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The Specific Impact of Monetary Policy on Macroeconomic Fluctuations

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Abstract: The stability of monetary policy is crucial for overall economic stability, as both excessive tightening and excessive easing may lead to increased economic fluctuations and financial risks. This paper incorporates zero-interest-rate constraints and monetary policy shocks into a general equilibrium model to discuss the specific impact of monetary policy on macroeconomic fluctuations. The study reveals that when the economy reaches the zero lower bound of interest rates, the overall instability and vulnerability of the macroeconomy significantly increase. Even minor shocks can then result in severe fluctuations. In such circumstances, corresponding monetary policies can be employed to maintain the stability of the financial system. Additionally, effective coordination between monetary policy and macroprudential policy should be emphasized to minimize the losses from adverse shocks.

Keywords: Monetary Policy, Macroeconomic Fluctuations, General Equilibrium

1. Introduction

Since the 2008 crisis, the role of financial factors in the transmission of macroeconomic fluctuations has been increasingly emphasized. Financial stability and macroeconomic policies have become focal points of concern for scholars and central banks. Many countries have introduced macroprudential regulatory frameworks to prevent systemic risks and maintain the stability of the financial system and macroeconomy. Building upon Bernanke et al. [1], this section introduces financial frictions and macroprudential regulatory policies to explore the specific mechanisms through which financial shocks gradually transmit to the real economy. On this basis, it analyzes the coordination issues between monetary policy and macroprudential policy.

On the other hand, considering the numerous central banks that have implemented Quantitative Easing (QE) policies to stimulate the economy since the recent crisis, and nominal interest rates in major developed economies are already at extremely low levels. Since 2016, central banks including the European Central Bank, Sweden, Japan, and others have implemented negative interest rates. The Zero Lower Bound (ZLB) has become a challenging problem for many central banks in their monetary policy operations. Fischer [2] pointed out that when interest rates are in an ultra-low environment, the fragility and instability of the financial system significantly increase. To comprehensively depict the amplification mechanism of financial shocks on the real economy, this paper introduces the zero-interest-rate constraint based on the standard BGG model and analyzes the differential responses to exogenous shocks and the coordination of policy combinations when the economy is in the zero-interest-rate and normal ranges.

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The existence of the zero lower bound can have adverse effects on the economy; therefore, monetary policy should respond accordingly to maintain the stability of the financial system. In fact, since the recent crisis, many scholars have advocated for the inclusion of financial stability in the framework of monetary policy formulation. However, there is no consensus on whether monetary policy should respond to financial stability and how to respond. Yalen and Williams [3,4] argue that monetary policy is more suitable for maintaining the stability of output and inflation gaps and faces significant limitations in dealing with financial instability. They suggest that macroprudential policy can quickly maintain the stability of the financial system. The IMF [5] also believes that macroprudential policy should be the first line of defense against preventing financial risks. Svensson [6] further establishes a cost-benefit analysis of policy to discuss the benefits and costs of implementing monetary policy targeting financial stability. However, Stein [7] argues that macroprudential policy also has considerable limitations, as a significant amount of shadow banking and private lending often circumvent regulations, creating a vacuum in macroprudential policy. In contrast, monetary policy can influence the behavior of all borrowers and lenders, thereby maintaining the stability of the financial system.

2. Model

2.1. Consumers

Assuming a representative consumer with an infinite life span, forming a continuous time interval on $(0,1)$. The consumer generates income by providing labor and purchasing bonds each period, consumes after paying taxes, and subsequently purchases bonds for the next period. The representative consumer maximizes their expected lifetime utility subject to budget constraints:

$$maxE_t\Sigma_{k=0}^{\infty}\beta^k\left[lnC_{t+k}+\zeta ln\left(\frac{M_{t+k}}{P_{t+k}}\right)-\frac{N_{t+k}^{1+\xi}}{1+\xi}\right] \tag{1}$$

Where, E_t is the expectation operator, β is the intertemporal discount rate, M_t and C_t are the quantity of money and consumption held by the consumer in period t, respectively. N_t represents the labor provided by the consumer to entrepreneurs in period t. ζ measures the marginal utility of money, while ξ represents the elasticity of labor substitution. The consumer's budget constraint is expressed as follows:

$$P_tC_t+B_{t+1}+M_t=W_tN_t+M_{t-1}+R_tB_t+\Pi_t-T_t \tag{2}$$

In this section, the sources of consumer income are presented. W_t represents the nominal wage level, B_t represents the risk-free bonds held by the consumer, and the yield is R_t. Given the assumption that all businesses are ultimately owned by households, Π_t and T_t represent the dividend income received by households from businesses and the taxes paid to the government, respectively. After acquiring income, consumers engage in consumption and purchase bonds B_{t+1} for the next period. Therefore, the optimization problem for consumers can be summarized as choosing the optimal consumption C_t , bond purchase quantity B_{t+1}, and labor N_t to maximize the expected utility in Equation (1) subject to the constraint in Equation (2). The first-order optimization conditions are:

$$\frac{1}{C_t}=\beta E_t\left(\frac{R_t}{\pi_{t+1}C_{t+1}}\right) \tag{3}$$

$$\frac{w_t}{C_t}=N_t^{\xi} \tag{4}$$

2.2. Entrepreneurs

This paper assumes entrepreneurs are risk-neutral and follow a uniform distribution in the interval $(0,1)$. Entrepreneurs engage in production by hiring labor and purchasing capital, selling the produced goods to intermediaries to generate profits. The production function is assumed to take the Cobb-Douglas form:

