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A Prospective Study of the Macroeconomic Effects of China's Unconventional Monetary Policy

Xudong Lin[1, 2], Xiaofeng Han[2]

[1]School of Mathematics and Statistics, Sichuan University of Science and Engineering, Zigong, 643000, China

[2]School of Statistics, Southwestern University of Finance and Economics, Chengdu, 611130, China

Abstract: ***In this paper, it constructs a DSGE model with the segmentation of the bond market and examine the responses of the economic system after the implementation of the unconventional monetary policy without a zero bound constraint. The results show that, the long-term interest rates decrease by quantitative easing or operation twist, accompanied with rise in output and inflation. The results also reveal the response of output to unconventional monetary policy has obvious persistence feature. Finally, this paper comes to the conclusion that China's economy is more suitable for operation twist at present stage.***

Keywords: Quantitative Easing；Operation Twist；DSGE

1. Introduction

In monetary policy with inflation as the main target, the monetary authorities maintain low real interest rates by adjusting short-term interest rates to ensure steady economic growth. Although moderate inflation levels are considered to be beneficial to economic development, such low interest rate policies will result in greater accumulation of financial risks. In a low interest rate environment, when the economy encounters a negative shock, the policy rate will be adjusted to be close to zero, reaching the so-called "zero lower bound". At this time, the real interest rate is high, the private sector will not carry out financing to expand production, and the means of improving the credit market in the financial market by regulating policy interest rates will be ineffective. The traditional monetary policy will no longer have a stimulating effect on the economy. At the beginning of the 21st century, in response to the country's sustained economic downturn and low willingness to invest, Japan's central bank began to purchase large amounts of long-term bonds, that is, "quantitative easing". In the following five years, the Japanese economy gradually showed signs of recovery. Quantitative easing is different from the traditional adjustment of short-term interest rates. The former does not change the short-term interest rate, and the slope of the yield curve is reduced by large-scale asset purchases, which reduces the long-term financing costs of enterprises and promotes economic recovery. After the 2008 financial crisis, although the Fed has reduced the federal funds rate to zero, it still cannot stop the economic collapse, and the crisis spread to the global scope.[1] Subsequently, the United States began to adopt the unconventional monetary policy including quantitative easing to intervene economy, and later proved that such policies played an important role in mitigating the financial crisis and promoting economic recovery.

In general, unconventional monetary policy includes forward-looking guidance and balance sheet policies. Since the public's expectations for future policies will greatly affect the current interest rate level, government commitment to short-term interest rates can play an important role in stabilizing public expectations.[2] The balance sheet policy includes expanding the size of the central bank's assets and liabilities or adjusting its composition. The former is that the monetary authorities directly increase the base money by increasing their liabilities, that is, quantitative easing; the latter is adopted without changing the total debt. Selling short-term assets to finance, the purchase of long-term assets has changed the position of the central bank holding portfolios of different maturities, that is, operation twist. Usually unconventional monetary policy is the monetary policy used in the face of the zero lower bound, but it should be pointed out that even without the zero lower bound, the unconventional monetary policy can play a certain role.

At present, China's short-term interest rate is far from the zero lower bound, and there is a large policy space. However, with the structural adjustment of China's economy and the gradual deepening of financial reform, it is especially necessary to use different policy measures to ensure employment and economic stability. At present, China's economy is in a transitional stage. Since 2015 the central bank has cut interest rates seven times in five consecutive years, but the downward pressure on the economy is still relatively large. At the same time, under the trend of appreciation of the US dollar, the pressure of RMB depreciation has increased. The need to prevent excessive capital outflows and regulate domestic housing prices has forced the central bank to not directly lower policy interest rates. Traditional monetary policies are facing dilemmas. Therefore, studying the transmission mechanism and economic effects of unconventional monetary policy has important reference for China, which helps the monetary authorities to have more flexible policy tools to implement in the face of economic difficulties.

