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Study on Wealth Effect, Inflation Effect and Liquidity Effect of Stock Market based on LSTVAR Logic Smooth Transfer Process

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Abstract： Considering the fact that the stock market has different influence on the real economy under different monetary policy cycles, this paper sets the monetary policy variable as a transfer variable and uses the LSTVAR model. By introducing a continuous transfer function, this paper examines the different effects of the monetary policy stock market on the real economy in LSTVAR logic smooth transfer process. This paper found that when currency growth changes, stock market variables have different and significant impacts on the real economy. Under the mechanism of low currency growth, the stock market has a stronger correlation with the real economy. The study found that China's stock market has a strong wealth effect, inflation effect and systemic liquidity effect. At the same time, China's stock market has a relatively high degree of maturity and it can better allocate currency. The stock market has an indicative role in the development of the national economy, and it has assumed its "barometer" function.

Keywords: stock market; "barometer" function; LSTVAR model; generalized impulse response.

1. Research background and status

The impact of the stock market on the real economy can be reflected in the following two aspects: first, asset prices affect total demand through consumption channels; second, asset prices affect total demand through investment channels. Asset prices have an impact on the real economy through these two channels. Since monetary policy directly affects the real economy, it is of great significance to study the impact of the stock market on the real economy under different monetary policy cycles, thereby ensuring the stable and healthy development of the financial market and economic structure.

Scholars mainly carry out empirical research around life cycle theory, agency hypothesis, and Tobin Q theory [1-4]. Bulmash (2002) studied the wealth effect of the US stock market. After research, he found that the wealth effect of the stock market is relatively weak in the short term, and the wealth effect of the stock market is relatively strong in the medium and long term [5]. Park and Cho (2006) conducted research and calculations based on household income data about Korean residents. He found that households with high household income would hold a large number of stocks, which showed higher stock market liquidity [6]. Peltonen and Sousa (2012) studied the wealth effect of the stock markets in the world's major emerging economies. The study found that once the stock price rose by 10 percentage points, consumption would rise by 0.26 percentage points to 0.3 percentage points [7]. Herrerias and Joyeux (2013) used the GARCH model to study the relationship between the Chinese real economy and the liquidity of the stock market, and concluded that the liquidity of the stock market has a strong correlation with the inflation rate [8]. By establishing the DSGE model, Chen and Funke (2016) used data from 1998 to 2009 to study and found that the wealth effect of the Chinese stock market has a significant positive effect on consumption and CPI [9]. In China, Hu Yonggang and Guo Changlin (2013) studied the wealth effect of the Chinese stock market, and they found that the Chinese stock market has an asymmetric wealth effect, and the stock price will have a greater impact on residents' consumption expenditure in the long run [10]. Zhong Chongwen and Wu Su (2014) used the error correction model and Granger causality test to find that the stock market reflects its "barometer" function in economic development process to some extent [11]. Yang Fan and Yang Lige (2015) used the cointegration test model to conduct an empirical analysis on the relationship between the real economy and stock price fluctuations. Through the research, they found that the basis of China’s stock market is weak and cannot effectively support the real economy. There is no long-term cointegration relationship, between the real economy and stock market, that is to say, China's stock market does not have a "barometer" function [12].

This paper selects a non-linear logic smooth transfer vector autoregressive model (LSTVAR) to carry out research. The model covers monetary policy, stock market, and actual economic variables in the economic system, and sets monetary policy variables as transfer variables, and examines the different effects of the stock market on the real economy under different monetary policy cycles.

2 Variable selection and threshold logic smooth transfer model

2.1 Selection of variables

In this paper, the amount of currency (LM2) and interest rate (OYR) are selected as the proxy variables of monetary policy, and the stock price (SPR) and liquidity of the stock market system are selected as the proxy variables of the stock market. This paper selects the stock market system liquidity index proposed by Chordia (2011) as the proxy variable of stock market liquidity. It is recorded as LIQ in this paper, and the data comes from the RESSET financial database.

This paper selects CPI and industrial added value (referred to as IAV in the text) as the proxy variables of the real economy. This paper sets the research sample period from January 1997 to December 2019, using monthly time series data, there are a total of 276 sets of data, and the research period is as long as more than 20 years.