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha} \tag{5}$$

Here, K_t and N_t represent the capital and labor inputs in period t, Y_t is the output of entrepreneurs each period, α is the share of capital income in total income, and A_t is the total factor productivity. It is assumed that A_t follows a first-order logarithmic autoregressive process:

$$lnA_t = \rho_a lnA_{t-1} + \varepsilon_t^a \quad \varepsilon_t^a \sim i.i.d\ N(0, \sigma_a^2) \tag{6}$$

Following Bernanke et al. [1], the capital entrepreneurs need to purchase at the end of period t is K_{t+1}, and the market price for capital goods at this time is Q_t. Therefore, the total expenditure required for business investment is $Q_t K_{t+1}$. Assuming that businesses use internal financing and external bond issuance to raise funds for total expenditure, if the net worth of the business itself in period t is V_t, the scale B_t of bonds to be issued is:

$$B_t = Q_t K_{t+1} - V_t \tag{7}$$

The return rate of capital from period t to t+1, $E_t R_{t+1}^k$, is the sum of two parts: the marginal product of capital and capital gains. If the depreciation rate of capital is δ, the expected return rate of capital is:

$$E_t R_{t+1}^k = E_t \frac{\frac{1}{X_{t+1}} \frac{\alpha Y_{t+1}}{K_{t+1}} + Q_{t+1}(1-\delta)}{Q_t} \tag{8}$$

Here, X_t represents the markup rate, i.e., the markup rate when entrepreneurs sell intermediate goods to retailers. Entrepreneurs choose the demand for labor based on the marginal product value of labor, which is equal to the marginal cost:

$$\frac{W_t}{P_t} = \frac{1-\alpha}{X_t} \frac{Y_t}{N_t} \tag{9}$$

Simultaneously, entrepreneurs' activities are subject to exogenous shocks in productivity ω. This results in the income of entrepreneur j, denoted as $\omega^j R_t^k$. Furthermore, all ω^j are independently and identically distributed according to a log-normal process. Setting the distribution function and probability density function of ω^j as $F(\omega^j)$and $f(\omega^j)$, respectively, with a mean of $E(\omega^j) = 1$. According to Bernanke et al. [1], due to frictions in the credit market, only entrepreneurs can observe ω^j, and financial institutions cannot. However, financial intermediaries, in order to observe ω^j, can incur monitoring costs, which are proportional to the income from capital, denoted as $\sigma_{t+1} \omega_{t+1} R_{t+1}^k Q_t K_{t+1}$. When ω_t is less than a certain threshold ϖ, entrepreneurs will default. In this case, ϖ satisfies:

$$\varpi_{t+1} R_{t+1}^k Q_t K_{t+1} = R_{t+1}^b B_{t+1} \tag{10}$$

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In Equation (10), R_{t+1}^{b} represents the interest rate on bank loans that businesses can obtain in the absence of default. The debt contract arrangement between entrepreneurs and banks is as follows: if $\omega_t \geq \varpi_t$, entrepreneurs operate normally and pay interest $R_t^b B_t$ when due. If $\omega_t < \varpi_t$, entrepreneurs declare bankruptcy, and banks liquidate, obtaining all remaining assets $\omega_t R_{t+1}^{k} Q_t K_{t+1}$ of the business. After deducting the monitoring costs paid, the bank's profit is $(1-\sigma_{t+1})\omega_{t+1} R_{t+1}^{k} Q_t K_{t+1}$. Assuming financial intermediaries are risk-neutral and can fully diversify risk, their income should equal their costs, resulting in zero equilibrium profit.

$$[1-F(\varpi_t)]R_{t+1}^{b}B_{t+1} + (1-\sigma_t)\int_0^{\varpi_{t+1}} \omega_t R_{t+1}^{k} Q_t K_{t+1} dF(\omega_t) = R_{t+1}^{n} B_{t+1} \tag{11}$$

The proportion of bank profits is $\Gamma_t(\varpi_{t+1}) = \int_0^{\varpi_{t+1}} \omega_t dF(\omega_t) + \varpi_{t+1}\int_{\varpi_{t+1}}^{\infty} f(\omega_t) d\omega_t$, denoted as $\Theta_t(\varpi_{t+1}) = \int_0^{\varpi_{t+1}} \omega_t dF(\omega_t)$, and the proportion of net bank profits is $\Gamma_t(\varpi_{t+1}) - \sigma_{t+1}\Theta_t(\varpi_{t+1})$, thereby the proportion of profits for businesses is $1-\Gamma_t(\varpi_{t+1})$. Substituting into Equation (11) for rearrangement, the result is:

$$[\Gamma_t(\varpi_{t+1}) - \eta_{t+1}\Theta_t(\varpi_{t+1})]R_{t+1}^{k} Q_t K_{t+1} = R_t(Q_t K_{t+1} - V_t) \tag{12}$$

Entrepreneurs choose the optimal K_{t+1} and ϖ_{t+1} to maximize profits:

$$\max[1-\Gamma_t(\varpi_{t+1})]\, R_{t+1}^{k} Q_t K_{t+1} \tag{13}$$

According to Bernanke et al. [1], credit market frictions prevent borrowers from always borrowing at a risk-free rate. Borrowers receive credit allocation based on their qualifications and credit records. The higher the risk of the borrower, the higher the financing premium they demand. Additionally, as enterprises with higher debt ratios exhibit greater moral hazard, the external financing spread for enterprises should be an increasing function of their debt ratio:

$$E_t R_{t+1}^{k} = f_t E_t\left(\frac{R_t}{\pi_{t+1}}\right)\Psi\left(\frac{V_t}{Q_t K_{t+1}}\right), \Psi(1) = 1, \Psi'(\cdot) < 0 \tag{14}$$