2. Literature Review

Before the 2008 financial crisis, the steady growth of low inflation, low volatility output in OECD countries, and the progress of theoretical in monetary economics research undoubtedly think that monetary policy was effective. However, the emergence of the financial crisis has led scholars to reflect on the shortcomings of conventional monetary policy. Therefore, the research direction began to focus on unconventional monetary policy.

Benford et al. (2009) proposed that asset purchases increased the value of assets in the private sector and reduced financing costs in the analysis of quantitative easing policy in the UK. The central bank's currency creation also increased the excess reserves of commercial banks.[3] Gambacorta, Hofmann, Peersman (2014) used a post-crisis balance sheet from several developed economies to construct a panel structure vector autoregressive model to evaluate monetary policy, and argue that monetary policy on the balance sheet can rise economic output and price levels, but the persistence of policy shock response is weak.[4] Dynamic Stochastic General Equilibrium (DSGE) is a modeling method that describes the effect of policy in macroeconomics. However, since the policy objectives of unconventional monetary policy are often no longer short-term interest rates, if long-term assets are directly introduced into the general equilibrium model, the existence of no arbitrage makes unconventional monetary policy not different from the traditional way to influence the term structure of interest rates. Therefore, Anders et al. (2004) increase the friction between assets of different maturities by increasing transaction costs and family investment constraints, thus providing other ways to implement unconventional monetary policy.[5] Chen (2012) describes the risk premium as the difference between the long-term yields described as assetless friction and asset friction, confirming that there is no risk premium under conventional monetary policy. And because of the existence of risk premium under unconventional policies, it has changed the consumption decisions of different types of households.[6] Harrison (2012) found that traditional policies have raised long-term risk premiums while reducing short-term interest rates. If asset purchases are used as a superimposed policy, they will improve the zero lower bounds of short-term interest rates in the face of negative economic shocks.[7]

As mentioned in the introduction, China's current downward pressure on the economy is still relatively large, and the reduction of short-term interest rates faces many constraints. Based on this, this paper intends to explore the policy mechanism of unconventional monetary policy applicable to China's economic environment by constructing a dynamic stochastic general equilibrium model with a segmented bond market.

3. Model Setting

This paper draws on the research of Christiano et al. (2011) Andrés et al. (2004) and Chen (2012) to construct the DSGE model.[8,5,6] Introduce partial indexation price, investment adjustment cost and variable capital utilization rate to reflect the various frictions in the real economy; the bond market is set by the different transaction costs of the two types of households with constraints and unconstrained divide; divide government expenditure into productive and non-productive expenditures into different sectors to reflect China's unique economic environment.

3.1. Household

Williams (2012) proposes that large-scale asset purchases can be effective because of the market's imperfect characteristics.[9] In order to reflect the imperfect characteristics of the market, assuming that the market has both short-term bonds and long-term bonds, household investment depends on their investment preferences. They tend to invest in long-term assets to hedge their long-term debts. Even when long-term assets rise due to changes in supply and demand, such investors will not shift their investment targets to short-term bonds. In addition, since such investors focus on the long-term asset market, it can be reasonably assumed that their transaction costs are very low, and the proportion of households subject to the investment target is assumed to be ω_r.Unconstrained households is in need of risk diversification. They need to allocate some long-term bonds in the household's portfolio, assuming that the transaction cost per unit long-term bond is ζ_t, the proportion of such households is ω_u.

