconomic models, many research scholars try to explain the reason for economic fluctuations. However, the conclusions are different. Economic fluctuations have become an important part of macroeconomic research. For a healthy economy, there should not be large volatility. Chinese economy develops faster than developed countries, while, in terms of the stability, China does worse. As for the United States and other developed countries they have a more stable economic entity. At present, China's economy is still far from the "balanced growth path". Then, steady economic growth is particularly important during the critical period of China's economic reform. Until now, there has been a great progress in the field of research on Chinese economic
fluctuations. At the same time, we also have to face the facts that we conclude different causes for economic fluctuations due to different research methods. Some scholars use traditional econometrics methods. For example, based on AD-AS model, Gong Min et al (2007) estimated the structure vector autoregression model containing the output and the price level, in order to reveal the change of Chinese supply and demand forces causing Chinese economic fluctuations. Zhang et al (2005) used Blanchard etc. (1989) method to analyse the origin of Chinese macroeconomic fluctuations by using the quarterly data 1985-2000. Real business cycle theory attributes economic volatility shocks to the technology shocks which reflect the supply shocks. For RBC, domestic scholars also did a lot of work. For example, based on RBC model, Bu Yongxiang, Jin Yan (2002), Chen Kunting, Gong six and Zouheng Fu (2004), Huang Ze Lin (2005), etc. explains the major part of China's economic fluctuations. For China, government plays a very important role in the economy. More and more people begin to use the the new Keynesian DSGE model to study Chinese economy. For example, Li Chunji and Meng Xiaohong (2006) analyze the Chinese macroeconomic fluctuations based on the new Keynesian DSGE model with the Chinese monopolistic competition. Learning from Christiano et al (2007), Tong Bing (2010) constructed a complex DSGE model, the result of impulse response and variance decomposition shows that the main factors of output fluctuation are exogenous demand, investment efficiency, everlasting technology, monetary policy and investment goods price shocks, while the main factors of inflation are the currency impact, markup shocks, investment efficiency and everlasting technology shocks.

As we can see from the above, the ideas about the source of economic fluctuations are different. According to the analysis above, this paper will base the frame of Ireland (2011) and try to construct the new Keynesian model with introducing some shocks such as technology shocks, markup shocks, government spending shocks, consumer preference shock, interest rate shock. Wang Yanwu, Wang Junhai (2011), also introduced these shocks, however, the production function is too idealistic, far from the reality. Guo Lifu, Yao Jian, Gao Tiemei (2013) also constructed the New Keynesian DSGE model with these shocks to analyze the supply and demand shocks using Bayesian estimation method, the only drawback is that the production function is too ideal. Then, in this paper, the C-D production function is used. We use impulse response analysis and variance decomposition techniques to analyze the impact of technology shocks, markup shocks, government spending shocks, consumer preferences shocks, interest rate shocks, on Chinese macroeconomic fluctuations, and to compare the different impact on Chinese economic fluctuations from the two aspects of supply and demand. This paper is organized as follows: The first part is an introduction; the second part is to build a DSGE model; the third part is the impulse response analysis and variance decomposition; the last part is some conclusions and policy recommendations.
2. **DSGE Model Building.** In this paper, we suppose that the economy consists mainly of five economies: household, final goods producers, intermediate goods producers, governments and central banks. Household provide differentiated labor to intermediate goods producers, obtain wage and share intermediate goods producer's net profit, use income to buy goods that are produced by the final goods producers, purchase the government bonds and receive government transfer payments, and invest. Intermediate goods producers hire labor from the household sector, produce differentiated intermediate products, then sell to the final goods producers at the markup price. Using intermediate goods, final goods producers produce the homogeneous final products to meet the demands of household consumption and government spending. Central banks implement monetary policy.

2.1. **The Representative Household.** In this paper, we assume that families in the market are homogeneous. It means that there is no difference between different families. Under this assumption, we can just study the representative household. At the beginning of the period $t$, the representative household has $m_{t-1}$ units of cash, and will hold $m_t$ of units cash at the end of the period $t$. It also owns $b_t$ units of government bonds, and receives a lump-sum nominal transfer $t_t$ from the government. $R_t$ is the nominal interest rate on the bond at the periods of $t$ to $t+1$. At the period of $t$, the representative household provides $n_t$ units of labor to intermediate goods producers and gets $\omega_t n_t$ units of real wages. As the actual return on capital is $r^c_t$, then the representative household can get $r^c_t k_{t-1}$ units of the actual capital gains. And at every period, the household receives actual dividend payments totaling $\Pi_t$ from the intermediate goods-producing firms. At the same
time, the house-hold consumes \( c_t \) units of the final goods.

Following Driscoll (2000) and Ireland (2002), in this paper, the representative household sector’s discounted expected utility are described as follows.

For the representative household, the most things they want to do are to maximize their expected utility. Equation 1 is the expected utility function.

\[
U = E\sum_{t=0}^{\infty} \beta^t [A_t \ln(c_t) + \ln(m_t) - \frac{n_t}{\eta}]
\]  

(1)

There are some parameters in equation 1, and we will show their meanings one by one. \( \beta \) is the discount factor. \( A_t = e^{a_t} \) reflects consumption preference. \( \eta \) is the labour supply shock, \( 0 < \beta < 1, \eta > 1 \). \( c_t \) is the consumption of a bundle of goods.

The consumption preference shock \( a_t \) follows the autoregressive process below.

\[
a_t = \rho a_{t-1} + \varepsilon_t
\]

In the equation above, for \( t = 0, 1, 2..., 0 \leq \rho < 1 \). Besides that, \( \varepsilon_t \), the serially uncorrelated random disturbance, meets normal distribution with the mean of zero and the standard deviation of \( \sigma_a \).