Where, V_t represents the net worth of entrepreneur in period t. $\Psi(\cdot)$ reflects the sensitivity of the external financing spread to the net worth of the enterprise. f_t is an exogenous financial shock and follows the following first-order autoregressive process:

$$lnf_t = \rho_f lnf_{t-1} + \varepsilon_t^f \quad \varepsilon_t^f \sim i.i.d\ N(0, \sigma_f^2) \tag{15}$$

As a fixed proportion of enterprises go bankrupt each period, and only those accounting for φ survive, the equation governing the movement of enterprise net worth is as follows:

$$V_{t+1} = \varphi\left(R_{t+1}^{k} Q_t K_{t+1} - E_t\left(\frac{R_t}{\pi_{t+1}}\right)\Psi\left(\frac{V_t}{Q_t K_{t+1}}\right)(Q_t K_{t+1} - V_t)\right) \tag{16}$$

2.3. Capital Goods Producer

In period t, the capital goods producer invests in new capital, denoted as I_t, and together with old capital, K_t, produces the next period's capital, K_{t+1}. The evolution path of the capital goods stock is given by:

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right)K_t + (1-\delta)K_t \tag{17}$$

Where $\Phi(\cdot)$ is the adjustment cost function for investment, with $\Phi'(\cdot) > 0$ and $\Phi''(\cdot) < 0$. The domestic capital goods producer maximizes its profit under the constraint in Equation (17):

$$maxE_t\Sigma_{t=0}^{\infty}\Lambda_t(Q_tK_{t+1} - Q_tK_t - I_t) \tag{18}$$

Where, Λ_t is a stochastic discount factor. Based on the optimization conditions, the equilibrium asset price Q_t can be derived as:

$$Q_t = \left[\Phi'\left(\frac{I_t}{K_t}\right)\right]^{-1} \tag{19}$$

2.4. Retailer

This paper introduces the retail sector to generate price stickiness. Assuming there is a continuous distribution of domestic product retailers i over the interval $[0,1]$ in each period, each retailer purchases goods $Y_t(i)$ from domestic entrepreneurs at a wholesale price P_t^W, repackages them, and sells them at a price P_t. The specific forms of final products Y_t and the corresponding price index P_t are as follows:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\psi-1}{\psi}}\right)^{\frac{\psi}{\psi-1}} \tag{20}$$

$$P_t = \left(\int_0^1 P_t(i)^{\frac{\psi-1}{\psi}}\right)^{\frac{\psi}{\psi-1}} \tag{21}$$

Each retailer i faces a domestic product demand curve:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\psi} Y_t \tag{22}$$

According to Calvo et al. [8], only a proportion $1 - \theta$ of retailers can flexibly set prices each period, while the rest maintain their prices at the previous period's level. Therefore, the movement equation for the domestic price P_t is:

$$P_t = P_{t-1}^{\theta} P_{t-1}^{*1-\theta} \tag{23}$$

The retailer's optimal pricing decision is to choose $P_t^*(i)$ to maximize its profit:

$$E_t\Sigma_{k=0}^{\infty}\theta^k\left(\frac{P_t^*(i)}{P_{t+k}} - \frac{P_{t+k}^W}{P_{t+k}}\right)Y_{t+k}(i) \tag{24}$$

Substituting the expression of the demand curve $Y_{t+k}(i)$, the optimal price expression $P_t^*(i)$ can be obtained as follows:

$$P_t^*(i) = \mu\Pi_{k=0}^{\infty}(P_{t+k}^W)^{(1-\beta\theta)(\beta\theta)^k} \tag{25}$$

Where, $\mu = \frac{\psi}{\psi-1}$ represents the markup on prices. Combining equations (24) and (25), the inflation rate of domestic goods can be obtained as follows:

$$\frac{P_t}{P_{t-1}} = \left(\mu \frac{P_t^W}{P_t}\right)^{\lambda} E_t \left(\frac{P_{t+1}}{P_t}\right)^{\beta} \tag{26}$$

Where, $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$, linearizing equation (26) around the steady-state inflation rate provides the Phillips curve as shown in equation (27). Here, x_t is the log deviation from X_t and its steady state, and π_t represents the inflation rate level of the domestic country.

$$\pi_t = \beta E_t \pi_{t+1} - \frac{(1-\theta)(1-\beta\theta)}{\theta} x_t \tag{27}$$

2.5. Government Sector

The government sector acquires income through issuing currency and taxation for government purchases. Its balance sheet can be represented as:

$$\frac{M_t - M_{t-1} + T_t}{P_t} = G_t \tag{28}$$

Additionally, the government sector must formulate monetary and macroprudential policies to maintain stability in the macroeconomy and financial system. We assume that government monetary policy operations follow a Taylor rule, and its specific control mode can be represented as:

$$R_t = R_{t-1}^{\gamma_0} \left[\bar{R} \left(\frac{P_t}{P_{t-1}}\right)^{\gamma_1} \left(\frac{Y_t}{\bar{Y}}\right)^{\gamma_2}\right]^{1-\gamma_0} e_t^R \tag{29}$$

Where, $\bar{R}$ represents the level of interest rates when the economy reaches a steady state, $\bar{Y}$ represents the potential GDP level, and γ_0 indicates the responsiveness of the current interest rate to the previous period's interest rate. γ_1, γ_2 are the sensitivities of the central bank's interest rate to inflation and output gaps, respectively. e_t^R represents a monetary policy shock, assumed to follow a logarithmic AR (1) process.