The household sector consists of a continuum of two households, and the utility function for a household is:

$$\max \sum_{t=0} (\beta^j)^s (\ln c_t^j - b^j c_{t-1}^j) + \eta \ln g_{c,t} - A_L^j \frac{(h_{i,t}^j)^{1+\sigma_L^j}}{1+\sigma_L^j}) \quad (1)$$

Where $j = u, r$ denote unconstrained families and constrained families, respectively. The risk appetite and the consumption inertia of the two types of households is different, so we set different discount factors β^j and b^j. Taking into account the externalities of government non-productive expenditures, we introduce government consumption $g_{c,t}$ into the utility function. The j household labor supply elasticity parameter is σ_L^j, $\sigma_L^j > 0$. Households receive income by providing labor, but different household types lead to different forms of budgetary constraints. For ω_u part of the household, short-term and long-term bonds can be purchased, but the long-term bond purchase has a transaction cost ζ_t, so its budget constraint is

$$\begin{aligned} & P_t c_t^u + B_t^u + (1+\zeta_t) P_{L,t} B_{L,t}^u \\ & = W_t^u h_t^u + R_{t-1} B_{t-1}^u + P_{L,t} R_{L,t} B_{L,t-1}^u + \Pi_t^u - T_t^u \end{aligned} \quad (2)$$

where B_t is a short-term bond with a short-term rate of return R_t; a long-term bond $B_{L,t}$ is a perpetual bond with a period of interest ι, and the price at time t is $P_{L,t}$, and

$R_{L,t}$ represents the long-term bond yield. Π_t^u, T_t^u are corporate dividends and the government's one-time total tax respectively. Similarly, the budget constraint for ω_r has the following form.

$$P_t c_t^r + P_{L,t} B_{L,t}^r = W_t^r h_t^r + P_{L,t} R_{L,t} B_{L,t-1}^r + \Pi_t^r - T_t^r \quad (3)$$

Chen (2012) assumes that transaction costs ζ_t are a function of the ratio of long-term bonds to short-term bond market capitalizations. Where $\zeta_t = \zeta(P_{L,t}B_{L,t}/B_t, \varepsilon_{\zeta,t})$. And when the steady state is satisfied we have $\zeta(\cdot) > 0$ and $\zeta'(\cdot) > 0$.[6] The first condition guarantees that there is a positive premium for the short-term interest rate, and the second condition ensures that the long-term interest rate declines when the long-term bond balance is reduced substantially. This mechanism enables the long-term interest rate adjustment target of unconventional monetary policy to be realized. Therefore, the function form of $\zeta(\cdot)$ is:

$$\zeta_t = \zeta + \rho_\zeta \ln\left(\frac{Ratio_{b_L y,t}}{Ratio_{by,t}} \Big/ \frac{Ratio_{b_L y}}{Ratio_{by}}\right) + \varepsilon_{\zeta,t} \quad (4)$$

Where ζ is the steady-state value of ζ_t, $Ratio_{b_L y,t}$ is the ratio of the long-term debt debt to the total output and $Ratio_{by,t}$ is the ratio of short-term debt to total output at time t.

3.2. Entrepreneur

At time t, entrepreneurs provide effective capital to intermediate firms through capital utilization k_t, $k_t = u_t \bar{k}_{t-1}$. The original capital stock is $\bar{k}_t$, which accumulates the equation as

$$\bar{k}_{t+1} = \bar{k}_t(1-\delta) + F(i_t, i_{t-1}) \quad (5)$$

The form of investment adjustment equation $F_t(i_t, i_{t-1})$ is based on the setting of Christiano et al. (2011). In steady state, we have $F_1(i,i) = 0$ and $F_2(i,i) = 0$.[8] Since the capital-producing enterprises are actually composed of households, the discount rate for future earnings for entrepreneurs depends on the average marginal utility level of the two types of households. Therefore, the objective function of the entrepreneur to maximize its utility.

$$\max_{u_t, i_t} \sum_{s=0} (\omega_u (\beta^u)^s v_{t+s}^u + \omega_r (\beta^r)^s v_{t+s}^r) \\ (R_{t+s}^k u_{t+s} \bar{k}_{t+s-1} - a(u_{t+s}) \bar{k}_{t+s-1} P_{t+s} - P_{t+s} i_{t+s}) \quad (6)$$

where v_t^j is the marginal utility of the jth family, $j = u, r$; R_t^k is the return on capital; $a(u_t)$ is the original capital utilization cost function and in steady state we have $a(1) = 0$ and $a''(\cdot) = 0$.