Consumer’s consumption budget conditions are as below.

\[
c_t + i_t + m_t + g_t + b_t = \frac{m_{t-1}}{\pi_t} + \frac{R_t}{\pi_t} b_{t-1} + r_t k_{t-1} + \omega n_t + t_t + \Pi_t
\]  

(2)

Capital transfer equation is as below.

\[
k_t = i_t + (1 - \delta) k_{t-1}
\]  

(3)

Next, we will show the meanings of the parameters in equation (2). \( m_{t-1} \) denotes nominal money stock in the beginning of period \( t \). \( \omega n_t \) denotes the nominal wage during the period of \( t \). By renting capital, the household can get the gains of \( r_t k_{t-1} \). The household gets the actual monopoly profits \( \Pi_t \), which is the totaling of monopoly profits from every intermediate firm. We can obviously see from the equation below \( \Pi_t = \int_0^t \Pi_t(i)di, i \in [0, 1] \), \( i_t \) denotes the actual investment. \( \pi_t = \frac{P_t}{P_{t-1}} \) denotes inflation. \( g_t \) denotes the actual government consumption.

Next, we will establish Lagrangian function.

\[
Q = \max E\sum_{t=0}^{\infty} \beta^t [A_t \ln(c_t) + \ln(m_t) - \frac{n_t}{\eta} - \lambda_i (c_t + k_t - (1 - \delta)k_{t-1} + m_t + g_t + b_t - \frac{m_{t-1}}{\pi_t} - \frac{R_t}{\pi_t} b_{t-1}]
\]  

\[-r_t k_{t-1} - \omega n_t - t_t - \Pi_t])
\]

(4)

In this model, under the intertemporal budget constraint conditions, the representative
household select the optimal $c_t$, $n_t$, $m_t$, $b_t$, and $k_t$, to maximize their own expected utility.

With respect to equation (4), we calculate the first-order conditions of $c_t$, $n_t$, $m_t$, $b_t$, and $k_t$. The results are as follow.

\[ c_t \cdot \frac{A_t}{c_t} - \lambda_t = 0 \]  
\[ n_t = n_t^{\eta-1} + \lambda_t \omega_t = 0 \]  
\[ m_t = \frac{1}{m_t} - \lambda_t + \beta E_t \frac{\lambda_{t+1}}{\pi_{t+1}} = 0 \]  
\[ b_t = -\lambda_t + \beta E_t \frac{\lambda_{t+1} R_{t+1}}{\pi_{t+1}} = 0 \]  
\[ k_t = -\lambda_t + \beta E_t \lambda_{t+1} (1 - \delta) + r_{t+1}^k = 0 \]  

From equation (5) and (6): We obtain equation (10)
\[ n_t^{\eta-1} \frac{c_t}{A_t} = \omega_t \]  

It reflects the relationship between real wages and the marginal substitution utility of leisure and consumption.

From equation (5) and (8): We obtain equation (11)
\[ \frac{A_t}{c_t} = \beta E_t \{ \frac{A_{t+1} R_{t+1}}{c_{t+1} \pi_{t+1}} \} \]  

The equation above reflects the optimal conditions for intertemporal consumption. Equation (11) shows the relationship between inflation-adjusted nominal interest rate and the substitution rate of intertemporal consumption.

From equation (5), (7) and (8). We obtain equation (12)
\[ \frac{c_t}{A_t m_t} = E_t \left( \frac{R_{t+1} - 1}{R_{t+1}} \right) \]  

The equation (12) reflects the relationship between consumption and the actual remaining sum.

From equation (8) and (9): We obtain equation (13).
\[ 1 - \delta + r_{t+1}^k = \frac{R_{t+1}}{\pi_{t+1}} \]  

From equation (5) and (9): We obtain equation (14)
\[ \frac{A_t}{c_t} = \beta E_t \frac{A_{t+1}}{c_{t+1}} (1 - \delta) + r_{t+1}^k \]  

Equation (10) is the labor supply equation, which shows that with higher real wages, there are less labor supplies and more current consumption. Equation (11) is the household sector's intertemporal first-order condition. It reflects the choice of the household sector between the current consumption and future consumption. More specifically, in the case of stable inflation, the rise of terminal nominal deposit rates will reduce the current consumption and increase future consumption. Equation (12) is the money demand
equation. Equation (13) reflects the relationship between the deposit rate and the return on capital. In the case of stable inflation, the rise of nominal interest rates will contribute to improving returns on capital. Equation (14) shows that the rise of terminal return on capital will spur people to reduce current consumption and increase future consumption.

2.2. The Representative Final Goods-Producing Firm. Using intermediate goods, final goods producers produce the final consumption good in perfect competition, then sell these final goods to other economic entities. We assume that intermediate goods subject to a continuous distribution in the interval of $[0,1]$. The final good $y_t$ is produced from the intermediate goods in the way just as equation (15) shows.

$$y_t = \int_{0}^{1} y_{t}(i) \frac{\theta_{i} - 1}{\theta_{i}} di$$

(15)

In the equation above, $y_t$ is the final product, $y_{t}(i)$ is the $i$-th intermediate product, $\theta_t$ means markup price shock.

Here, this markup shock follows the autoregressive process as equation (16) shows.

$$\ln(\theta_{t}) = (1 - \rho_{\theta}) \ln(\theta) + \rho_{\theta} \ln(\theta_{t-1}) + \epsilon_{t}^{\theta}$$

(16)

In the equation above, for $t = 0,1,2,...$, $0 \leq \rho_{\theta} < 1$, Besides that, $\epsilon_{t}^{\theta}$, the serially uncorrelated random disturbance, meets normal distribution with the mean of zero and the standard deviation of $\sigma_{\theta}$.