On the other hand, considering that since the recent crisis, most countries have lowered interest rates to stimulate the economy, the interest rate levels of major economies are already very low. Neri and Notarpietro [9] pointed out that in a zero-interest-rate environment, even small adverse shocks can lead to significant economic fluctuations. Therefore, to explore the impact of the zero lower bound on the macroeconomy, we further incorporate the zero-interest rate constraint on the basis of the above equation:

$$R_t = max\left\{R_{t-1}^{\gamma_0} \left[\bar{R} \left(\frac{P_t}{P_{t-1}}\right)^{\gamma_1} \left(\frac{Y_t}{\bar{Y}}\right)^{\gamma_2}\right]^{1-\gamma_0} e_t^R, 1\right\} \tag{30}$$

Due to the difficulty of conventional DSGE models in handling interest rate rules with non-negative constraints, according to the method of Paetz and Tom Holden (2012), we first take the logarithm of the above equation and then introduce a stochastic shock to the shadow price.

$$lnR_t = \gamma_0 lnR_{t-1} + (1-\gamma_0)\left[\gamma_1 ln\left(\frac{P_t}{P_{t-1}}\right) + \gamma_2 ln\left(\frac{Y_t}{\bar{Y}}\right)\right]^{1-\gamma_0} + shadow\_price \tag{31}$$

In equation (39), $shadow\_price$ represents the shadow price shock of the interest rate, which can determine when the interest rate reaches the zero lower bound and the duration of staying at zero interest rates.

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Simultaneously, since the global financial crisis, macroprudential policy has gradually become a focus for central banks in many countries. Especially after 2010, the introduction of Basel III has further emphasized macroprudential regulation to an unprecedented level. To address the coordination of monetary policy and macroprudential policy in the model, we refer to Kannan et al. [10] and introduce the regulatory tools of macroprudential policy as follows:

$$E_t R_{t+1}^k = f_t E_t \left(\frac{R_t}{\pi_{t+1}}\right) \Psi \left(\frac{V_t}{Q_t K_{t+1}}\right) \left(\frac{cg_t}{\overline{cg}}\right)^{\rho_\tau} \tag{32}$$

Where cg_t represents the total social credit growth rate, defined as follows:

$$cg_t = \frac{B_t}{B_{t-1}} \tag{33}$$

ρ_τ is the macroprudential policy adjustment tool chosen by the policymaker. When the economy is prosperous, macroeconomic fundamentals are good, funds are abundant, and there are also many investment opportunities for enterprises, often resulting in excessively fast credit growth. In this case, policymakers can choose a larger ρ_τ to increase the financing cost for businesses, thereby maintaining the stability of credit growth. Conversely, in an economic downturn, output and investment will decline significantly, and the probability of business bankruptcy and default will be higher. In this scenario, credit growth tends to decline. Policymakers can choose a smaller ρ_τ to alleviate the financing constraints of businesses, thereby stimulating credit growth.

Finally, when the model reaches a general equilibrium, according to the definition of GDP, we have the following market clearing condition:

$$Y_t = C_t + I_t + G_t \tag{34}$$

3. Parameter Calibration and Bayesian Estimation

This paper employs the Bayesian estimation method to estimate the parameters of the log-linearized model. The data used in this study cover the quarterly period from 1980Q1 to 2016Q4 in the United States, including GDP, nominal interest rates, inflation rates, the S&P 500 index, credit loans, and more. All data in this paper are sourced from the FRED and CEIC databases. The calibrated parameters in this paper are shown in Table 1. Following references from classical literature, the subjective discount factor β is set to 0.99, and the depreciation rate δ is set to 0.025, equivalent to an annual depreciation rate of 0.1. The relative utility weight of labor ξ is set to 3, and the capital ratio α in the production function is set to 0.33. The asset-liability ratio of enterprises in the steady state is set to 2. Following the pricing method of Calvo et al. [8], the probability of enterprises maintaining unchanged prices is set to 0.75. Referencing Bernanke et al. [1], the survival probability of enterprises in this paper is set to 0.9728, which is equivalent to an enterprise's survival period of 36 years.

Table 1: Calibrated Parameters

	Parameters	Values
β	Subjective Discount Factor	0.99
δ	Depreciation Rate	0.025
ξ	Labor Relative Utility Weight	3
θ	Probability of Price Invariance	0.75
φ	Enterprise Survival Rate	0.9728

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Table 1: (continued).

η	Risk Premium	0.02
α	Capital Ratio	0.33
$\frac{K}{V}$	Steady-State Enterprise Asset-Liability Ratio	2

The parameters estimated in this paper are presented in Table 2, including the prior distribution, posterior distribution, and estimated means of the parameters. The autoregressive coefficients ρ_a, ρ_g and ρ_f are assumed to follow a Beta distribution for their prior distributions. The smoothing coefficient γ_0 in the interest rate rule has a prior distribution set as a Beta distribution, while the coefficients for the inflation gap and output gap multiplied by $(1-\gamma_0)$ have prior distributions set as Gamma distributions. The standard deviations σ_r, σ_g, σ_a and σ_f have prior distributions set as Inverse Gamma distributions. Figure 1 illustrates the prior and posterior distributions of the estimated parameters. The posterior estimate for σ_r is constant, and the posterior means of σ_r, σ_a and σ_f are relatively small, all less than the prior means. In contrast, the posterior mean of σ_g is notably larger than the prior mean. The posterior means of ρ_a, ρ_g and ρ_f are all greater than their respective prior means. The posterior mean of the smoothing coefficient is 0.7545, and the posterior means of the coefficients for the inflation gap and output gap multiplied by $(1-\gamma_0)$ are 0.4044 and 0.0629, respectively, implying coefficients for the inflation gap and output gap of 1.6473 and 0.2562.