3.3. Firm

The final product firms also use Dixit and Stiglitz (1977) for the difference products of intermediate firms, $y_t = [\int_0^1 y_{i,t}^{1/\lambda_f}]^{\lambda_f}, \lambda_f > 1$, in where λ_f indicates the intermediate product bonus.[10] The demand function of the intermediate product can be obtained by the profit maximization problem of the final product manufacturer.

$$y_{i,t} = \left(\frac{P_t}{P_{i,t}}\right)^{\lambda_f/(\lambda_f - 1)} y_t \quad (7)$$

Where $y_{i,t}$ and y_t are the output and total output of the manufacturer in period t, $P_{i,t}$ and P_t are the corresponding prices. This paper considers the important role and externalities of the government in infrastructure investment and specific research areas, and records the government capital of production nature as public capital. Therefore, referring to the setting of Leeper et al. (2010), the production function of the intermediate firm i has the following form.

$$y_{i,t} = \dot{\varrho}_t k_{i,t-1}^{\alpha} l_{i,t}^{1-\alpha} g_{k,t-1}^{\alpha_g} - \Phi \quad (8)$$

where $k_{i,t}$ represents the effective capital investment of period t, $l_{i,t}$ and $g_{k,t}$ represent the labor invested by the firm and the stock of public capital respectively.[11] Parameters α ($\alpha > 0$) and α_g ($\alpha_g > 0$) represent the elasticity of private capital output and the elasticity of public capital output, respectively, and the parameters satisfy $\alpha + \alpha_g < 1$. Θ is a fixed cost, $\dot{\varrho}_t$ is a smooth neutral technology shock and we have $E(\dot{\varrho}_t) = 1$. The marginal cost of the firm has the following form.

$$mc_t = \frac{\tilde{w}_t^{1-\alpha} (\tilde{r}_t^k)^{\alpha}}{\dot{\varrho}_t \alpha^{\alpha} (1-\alpha)^{1-\alpha} g_{k,t-1}^{\alpha_g}} \quad (9)$$

As a provider of differentiated products, intermediate manufacturers have certain monopolistic competitiveness. Therefore Calvo (1983) is used for pricing. The probability that firms can freely adjust prices in each period is $1-\xi_p$. And those who cannot adjust prices are partially indexed, $P_{jt} = \tilde{\pi}_t P_{jt-1}$, $\tilde{\pi}_{p,t} = (\pi_{tar,t})^{\kappa_p} (\pi_{t-1})^{1-\kappa_p}$, in where κ_p is the indexing parameter.[12] Consistent with the firm's target income function, the firm is actually owned by the household, so the discount of the expected return should also be discounted by the average marginal utility of the household.

$$\max E_t \sum_{s=0} \xi_p^s (\omega_u (\beta^u)^s v_{t+s}^u + \omega_r (\beta^r)^s v_{t+s}^r) \\ (P_{j,t+s} y_{j,t+s} - mc_{t+s} P_{t+s} y_{j,t+s}) \quad (10)$$

3.4. Government

For China, the government not only provides public goods $g_{c,t}$, so we introduces government capital $g_{k,t}$. And government capital is also completed by accumulating equations.

$$g_{k,t+1} = g_{k,t}(1-\delta) + F_t^G(g_{i,t}, g_{i,t-1}) \quad (11)$$

Then at time t, the government's non-productive expenditure $g_{c,t}$ and productive expenditure $g_{i,t}$ are financed by means of taxation and issuance of bonds, and the budget constraints faced have the following forms.

$$\begin{aligned} &B_t + P_{L,t}B_{L,t} + T_t \\ &= R_{t-1}B_{t-1} + (1+\iota P_{L,t})B_{L,t-1} + P_t g_{c,t} + P_t g_{i,t} \end{aligned} \quad (12)$$