Thus, during each period $t = 0,1,2,...$, the final goods-producing firm chooses $y_{t}(i)$ for all $i \in [0,1]$ to maximize its profits. Equation (17) can reflect this action clearly.

$$\max_{y_{t}(i)} : P_t y_t - \int_{0}^{1} P_t(i) y_{t}(i) di$$

(17)

Combined with the production function, we can obtain equation (18), the first-order condition.

$$y_{t}(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\theta_{t}} y_{t}$$

(18)

The equation above is the demand function for product $i$. For all $i \in [0,1]$ and $t = 0,1,2,...$, (18) measures the time-varying demand elasticity for each intermediate goods.

For a perfect competition market, then in equilibrium conditions, the final goods producing firm's profits will be zero. $P_t$ will be determined as equation (19) shows to us.

Equation (19) also tells us the pricing rules for the final product.

$$P_t = (\int_{0}^{1} P_t(i)^{-1-\theta_{t}} di)^{-\frac{1}{1-\theta_{t}}}$$

(19)

2.3. The Representative Intermediate Goods-Producing Firm. We assume that the intermediate product market is monopolistic competition market, and intermediate goods-producing firm has the pricing power. Here, for intermediate product pricing, we adopt Calvo’s (1983)’ pricing strategy.

Intermediate goods-producing firm’s function is as follows.
We suppose that residents and firms are homogeneous. Then, equation (20) can be turned to equation (21)

\[ y_t = Z_t k_{1-t}^\alpha n_t^{1-\alpha} \]  

In equation (20), \( n_t(i) \) is the labor number used to produce the intermediate product, \( Z_t = e^{\xi_t} \) means the level of technology. \( Z_t \) follows the stationary autoregressive process just as equation (22) shows to us.

\[ z_t = \rho z_{t-1} + \epsilon_t \]  

In the equation (22), for \( t = 0,1,2,\ldots \), \( 0 \leq \rho < 1 \). Besides that, \( \epsilon_t \), the serially uncorrelated random disturbance, meets normal distribution with the mean of zero and the standard deviation of \( \sigma_z \).

We assume intermediate goods producers are the sellers in the monopolistic competition market. Besides that, intermediate goods can’t substitute each other. Therefore, intermediate goods-producing firms have to face up to the second nominal price adjustment costs. In this paper, we adopt the adjusting costs proposed by Rotemberg (1982). The specific expression is just like equation (23) shows to us.

\[ \frac{\phi}{2} \left[ \frac{P_t(i)}{\pi P_{t-1}(i)} - 1 \right] Y_t \]  

In equation (23), \( \phi \geq 0 \), \( \phi \) functions as governing the magnitude of the price adjustment. \( \pi \) denotes the average rate of inflation in the steady-state. When the cost of price adjustment exists, in order to optimize, the intermediate goods producing firm face the facts of dynamism. For \( t = 0,1,2,\ldots \), intermediate goods producing firm chooses \( P_t(i) \) to maximize its total market value.

\[ E \sum_{t=0}^{\infty} \beta^t \left( \frac{\alpha_t}{c_t} \right) \left( \frac{\Pi_t(i)}{P_t} \right) \]  

When the representative household gets an additional unit of real profits in the form of dividends during the period \( t \), \( \beta^t \left( \frac{\alpha_t}{c_t} \right) \) in the equation (24) measures the marginal utility value. \( \frac{\Pi_t(i)}{P_t} \) is the actual profits for the firm \( j \) during the period \( t \). \( \frac{\Pi_t(i)}{P_t} \) can be expressed specifically as equation (25) shows us.

\[ \frac{\Pi_t(i)}{P_t} = \left[ \frac{P_t(i)}{P_t} \right]^{1-\theta} Y_t - \frac{P_t(i)}{P_t} \theta \left( w_t h_t + r^k k_{t-1} \right) - \frac{\phi}{2} \left[ \frac{P_t(i)}{\pi P_{t-1}(i)} - 1 \right] Y_t, \]  

In equation (25), \( n_t \) and \( k_{t-1} \) can be defined as follows.

\[ n_t = \frac{y_t}{z_t} \left[ \frac{(1-\alpha)Y_t}{aw_t} \right]^{\alpha}, \quad k_{t-1} = \frac{y_t}{z_t} \left[ \frac{(1-\alpha)k_{t-1}}{aw_t} \right]^{\alpha-1} \]  

From the two equations above, we obtain equation (26).
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\[ \frac{n_t}{k_{t-1}} = \frac{(1-\alpha)\pi_t^k}{\alpha w_t} \]  

(26)

In each period \( t = 0, 1, 2, \ldots \), the representative intermediate goods-producing firms select the price \( P_t(i) \) to make the optimal decisions. The first-order condition is as below.

\[
(1-\theta_t)[\frac{P_t(i)}{P_t}]^{-\theta_t} = \theta_t[\frac{P_t(i)}{P_t}]^{-\theta_t-1} (w_t h_t + r_{k,t} k_{t-1}) - \phi[\frac{P_t(i)}{\pi P_{t-1}(i)} - 1][\frac{y_t}{\pi P_{t-1}(i)}] 
+ \beta\varphi E_{t} \left\{ \frac{\alpha_{t+1}}{a_t} c_t \left[ \frac{P_t(i)}{\pi P_{t-1}(i)} \right] \left[ \frac{y_{t+1}}{P_t(i)} \right] \right\} 
\]