Table 2: Bayesian Estimation Parameters

Parameters	Prior Distribution			Posterior Distribution		
	Density	Mean	Standard Deviation	5%	Mean	95%
ρ_a	Beta Distribution	0.5	0.25	0.8230	0.8781	0.9272
ρ_g	Beta Distribution	0.5	0.25	0.7052	0.7413	0.7792
ρ_f	Beta Distribution	0.5	0.25	0.9203	0.9436	0.9708
γ_0	Beta Distribution	0.5	0.25	0.7023	0.7545	0.8066
s_1	Gamma Distribution	0.25	0.125	0.3169	0.4044	0.4941
s_2	Gamma Distribution	0.25	0.125	0.0522	0.0629	0.0736
σ_r	Inverse Gamma Distribution	0.1	2	0.0107	0.0107	0.0107
σ_g	Inverse Gamma Distribution	0.1	2	0.5918	0.6606	0.7245
σ_a	Inverse Gamma Distribution	0.1	2	0.0153	0.0189	0.0221

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Table 2: (continued).

σ_f	Inverse Gamma Distribution	0.1	2	0.0382	0.0443	0.0499

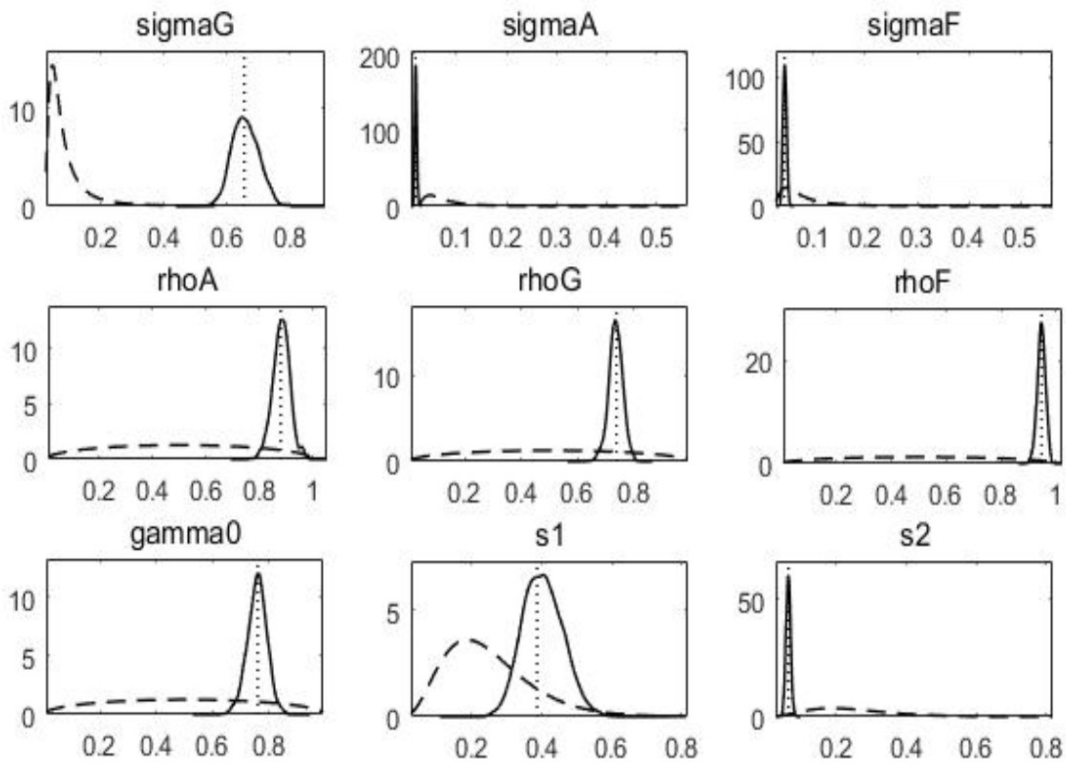

Figure 1: Prior (dashed line) and Posterior (solid line) Distribution Plots

4. Model Dynamics

Impulse response functions can depict the response curves of key variables in the economy when subject to exogenous shocks. By considering one-unit financial shock and productivity shock, we illustrate the impulse response of major macro variables in the model. Figure 2 presents the response of various variables to a one-unit negative financial shock.

From Figure 2, it can be observed that a negative financial shock leads to a rapid decline in asset prices, shrinking the net worth of businesses and deteriorating the balance sheet situation, thereby causing an increase in external risk premium. The rise in external financing costs increases the financing expenses for businesses, resulting in reduced investment, leading to a decline in output, consumption, employment, capital stock, and inflation rate. This phenomenon is known as the "financial accelerator" effect, which is entirely consistent with the findings of Bernanke et al. [1]. This indicates that under conditions of imperfect credit markets and financial frictions, financial shocks amplify the fluctuations in the real economy through a series of channels.

On the other hand, it is noteworthy that when the zero lower bound exists, the responses of various variables, especially output and capital, are stronger compared to the responses in the absence of the zero lower bound. The increase in external financing premium is even more pronounced. This suggests that the presence of the zero lower bound can amplify the "financial accelerator" effect,

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thereby increasing the instability and vulnerability of the economy. This is because when the economy reaches the zero lower bound, it often corresponds to an economic recession period, where the likelihood of business bankruptcies and defaults is higher, intensifying credit rationing in the credit market and further magnifying the effect of the financial accelerator.