Drawing on the monetary policy form of Christiano et al. (2011), the current policy interest rate depends on the interest rate, target inflation, and output change in the lag period, and the monetary policy has a smoothing mechanism.[8] Moreover, Taylor (2008) also suggested that the movement of the spread, so this paper sets the extended form Taylor rule as follows.[13]

$$\begin{aligned} &\ln(\frac{R_t}{R}) = \rho_R \ln(\frac{R_{t-1}}{R}) + \\ &(1-\rho_R)[\ln(\frac{\pi_t^{tar}}{\pi^{tar}}) + r_\pi(\ln(\frac{\pi_{t-1}}{\pi}) - \ln(\frac{\pi_t^{tar}}{\pi^{tar}})) \\ &+ r_y \ln(\frac{y_{t-1}}{y}) + r_s((R_{L,t-1} - R_{t-1}) - (R_L - R))] + \varepsilon_{R,t} \end{aligned} \quad (13)$$

Where R_t, π_t^{tar}, π_t and y_t is policy interest rate, inflation target, actual inflation and actual output, their steady state values are R, π^{tar}, π and y respectively, ρ_R is the interest rate smoothing coefficient, r_π and r_y are the reaction coefficients of inflation and output, respectively, r_s is the reaction coefficient to the slope of the interest rate curve. Chen (2012) argues that the Fed's large-scale asset purchases can be considered to directly change the long-term bond supply and demand in the market. Therefore, this paper takes the long-term actual debt-to-output ratio $Ratio_{b_L y,t}$ as a policy control variable to satisfy the first-order autoregressive process.[6]

$$\ln(\frac{Ratio_{b_L y,t}}{Ratio_{b_L y}}) = \rho_{b_L y} \ln(\frac{Ratio_{b_L y,t-1}}{Ratio_{b_L y}}) + \varepsilon_{b_L y,t} \quad (14)$$

3.5. Market clearing

When the market is balanced, households and firms are in a state of maximizing their objective function. The total resource constraints of the market have the following forms.

$$y_t = \omega_u c_t^u + \omega_r c_t^r + i_t + g_{i,t} + a(u_t)\bar{k}_{t-1} + g_{c,t} \quad (15)$$

Let $\dot{p}_t$ denote the degree of price dispersion, $\dot{p}_t = [\int_0^1 (P_{i,t}/P_t)^{\lambda_f/(1-\lambda_f)} di]^{(1-\lambda_f)/\lambda_f}$. When the product market is balanced, the following formula is established.

$$y_t = (\dot{p}_t)^{\frac{\lambda_f}{1-\lambda_f}} (\dot{o}_t k_{t-1}^{\alpha} l_t^{1-\alpha} g_{k,t-1}^{\alpha_g} - \Phi) \quad (16)$$

4. Calibration

Because China has not actually implemented unconventional monetary policy, it is not possible to estimate the model through historical data. This paper uses the calibration method to give the model parameter estimates.

According to the literature, the calibration values of each parameter are given in Table 1.

Table 1: Parameter calibration value

parameter	value	parameter	value	parameter	value
ω_u	0.93	α_g	0.2	$Ratio_{b_L y}$	0.2098
ω_r	0.07	δ	0.025	$\sigma_{\dot{o}}$	0.047
β^u	0.997	λ_f	1.2	σ_R	0.03
R_L	0.039	ξ_p^g	0.75	σ_ζ	0.2
β^r	0.995	κ_p	0.7	$\sigma_{b_L y}$	0.3686
b^j	0.85	r_π	1.5	σ_g	0.1965
σ_L^j	0.818	r_y	0.3	σ_{g_c}	0.1817
α	0.5	r_s	0.4		