(27)

Let’s suppose a situation. There is a central planner who can overcome the friction and obstacle. In every period \( t = 0, 1, 2, \ldots \), the central planner can put into \( n_t(i) \) units of labor and \( k_{t-1}(i) \) units of capital to produce \( Q_t(i) \) units of intermediate products. As the paper above has defined, \( i \in [0, 1] \). Then produce \( Q_t(i) \) units of final goods using a variety of intermediate products. Like above, production technology meets constant returns to scale. Therefore, the social planner chooses \( Q_t(i) \) and \( n_t(i) \) to maximize the welfare of the household sector \( t = 0, 1, 2, \ldots \), and \( i \in [0, 1] \). Namely, we should maximize equation(28).

\[
E \sum_{t=0}^{\infty} \beta^t [A_t \ln(Q_t) - (1/\eta) n_t^\eta] 
\]

(28)

Even though we try our best to maximize equation(28), we have to subject to feasible constraints, as equation (29) shows.

\[
Z_t k_t^\alpha n_t^{1-\alpha} \geq Q_t 
\]

(29)

From optimal conditions, we obtain equation (30).

\[
Q_t = \frac{(1-\alpha)\Pi_t}{n_t^\eta} y_t 
\]

(30)

We can rewrite equation (30) to equation (31).

\[
Q_t = (1-\alpha)\Pi_t Z_t k_t^\alpha n_t^{1-\alpha-\eta} 
\]

(31)

In the equation (31), \( Q_t \) is the effective output, which is relative to the consumer preferences shock \( \alpha \), and technical shock \( Z_t \), but has no relationship with markup price shock \( \theta_t \). We define the output gap \( x_t \) is the ratio of actual output and the effective output, \( \frac{y_t}{Q_t} \). Thus, for all periods, we have:

\[
x_t = \frac{n_t^\eta}{(1-\alpha)\Pi_t} 
\]

(32)

We define the output growth rate \( \kappa_t \) as follows.

\[
\kappa_t = Y_t / Y_{t-1} = (y_t / y_{t-1}) / Z_t 
\]

(33)

2.4. Market Clearing. In the clearing market, all intermediate goods firms make identical decisions, so for \( i \in [0, 1] \) and \( t = 0, 1, 2, \ldots \), we have the following equation \( y_t(i) = y_t \), \( h_t(i) = h_t \), \( P_t(i) = P_t \) and \( \Pi_t(i) = \Pi_t \). Besides, for every period \( t = 0, 1, 2, \ldots \), the conditions
for market clearing are $M_t = M_{t-1} + T_t$ and $B_t = B_{t-1}$, which also mean the net supply of bonds is zero.

From the budget constraint equation (1), we can get the total resource constraint equation as the equation (34) shows to us.

$$y_t = c_t + i_t + g_t + \frac{\phi}{\pi} \left( \frac{\pi}{\pi} - 1 \right)^2 y_t$$  \hspace{1cm} (34)

3. The Analysis about the Model’s Steady-State .From the equation (10), we obtain equation (35).

$$n_{t-1} \frac{c}{A} = \omega$$  \hspace{1cm} (35)

In the steady state, wage has positive correlation with consuming and labor supply, while it has the inverse correlation with technology advances. When the consumption is constant, with the increase in wage, labor supply rises. Given the constant labor supply, if the consumption increases, which mean the increases of demand, then manufacturers have to expand production. What the manufacturers can do is that they can enhance staff’s motivation to increase output by increasing wages.

From the equation (11), we obtain equation (36).

$$R = \frac{\pi}{\beta}$$  \hspace{1cm} (38)

In the steady state, higher nominal deposit rates will lead to lower residents’ discount. From the equation (12), we obtain equation (37).

$$\frac{c}{Am} = \frac{R-1}{R}$$  \hspace{1cm} (37)

The equation (37) will show us the relationship between real money balances and nominal interest rates. Given the constant consumption and technology, with interest rates rising, people will believe that they will the maximum utility if they have their money stored for future consumption. As a result, people will reduce current consumption, which will lead to reduction of real money balances.

From the equation (13), we obtain equation (38).

$$1 - \delta + r^k = \frac{R}{\pi}$$  \hspace{1cm} (38)

In the equation (38), we know that $\frac{R}{\pi} = r^k$, which is the real interest rate. The equation (38) shows that given stable inflation, higher nominal deposit rates will improve the actual return on capital.

From the equation (21), we obtain equation (39).

$$y = z k^\alpha \alpha n^{1-\alpha}$$  \hspace{1cm} (39)

This equation is the steady-state expression of C-D production function.

From the equation (34), we obtain equation (40).

$$y = c + i + g$$  \hspace{1cm} (40)

This equation is the steady-state expression for the clearing market.

From the equation (26), we obtain equation (41).
\[ \frac{n}{k} = \frac{(1-\alpha)r^k}{\alpha w} \]  

(41)

4. Logarithmic Linearization.

From (8) we obtain:
\[ \hat{\alpha} - \hat{\epsilon} = E_i (\hat{\alpha}_{t+1} + \hat{R}_{t+1} - \hat{\epsilon}_{t+1} - \hat{\pi}_{t+1}) \]  

(42)

\[ \hat{\pi}_i = \beta E_i \hat{\pi}_{t+1} + \psi[\hat{\epsilon} + (1/\eta)(\hat{\epsilon}_i - \hat{y}_i)] - e_i \]  

(43)

This equation is the New Keynesian Phillips curve.

From (10) we obtain:
\[ \hat{x}_i = \eta \hat{n}_i - a_i \]  

(44)

This equation has defined the output gap volatility.