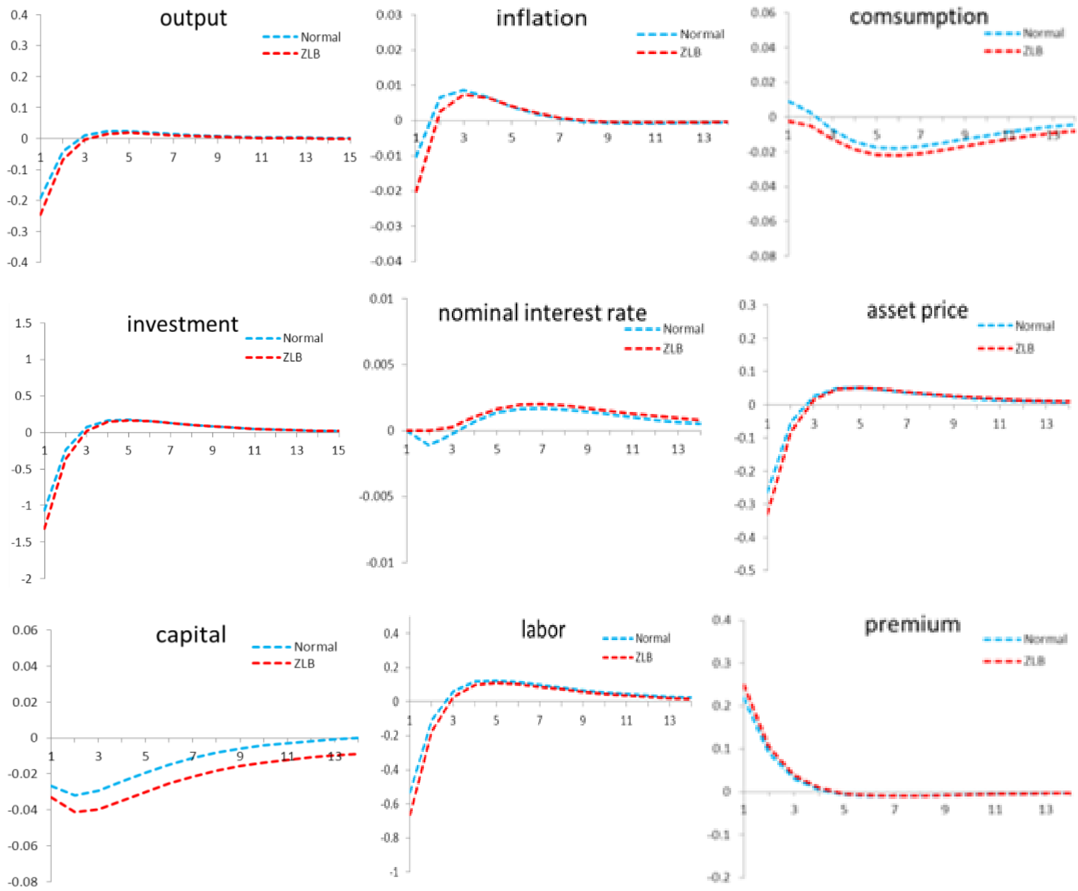

Figure 2: Response of the Economy to a One-Unit Negative Financial Shock

Figure 3 illustrates the impact of a one-unit negative technology shock on the economy. From the figure, it can be observed that the negative technology shock leads to a rapid decline in investment, followed by a decrease in capital stock and employment, which, in turn, suppresses output and consumption. Due to the deterioration of corporate financial conditions and net worth, this results in an increase in the risk premium of asset prices. Similar to the negative financial shock, the existence of the zero lower bound amplifies the impact of exogenous adverse shocks. This is because the zero lower bound restricts the extent of interest rate declines, and coupled with the impact of negative inflation expectations, it leads to a substantial increase in real interest rates, further severely deteriorating economic conditions and inhibiting economic growth.