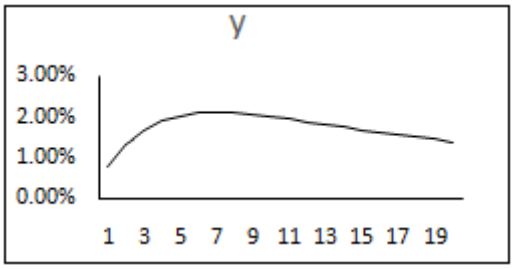
(The exogenous shock $\varepsilon_{x,t}$ is independent normal distribution and the mean is 0, and the standard deviation is σ_x. $x = \dot{o}$, R, ζ, $b_L y$, g_i, g_c represents smooth technical shocks, conventional monetary policy shocks, interest rate premium shocks, unconventional monetary policy shocks, government investment, and government consumption shocks respectively.)

5. Policy response

In conventional DSGE modeling, since the bond market is not segmented, because there is no arbitrage, the household will change the investment decision so that the returns of different assets are the same. In the model setting in this paper, the household's investment constraints actually break the no-arbitrage condition, and the exogenous shock of long-term bonds can be considered as an embodiment of unconventional monetary policy, so it can simulate the unconventional monetary policy.

5.1. Asset purchase

The first way of unconventional monetary policy is asset purchase. Generally, the central bank stimulates the economy by purchasing long-term government bonds or other long-term asset-backed securities directly on the open market. Figure 1 simulates the response of output, short-term interest rates, long-term interest rates, and inflation to large-scale asset purchase shocks.



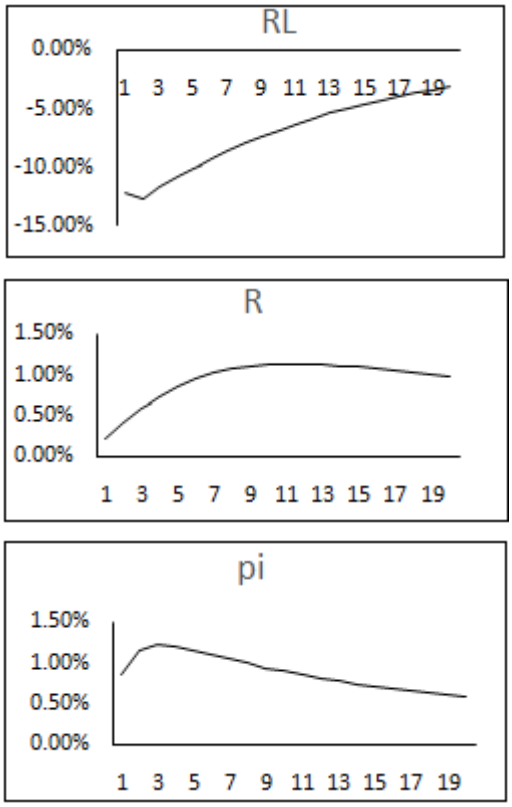


Figure 1: Quantitative Easing shock simulation

As can be seen from Figure 1, the large-scale purchase shock of long-term assets leads to a rise in long-term asset prices, a decline in long-term interest rates, a reduction in the financing costs of the private sector, a recovery in economic output, and an upward pressure on inflation. On the other hand, when output and inflation begin to rise, policy interest rates also change accordingly, and the rise of short-term interest rates has a negative impact on output. From the model simulation results, the positive effect of the long-term interest rate decline on the economy is greater than the negative effect, and the output shows a positive deviation from the steady state. Figure 1 shows that the large-scale asset purchase shock caused the long-term interest rate to immediately deviate from the steady state by 13%, the output level began to deviate from the steady state in the positive direction, and the impact response reached the highest point 2.1% after seven periods, shows a distinct "hump" feature. Inflation rose rapidly after the shock, the short-term interest rate immediately responded. The inflation deviation began to return to the steady state after three periods, and the maximum deviation was 1.3%.