From (3) we obtain:
\[ \hat{k}_i = \delta \hat{\epsilon}_i + (1-\delta) \hat{k}_{t-1} \]  

(45)

From (21) we obtain:
\[ \hat{\gamma}_i = z_i + \alpha \hat{k}_{t-1} + (1-\alpha) \hat{n}_i \]  

(46)

From (12) we obtain:
\[ (\hat{c}_i - a_i - \hat{m}_i) = \frac{1}{R-1} E_i \hat{R}_{t+1} \]  

(47)

From (34) we obtain:
\[ \hat{y}_i = \frac{c}{y} \hat{c}_i + \frac{i}{y} \hat{i}_i + \frac{g}{y} \hat{g}_i \]  

(48)

From (8) (9) we obtain:
\[ R \hat{R}_{t+1} = r^k r_{t+1} \]  

(49)

From (26) we obtain:
\[ \hat{n}_i = \hat{r}_i - \hat{\omega}_i + \hat{k}_{t-1} \]  

(50)

From (10) we obtain:
\[ (\eta-1) \hat{n}_i + \hat{c}_i - a_i = \hat{w}_i \]  

(51)

From (31) we obtain:
\[ \hat{\kappa}_i = \hat{y}_i - \hat{y}_{t-1} + z_i \]  

(52)

In China, People's Bank of China controls the interest rates. People's Bank of China uses nominal monetary aggregates as the operation tool to carry monetary policy. Then adopting one monetary policy rule that conforms to Chinese actual situation is very necessary. In this paper, we use the monetary policy rule proposed by Liubin (2003).

In this interest rate rule, we assume that People's Bank of China adjusts short-term nominal interest rate on account of the gap from the steady-state level in terms of interest rate, output, the inflation rate, money supply growth, and then performs the monetary policy as follows.
\[ \hat{R}_i = \rho_R \hat{R}_{t-1} + \rho_y \hat{y}_{t-1} + \rho_\pi \hat{\pi}_{t-1} + \rho_m \hat{m}_{t-1} + \epsilon_i^R \]  

(53)

In the equation, \( \epsilon_i^R \), the serially uncorrelated random disturbance, meets normal distribution with the mean of zero and the standard deviation of \( \sigma_R \).
We can get the equation (54) through the logarithmic linearization of the money supply growth $\mu = M_t / M_{t-1}$.

$$\hat{m}_{t-1} + \hat{\mu}_t = \hat{m}_t + \hat{\pi}_t$$  \hspace{1cm} (54)

Consumption preference shock equation:

$$a_t = \rho_a a_{t-1} + \epsilon_i^a$$  \hspace{1cm} (55)

Technology shocks equation:

$$z_t = \rho_z z_{t-1} + \epsilon_i^z$$  \hspace{1cm} (56)

Government consumption shock equation:

$$g_t = \rho_g g_{t-1} + \epsilon_i^g$$  \hspace{1cm} (57)

Markup shock equation:

$$e_t = \rho_e e_{t-1} + \epsilon_i^e$$  \hspace{1cm} (58)

Next, we will list the meanings of some parameters from the part of logarithmic linearization. In the equation (43), $\psi$ is defined as $\psi = \eta(\theta-1)/\varphi$. In the converted markup shock equation, $e_i$ is defined as $(1/\varphi)\hat{\epsilon}_i$. In the equation (58), we have $\rho_e = \rho_\theta$. Besides that, $\epsilon_i^e$, the serially uncorrelated random disturbance, meets normal distribution with the mean of zero and the standard deviation of $\sigma_e$.

5. Impulse Response Analysis and Variance Decomposition.

5.1. The Calibration of the Model Parameters. The equations from the equation (42) to the equation (58) together constitute a dynamic system, which includes 17 equations and 17 endogenous variables. The model includes 13 parameters: $\beta$, $\psi$, $\eta$, $\delta$, $\alpha$, $\rho_\mu$, $\rho_\gamma$, $\rho_x$, $\rho_z$, $\rho_\mu$, $\rho_g$, $\rho_e$, $\rho_a$, (the calibration values showed in Table 1). This paper uses the Chinese annual data from 1978 to 2011. These calibration values can measure the contribution of the observable and unobservable variables on the fluctuations. Through the steady-state relations and with some other calibration parameters, we can compute the value of $R$, $r^k$. As $Z$, $\pi$ has no effect on the model’s dynamics, then we can set $Z$ to 1, $\pi$ to 1.0249 (Jinzhongxia, Honghao, etc. (2013)). For $c$, $y$, $i$, $g$, in this paper, we respectively use the proportion of household consumption in output, the proportion of investment in output, the proportion of government consumption in output. We can calculate the three proportions just mentioned above using the statistical data from the statistical yearbook. We use the average value during the periods of 1978-2011 as the calibration value. The result is as follows: $c/y = 0.4045$, $i/y = 0.4531$, $g/y = 0.1424$. With reference to Liu Bin (2003), we set some parameters as below: $\rho_\mu = 0.4112$, $\rho_\gamma = 0.1423$, $\rho_x = 0.0599$, $\rho_\mu = 0.1366$. $\rho_\mu = 0.4112$ reflects that People's Bank of China’s interest rate adjustments have greater inertia. $\rho_\gamma = 0.1423$ and $\rho_\mu = 0.1366$, show that the central bank has a great reaction to output volatility and the money supply.
TABLE 1. Model Parameter Calibration Values