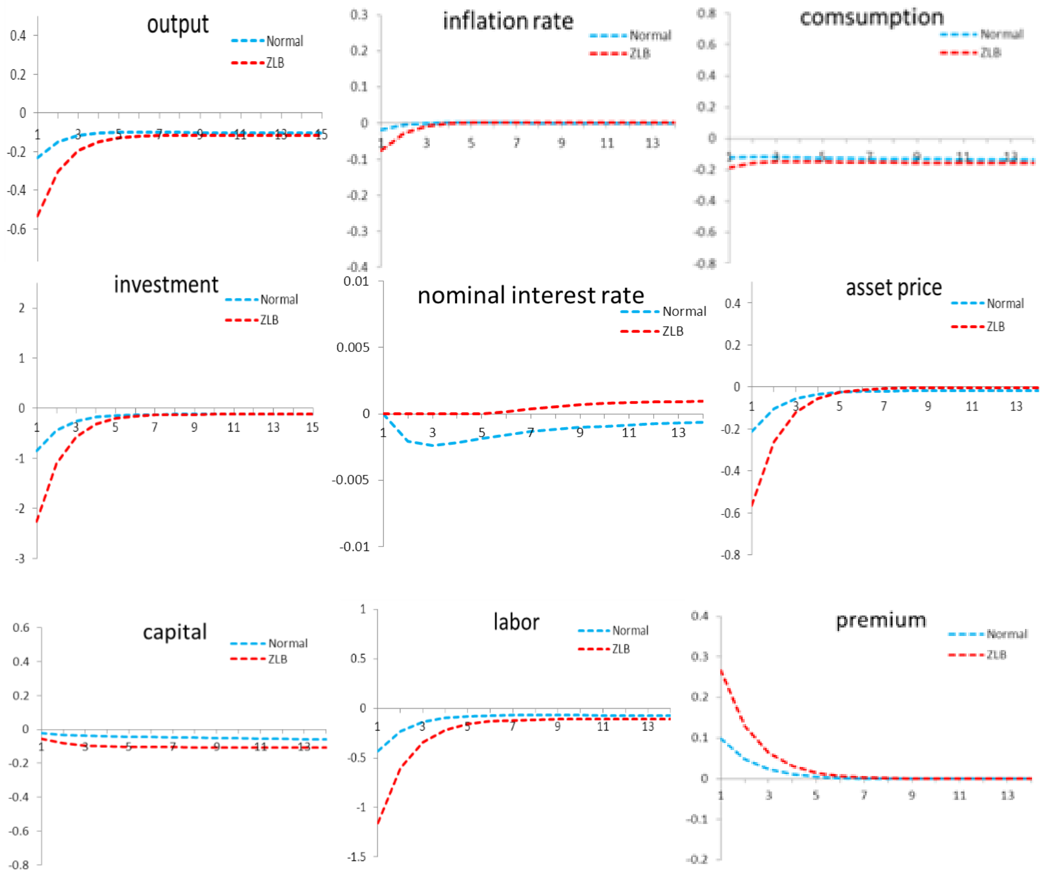

Figure 3: Response of the Economy to a One-Unit Negative Technology Shock

5. Simulation

The impulse response graph reflects the short-term dynamic responses of major macroeconomic variables when the system is subjected to exogenous shocks. To further analyze the long-term trends in the economy, we conducted additional simulation experiments. Using the Monte Carlo simulation method with a simulation period of 200 periods, we simulated the trends of economic variables such as interest rates, inflation, investment, asset prices, corporate credit, and output in the scenarios where the nominal interest rate reaches the zero lower bound and where it does not. Figures 4.1 to 4.6 present specific simulation results. The horizontal axis represents the simulation periods, and the vertical axis represents the percentage deviation from the steady state. Solid lines represent the trends of economic variables when the economy does not reach the zero lower bound constraint, while dashed lines represent the changes in variables when the zero lower bound has been reached.

Figure 4(a) provides the long-term trend of nominal interest rates in response to exogenous shocks to productivity and financial shocks. From Figure 4(a), it is evident that the solid lines represent periods with negative values, indicating the intervals where the zero lower bound is reached. It can be seen that the zero lower bound is reached for approximately 25 periods, accounting for 12.5% of the total sample. The simulation trends for inflation and investment are illustrated in Figures 4(b) and 4(c), respectively. It can be observed from the figures that the zero lower bound amplifies the volatility of investment and inflation, possibly because when the economy reaches the zero lower bound, the pessimistic expectations of entrepreneurs and households for the future intensify negative inflation expectations, leading to a rapid increase in real interest rates and a subsequent decline in investment levels.

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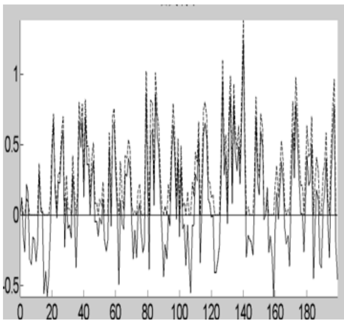