5.2. Operation twist

Private sector investment returns are expected to be more affected by long-term interest rates. Therefore, the objective of unconventional monetary policy is long-term interest rate. The distortion operation can achieve the interest rate target by adjusting the balance sheet duration of the central bank without increasing the balance of government debt. Taking into account the balance sheet constraints, we have increased the total debt constraint when simulating the distortion operation to ensure that the central bank's debt scale will not expand.

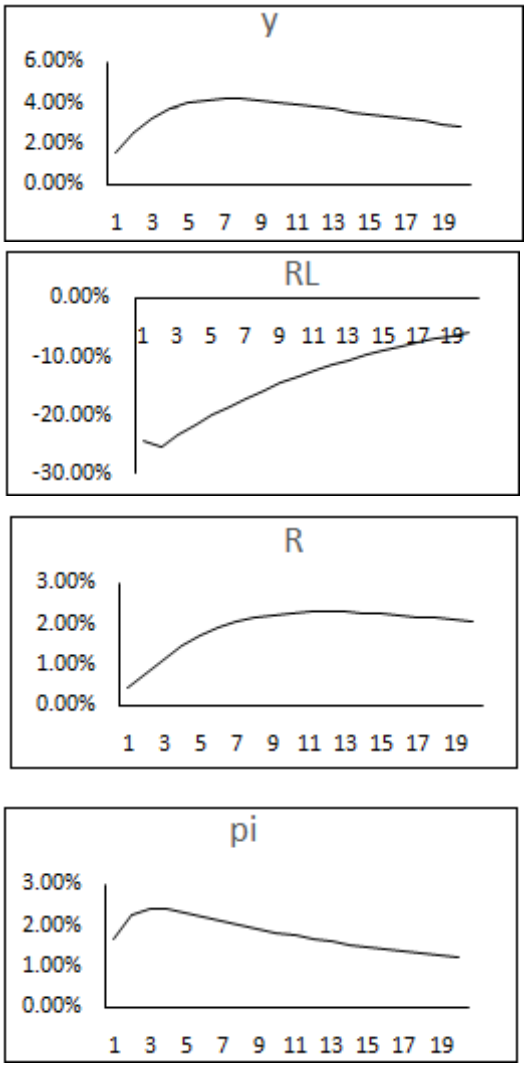


Figure 2: Twisting operation shock simulation

Figure 2 shows that long-term interest rates fall rapidly due to the increase in demand for long-term bonds, negatively deviating from the steady state of 26%. On the one hand, short-term interest rates increase due to short-term bond supply, and on the other hand, due to the role of Taylor's rule, the positive deviation from the steady state is up to 2.2%. Comparing the effects of quantitative easing, it is easy to find that the distortion operation makes the long-term and short-term interest rates deviate even more. From the impact reaction, the distortion operation caused the output to deviate from the steady state by 4.2%, which is twice the effect of the quantitative easing policy, the inflation level also increased accordingly, reaching 2.4% in the third period after the shock. Consistent with quantitative easing, under the premise of government departments participating in production, output changes have a certain delay and persistence, and the impact graphs of output and inflation also show the characteristics of “hump”.

Therefore, the distortion operation has more practical space in China at this stage, and it is more important to explore the policy effect of this policy.

6. Conclusion

By establishing a DSGE model with a bond market segmentation, this paper discusses the implementation of unconventional monetary policy and the economic system's policy response without the zero lower bound in detail. And both quantitative easing and distortionary operations will reduce long-term interest rates, increase output and inflation, and lead to rising short-term interest rates. But the difference is that because the distortion operation is affected by the debt balance constraint, the reduction of long-term bonds is accompanied by the increase of short-term bonds. The opposite direction of the two types of bonds with different maturity causes the long-term term interest rate premium to decrease more severely. From the simulation results, the distortion operation can bring greater impact on economic output.

However, unconventional monetary policy itself has some negative effects, such as a certain degree of inflation, and when long-term interest rates fall, capital will inevitably flow to higher-yield assets, so the financial system needs to take greater risks. There are also some negative results that we did not anticipate.

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