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$\psi$</th>
<th>$\delta$</th>
<th>$\alpha$</th>
<th>$\rho_R$</th>
<th>$\rho_\gamma$</th>
<th>$\rho_\tau$</th>
<th>$\rho_\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99</td>
<td>0.1</td>
<td>0.1</td>
<td>0.5</td>
<td>0.4112</td>
<td>0.1423</td>
<td>0.0599</td>
<td>0.1366</td>
</tr>
<tr>
<td>$\rho_\gamma$</td>
<td>$\rho_\tau$</td>
<td>$\rho_\mu$</td>
<td>$\eta$</td>
<td>0.4521</td>
<td>0.7090</td>
<td>0.4057</td>
<td>0.4643</td>
</tr>
</tbody>
</table>

5.2. **Impulse Response Graph.** As the deposit rates of China have not yet realized marketization, which is determined by the government department. The facts are that China adjusts interest rates according to the development requires. Then, the analysis about the impact of various shocks on interest rates has no practical significance. That is the reason why in this paper. We abandoned the concrete analysis about interest rates.

5.2.1. The impacts of technology shocks on output growth, output gap, household consumption, inflation and investment (Figure 2).
Given 0.01 units of technology shocks, we will show the impacts on output growth rate ($\kappa_t$), the shock to output gap ($k$), household consumption ($c_t$), inflation ($\pi_t$), investment ($i_t$) one by one.

Firstly, we will analyze the impact of 0.01 units of technology shocks on output growth rate ($\kappa_t$). And we find that the output growth rate increases by 0.02 units. At the same time, we also find that output growth rate quickly returns to the equilibrium, which indicates that the impact of technology shocks on output growth is not the main reason for economic fluctuations as real business cycle theory describes.

Secondly, we will analyze the impact of 0.01 units of technology shocks on the output gap ($k$). We have seen from the figure 2 that the output gap shows a positive fluctuation. Then in a short term positive fluctuation turns to negative fluctuations. The range of fluctuation reaches 0.005. After some time, the fluctuation returns to the stable condition. It reflects that for the output gap the technology shock has a great impact, and also has some certain continuity. As increasing the potential output, technological advances result in output gap. Besides that, technological advances also contribute to improving the ability to increase profitability, which will make enterprises increase the output actually. The result is that the real output will gradually close to the potential output, and ultimately achieve steady-state equilibrium.

Thirdly, we will analyze the impact of 0.01 units of technology shocks on the household consumption ($c_t$). For the household consumption, there are the positive fluctuations. The range of volatility is about 0.011 units. After some time, the fluctuations return to the steady state. The result shows that the technological advance will promote consumption in a long time.

Fourthly, we will analyze the impact of 0.01 units of technology shocks on the inflation ($\pi_t$). For inflation, there are the positive fluctuations. The range of volatility is about 0.002 units. After a fairly long time, the fluctuations of inflation return to the equilibrium. The result indicates that technological advances will exacerbate inflation. Because technological advances make enterprises make more profits. Then expanding the production is necessary. At the same time, enterprises have to increase the wages of workers and hire more labor. More affluent workers will consume more, which will improve the level of prices and cause inflation;
Lastly, we will analyze the impact of 0.01 units of technology shocks on the investment \( (i_t) \). For investment, there are the positive fluctuations. And there is still a long time for the fluctuations to return to steady state. The range of volatility is about 0.017 units. The result shows that technological progress has a positive impact on investment. As the enterprises have the ability to obtain greater profits, and then driven by the profits, companies will increase investment to expand their production.

5.2.2. The impact of consumer preferences shocks on output growth, output gap, household consumption, inflation and investment (Figure 3).

![Figure 3: The Pulse Diagram of Consumer Preference Shock](image-url)
Given 0.01 units of consumer preference shocks, we will show the impacts on output growth, output gap, household consumption, inflation and investment one by one.

Firstly, we will analyze the impact of 0.01 units of consumer preference shocks on the output growth rate. The output growth rate shows brief upward fluctuations, and then quickly turns to negative fluctuations, and then to positive fluctuations, the range of volatility is about 0.00028 units, which indicates that the volatility is not too large. At the same time, we find that it take a long time for the fluctuations to return to the steady state. The volatility of consumer preferences leads to large changes for some certain items. It means that some items are no longer preferred by consumers, while some others cater to some consumers’ preferences, which leads companies to cut or expand some corresponding products. Then, fluctuations come into being.

Secondly, we will analyze the impact of 0.01 units of consumer preference shock on the output gap. We have seen from the figure 3 that the impact of consumer preference shock on the output gap is negative. The range of fluctuation reaches 0.005. And it takes a long time to return to the stable state. The consumer preference shock will lead to changes in the demand for the products. Initially, residents prefer a product, while later they prefer other products. As it takes some time for the companies to adjust their products, then this will eventually lead to negative fluctuations in the output gap.

Thirdly, we will analyze the impact of 0.01 units of consumer preference shock on the consumption. At the beginning, the fluctuations are positive, later the fluctuations turn to negative. And the whole process lasts for a long time. The range of fluctuation reaches 0.0068 units. The positive volatility of consumer preferences is mainly due to consumers suddenly preferring a particular product. This will lead to increasing the consumption of those products. That’s why the volatility is positive. However, after a period of time, people’s passion for those products fall, which then leads to negative fluctuations. As we all know that preferences will last for a long time, and then the effect on consumption is also more durable.

Fourthly, we will analyze the impact of 0.01 units of consumer preference shock on the inflation. For inflation, there are the negative fluctuations. The range of volatility is about 0.0016 units.