Figure 4(a): Simulation of Nominal Interest Rates

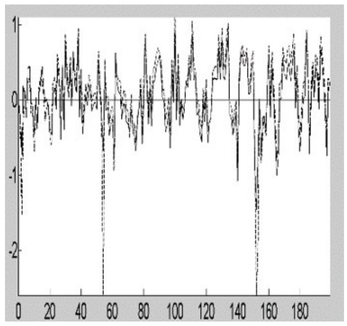

Figure 4(b): Simulation of Inflation

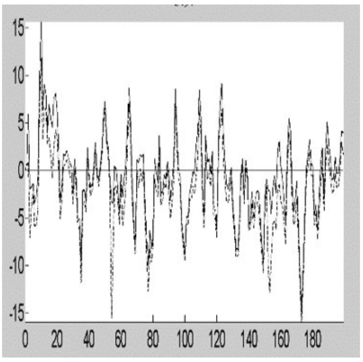

Figure 4(c): Simulation of Investment

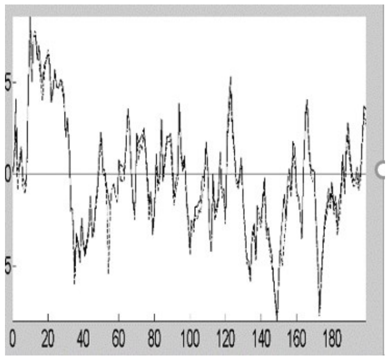

Figure 4(d): Simulation of Asset Prices

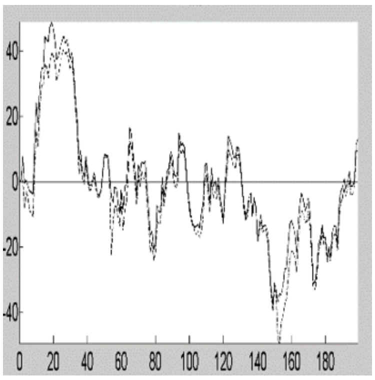

Figure 4(e): Simulation of Corporate Credit

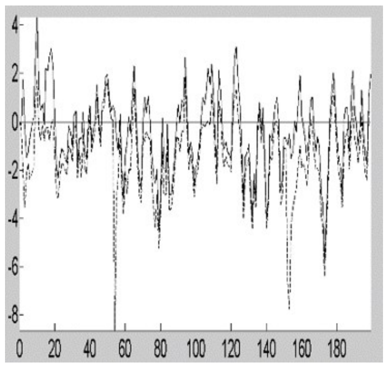

Figure 4(f): Simulation of Output

Figure 4: Time series of the simulated variables

Figure 4(d) to Figure 4(f) are simulation charts of asset prices, corporate credit, and output, respectively. From Figure 4(d), it can be observed that the zero lower bound constraint intensifies the volatility of asset prices. The rise in asset prices increases corporate net worth, making it easier for enterprises to obtain credit, while a decline in asset prices shrinks corporate net worth, making it more difficult to obtain loans through financial intermediaries. However, due to the more pronounced volatility in asset prices when the zero lower bound is reached, the zero lower bound constraint will also amplify the degree of corporate credit fluctuations. As analyzed earlier, when nominal interest rates touch the zero lower bound, preventing interest rates from falling, negative inflation expectations lead to a rapid increase in real interest rates, suppressing household and corporate investment and exacerbating output decline. This indicates that when the economy reaches the zero

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lower bound, the overall macroeconomic instability and vulnerability significantly increase, and even minor shocks can lead to drastic fluctuations.

Building on previous research by scholars, in order to analyze the coordinated combination of different policy frameworks, this paper introduces a Taylor rule for financial stability to reduce financial risks and maintain economic stability. The specific form of the extended Taylor rule is as follows:

$$R_t = R_{t-1}^{\gamma_0}\left[\bar{R}\left(\frac{P_t}{P_{t-1}}\right)^{\gamma_1}\left(\frac{Y_t}{\bar{Y}}\right)^{\gamma_2}\left(\frac{cg_t}{\overline{cg}}\right)^{\gamma_3}\right]^{1-\gamma_0} \tag{35}$$

Where γ_3 represents the response coefficient of monetary policy to credit growth. Subsequently, this paper uses four rules to test the reaction of the estimated model, comparing and analyzing the advantages and disadvantages of these four rules.

Rule (I): Use the standard Taylor rule as shown in equation (14).

Rule (II): Use the Taylor rule considering financial stability as shown in equation (17).

Rule (III): Simultaneously use the standard Taylor rule as shown in equation (14) and the macroprudential rule as shown in equation (15).

Rule (IV): Simultaneously use the Taylor rule considering financial stability as shown in equation (17) and the macroprudential rule as shown in equation (15).

Table 3 shows the standard deviation values of major economic variables under four different rules in the presence and absence of the zero lower bound. The results indicate that the volatility of major economic variables increases significantly when the zero lower bound is present. However, regardless of the existence of the zero lower bound, Rule (II) can reduce economic volatility. Yet, when the zero lower bound is present, the relative loss is 6.4%, significantly higher than the relative loss when the zero lower bound is absent. These results suggest that, when the zero lower bound is present, the extended Taylor rule is an effective tool for maintaining financial stability. This is because the extended Taylor rule takes credit growth into account and can adjust the financial market accordingly. Additionally, the relative loss of Rule (IV) is significantly higher than the other three rules, indicating that the effective combination of extended monetary rules and macroprudential rules can achieve greater benefits, especially when the zero lower bound is present.

Table 3: Responses of the Economy Under Different Policy Rules

Policy Rules		Output Sd (%)	Inflation Rate Sd (%)	Credit Sd (%)	Asset Price Sd (%)	Loss Function (%)	Relative Gain (%)
Rule (I)	NO ZLB	0.8534	0.8341	0.8290	0.8365	-0.83825	----
	ZLB	2.4366	0.8923	2.8974	2.9635	-2.29745	----
Rule (II)	NO ZLB	0.8416	0.8325	0.8528	0.8108	-0.83443	0.45
	ZLB	2.3394	0.8771	2.7968	2.5846	-2.14948	6.44
Rule (II)	NO ZLB	0.8194	0.8347	0.7693	0.7706	-0.7985	4.74
	ZLB	2.2450	0.9042	2.5909	2.6548	-2.09873	8.65
Rule (IV)	NO ZLB	0.8076	0.8362	0.7485	0.7518	-0.78603	6.23
	ZLB	2.1881	0.8965	2.5267	2.3394	-1.98768	13.48

Note: Sd represents the percentage of standard deviation. The loss function is the weighted sum of the standard deviations of major economic variables, and the relative loss gain is compared to the standard Taylor rule.

6. Conclusion

In recent years, the global economic situation has become increasingly complicated and the China's economic uncertainty has also obviously increased due to the increase of the complexity of the economic structure. Meanwhile, the rapid expansion of shadow banking, Internet finance and local government debt has accelerated the exposure of systemic financial risks. In recent years, the volatility of stock market in China has increased significantly. Motivated by the recent experience of the U.S. and other developed countries, we describe the quantitative properties of a New Keynesian DSGE model with a zero lower bound constraint (ZLB) on nominal interest rates, explicitly accounting for the nonlinearities that the bound brings about. Besides showing how such a model can be efficiently computed, we find that the behaviour of the economy is substantially affected by the presence of the zero lower bound.

Through the above analysis, it can be concluded that this paper introduces the zero lower bound constraint into the standard New Keynesian model and estimates and simulates it using U.S. data. The results show that the existence of the zero lower bound constraint amplifies the impact of exogenous shocks. When the economy reaches the zero lower bound, corresponding monetary policy can be used to maintain the stability of the financial system. Simultaneously, effective coordination between monetary policy and macroprudential policy should be enhanced to minimize the losses caused by adverse shocks. This paper implies that the government should take the possible influence of economic policy on capital markets into consideration to avoid fluctuation.

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