Lastly, we will analyze the impact of 0.01 units of consumer preference shock on the investment. For investment, there are downward fluctuations at first and upward fluctuations next. And it takes some time for the fluctuations to return to steady state. The range of volatility is about 0.0052 units. Under the shock of consumer preferences, companies will shift the direction of investment. However, before changing the direction of investment, companies need to terminate some of the original investment, which will lead to the reduction of investment in the short term. Later, the investment will increase quickly. The reality corresponds to the fluctuations showed in the picture 3. As consumers’ preferences will last for a long time, so the impact on investment is also more durable.

5.2.3. The impact of Government consumption shocks on output growth, output gap, household consumption, inflation and investment (Figure 4).
Given 0.01 units of government consumption shocks, we will show the impacts on output growth, output gap, household consumption, inflation and investment one by one.

Firstly, we will analyze the impact of 0.01 units of government consumption shocks on the output growth rate. Output growth shows the downward fluctuations at first, then back to the steady state. At the same time, we notice that positive volatility is small, and it is about 0.00011 units, which indicates that for government purchases shocks there is not too much impact on output growth rate. At present, enterprises produce the optimal output. Then, with the increasing of government purchases shocks, for the enterprises it isn’t necessary to increase the output. Besides that, the government has a relative stable
purchasing direction and purchasing amount. Then, even if the government increases some purchasing, the manufacturers can also meet their demands.

Secondly, we will analyze the impact of 0.01 units of government consumption shocks on the output gap. We have seen from the figure 4 that the impact of government consumption shocks on the output gap is positive. The range of fluctuation reaches 0.0009 units. For government consumption shocks, this means that the demand for the product increases, while the potential output doesn’t change. Then output gap increases. By the equations (1), we know that government spending generally has a stable direction, which will lead to small volatility of the output gap.

Thirdly, we will analyze the impact of 0.01 units of government consumption shocks on the consumption. From the figure 4, we know that the consumer volatility has a downward trend. Government consumption contributes to the demand for the products, resulting in the rising of the price. Then the price becomes high, consumers will reduce their consumption, which is the reason why the consumer fluctuations go downward.

Fourthly, we will analyze the impact of 0.01 units of government consumption shocks on the inflation. From the figure 4, we notice that the inflation is negative at first, then becomes positive. The government consumption will inevitably lead to higher demand of the products and the higher prices, which then lead to inflation.

Lastly, we will analyze the impact of 0.01 units of government consumption shock on the investment. For investment, the fluctuations are negative. The reason is as follows. As the government increases its spending, this makes price increase. The demand for money increases. However, the money supply is determined by the government. This means that the supply of money is inadequate. As a result, the loans from banks become more difficult. Then they have to reduce investment which leads to negative fluctuations.

5.2.4. The impact of markup shocks on output growth, output gap, household consumption, inflation and investment (Figure 5).
Given 0.01 units of markup shocks, we will show the impacts on output growth, output gap, household consumption, inflation and investment one by one.

Firstly, we will analyze the impact of 0.01 units of markup shocks on the output growth rate. From the figure 5, we know that the volatility of output growth is positive. The increase of the products prices will increase the corporate profits. Then, companies will expand production, which will lead to a positive volatility in the output growth. As the final product market is perfectly competitive, the price advantage will not remain too long. Therefore, fluctuations in output growth will not last too long;

Secondly, we will analyze the impact of 0.01 units of markup shocks on the output gap. We have seen from the figure 5 that the impact of markup shocks on the output gap is positive.

Thirdly, we will analyze the impact of 0.01 units of markup shocks on the consumption. From the figure 5, we know that the consumer volatility is negative. The rise of product prices will lead to the reduction of currency held by residents. Then, residents will reduce consumption, which contributes to negative fluctuations.

Fourthly, we will analyze the impact of 0.01 units of markup shocks on the inflation. From the figure 5, we know that inflation fluctuations are negative, because the final product market is perfectly competitive.

Lastly, we will analyze the impact of 0.01 units of markup shocks on the investment. As the prices raise, companies will gain greater benefits. Then, companies will expand their investment. This result conforms to the positive fluctuations.
5.2.5. The impact of interest rate shocks on output growth, output gap, household consumption, inflation and investment (Figure 6).

Given 0.01 units of interest rate shocks, we will show the impacts on output growth, output gap, household consumption, inflation and investment one by one.

Firstly, we will analyze the impact of 0.01 units of interest rate shocks on the output growth rate. From the figure 6, we know that the fluctuations of output growth rate goes downward first, then quickly back to the steady state. The impact on the output growth volatility from the interest rate shocks only has short-term effects. The range of fluctuation reaches 0.0023 units. The raised interest rates will lead to higher costs, which will make the
Secondly, we will analyze the impact of 0.01 units of interest rate shocks on the output gap. We have seen from the figure 6 that the impact of interest rate shocks on the output gap is positive. The range of fluctuation reaches 0.8, which means that the output gap will increase a lot with the interest rates rising, but the duration is very short. As we all know that most of the enterprises maintain production through the bank loan. Thus, the rising of interest rates will directly increase the production costs of enterprises. To reduce losses, enterprises reduce the output. One aspect is that the output is reduced, and the other aspect is that potential output doesn’t change, which results in the increasing of the output gap.

Thirdly, we will analyze the impact of 0.01 units of interest rate shocks on the consumption. From the figure 6, we know that interest rate shock has a positive impact on consumption, and there is a great volatility with the range of 0.02 units. With interest rates rising, residents expect their future earnings will increase. Then residents will increase current consumption to maximize lifetime utility.

Fourthly, we will analyze the impact of 0.01 units of interest rate shocks on the inflation. From the figure 6, we know that inflation fluctuations are positive. On one hand, the raised interest rates will lead to increasing the production costs. In order reduce loss, companies will raise prices, which is likely to cause cost-pushing inflation. On the other hand, from (3), we know that the current residents increasing their consumption. The increased demand will lead to higher prices, which also easily leads to demand-driving inflation. In one word, the impact on the inflation is positive.

Lastly, we will analyze the impact of 0.01 units of interest rate shocks on the investment. We know from the diagram 6 that investment shows the negative fluctuations. As most of the enterprises maintain production through the bank loan. Then the rising interest rates will increase the costs of enterprises directly. At this time, companies have to take greater risks. In order to reduce the risk, companies will reduce investment. Namely, positive shock in interest rates will lead to negative volatility of investment.

5.3. Variance Decomposition.

<table>
<thead>
<tr>
<th>Supply shocks</th>
<th>Supply shocks of the total shock</th>
<th>demand shock</th>
<th>Demand shocks of the total shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Shock</td>
<td>Markup Shock</td>
<td>(%)</td>
<td>Consumer Preference Shock</td>
</tr>
<tr>
<td>Consumer</td>
<td>23.21</td>
<td>37.58</td>
<td>60.79</td>
</tr>
<tr>
<td>Deposit rates</td>
<td>4.48</td>
<td>5.69</td>
<td>10.17</td>
</tr>
<tr>
<td>Inflation</td>
<td>3.6</td>
<td>62.15</td>
<td>65.75</td>
</tr>
<tr>
<td>output gap</td>
<td>0.46</td>
<td>6.08</td>
<td>6.54</td>
</tr>
<tr>
<td>output growth</td>
<td>54.39</td>
<td>19.78</td>
<td>74.17</td>
</tr>
<tr>
<td>Labor</td>
<td>0.46</td>
<td>6.1</td>
<td>6.56</td>
</tr>
<tr>
<td>Capital stock</td>
<td>6.48</td>
<td>40.73</td>
<td>47.21</td>
</tr>
<tr>
<td>Investment</td>
<td>16.84</td>
<td>41</td>
<td>57.84</td>
</tr>
<tr>
<td>Actual return on capital</td>
<td>4.48</td>
<td>5.69</td>
<td>10.17</td>
</tr>
<tr>
<td>Real wages</td>
<td>5.15</td>
<td>3.18</td>
<td>8.33</td>
</tr>
<tr>
<td>Ending money balances</td>
<td>10.64</td>
<td>28.58</td>
<td>39.22</td>
</tr>
<tr>
<td>Output growth</td>
<td>98.73</td>
<td>0.26</td>
<td>98.99</td>
</tr>
<tr>
<td>Money supply growth</td>
<td>7.08</td>
<td>14.29</td>
<td>21.37</td>
</tr>
</tbody>
</table>
Given 0.01 units of technology shocks, consumer preference shocks, government consumption shocks, markup shocks, and interest rate shocks, we get the variance decomposition results of output growth rate, the output gap, the consumer, inflation and investment from table 2.

Firstly, technology shocks explain 98.73% of the output growth volatility. We conclude that the volatility of output growth is mainly due to technology shocks.

Secondly, the consumer preference shock almost has no effect on the output growth volatility, fluctuations of the output gap, the investment volatility, the consumption fluctuations and the inflation volatility.

Thirdly, government consumption shocks almost have no effect on the output growth volatility, fluctuations of the output gap, the investment volatility, the consumption fluctuations and the inflation.

Fourthly, markup shocks can explain the most part of the inflation volatility. The ratio reaches up to 62.15%, which indicates that a large part of the inflation fluctuations are caused by the price factor.

Fifthly, interest rate shocks can explain 92.8% of the output gap volatility. Thus, we draw a conclusion that the volatility of the output gap is mainly due to the interest rate shocks.

Last but not the least, we will see the technology shocks, markup shocks as the supply shocks and regard the preference shock, government purchases shocks, interest rate shocks as the demand shocks. Then, we total the supply shocks and the demand shocks respectively. We reach the conclusion that in average sense the supply shocks can explain economic fluctuations better than the demand shocks. It means that economic fluctuations are mainly from supply shocks.

6. Conclusions. This article has established a New Keynesian DSGE model that includes the technology shocks, the consumer preferences shocks, government consumption shocks, markup shocks and interest rate shocks. From the impulse response analysis and variance decomposition we find the results as follows.

Firstly, on one hand, from the supply aspect, technology shocks explain 98.73% of the output growth volatility; markup shock explains 41% of the investment volatility and 62.15% of the inflation volatility. On the other hand, from the demand aspect, interest rate shock explains 39.56% of the investment volatility, 36.11% of household consumption volatility and 33.26% of the inflation fluctuations, while government consumption shocks have small impact on the economic fluctuations. From the pulse diagram, we find that all of these shocks just mentioned above have some continuous impacts on the economic fluctuations.

Secondly, interest rate shocks, technology shocks; markup shocks have a great impact on economic fluctuations. Then, if output growth rate is low, we can try to import new technology or improve the work efficiency to improve output growth rate. The price of the final products has great influence on the inflation. Thus, the government should supervise the level of price. Government consumption shocks have small impact on economic fluctuations. It means that through fiscal policy reform the government can guide the transformation and upgrading of industrial structure without causing much economic fluctuations.

Thirdly, in terms of supply shocks and demand shocks, supply shocks have greater
impact on economic fluctuations than demand shocks. Then, supply shocks are the main source of economic fluctuations. In other word, the fiscal policy and monetary policy have fewer effect on the economic fluctuations. Therefore, the government need not worry too much about the economic fluctuation when it carries out the fiscal policy and monetary policy. Especially for the fiscal policy, the impact on the fluctuations of the economy is very limited.

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