2.2 Construction of threshold logic smooth transfer model

Many scholars have tried to introduce the logic smooth transfer function to study the conduction process in economic phenomena. Bates and Watts (1988) introduced the logic smooth transfer state equation [13]:

$$\begin{aligned} y_t = \alpha_1\{1-D(z_t)\}x_t + \alpha_2 D(z_t) + \{1-D(z_t)\}u_{1t} + D(z_t)u_{2t} \\ +\{\beta_1(1-D(z_t)) + \beta_2 D(z_t)\}x_t \end{aligned} \quad (1)$$

In the formula, $i=1$ and $i=2$ respectively represent the error terms under the two policy states, z_t is the threshold value, c is the policy turning point, $x_{it} \sim NID(0,\delta_i^2)$, and the threshold value z_t follows the Heaviside function: $D(z_t)=1$, $z_t \ge c$; $D(z_t)=0$, $z_t \le c$. Subsequent research on the threshold regression model are mostly revolved around the calculation of the function forms $D(z_t)$ and c. Regarding the problem of whether the Heaviside function $D(z_t)$ is a continuous function, its

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poor analytical properties and it is not easy to explain the meaning of economics, Goldfeld and Quandt (1990) revised $D(z_t)$ to [14]:

$$D(z_t) = \frac{1}{\sqrt{2\pi}\delta}\int_{-\infty}^{z_t} \exp(-\frac{(z-c)^2}{2\delta^2})dz \qquad (2)$$

In the formula, $D(z_t)$ is the distribution function of the normal threshold variable $z_t \sim N(c,\delta^2)$, and at the same time, it is assumed that the difference under different states keep the same: $\delta_1^2 = \delta_2^2 = \delta^2$. This assumption allows the equation (16) to be a smooth threshold regression model. Granger and Teräsvirta (1993) further proposed a smooth threshold regression model, which defines $z_t = t$ as follows [15]:

$$y_t = (\alpha + \beta D(t))' x_t + \mu_t \quad (3)$$

In the formula, α and β are parameter vectors, and $D(t)$ is a continuous function of time t. When $D(t)=0$, x_t and y_t are linearly related; when $D(t)\neq 0$, x_t and y_t are nonlinear functions that change with time. The STAR model proposed by Granger is a single equation model. They initially proposed the STAR model to analyze the nonlinear characteristics of the economic cycle. Weise (2012) extended the STAR model proposed by Teräsvirta and Granger, he proposed a multi-equation model, and used the logistic function as the transfer function [16]. The mathematical equation of the LSTVAR model is:

$$x_{it} = \mu_i + \sum_{j=1}^{k} a_j x_{t-j} + [\mu_i + \sum_{j=1}^{k} b_j x_{t-j}]G(z_{t-d}) + u_{it} \qquad (4)$$

$$G(z_{t-d}) = \frac{1}{1+\exp\{-\gamma(z_{t-d}-c)/\delta\}} \quad , \quad \gamma > 0 \qquad (5)$$

Where x_{it} is the variable vector, μ_i is the intercept term, k is the lag period, u_{it} is the random perturbation term, d is the lag period of the threshold variable, δ is the standard deviation of the threshold variable z_{t-d}, and z_{t-d} is the monotonous rise function of the threshold variable, $G(z_{t-d})$ is Logistic smooth transfer function (also called transition function), γ stands for slope parameter (also called speed parameter or smoothness parameter), c is threshold parameter (also called position parameter)

3 Non-linear test and estimation results of LSTVAR model

3.1 Nonlinear test of LSTVAR model

First, conduct a nonlinear test on the conduction system. In equation (5), when $c \to 0$, the LSTVAR model becomes a linear model. When $c \to \infty$, the threshold variable $z_{t-d} = c$ is the turning point when the two linear state equations in the system alternate. The linear null hypothesis is:

$H_0 : C = 0$; The alternative hypothesis is: $H_1 : C > 0$

Granger and Teräsvirta (2003) first proposed the LM nonlinear test method for single equations, and Weise (2012) extended the test method to the multi-equation system model. Here, we will refer to Weise's three-step method to test whether the conduction system has nonlinear characteristics. In this paper, we consider six variables including currency amount, interest rate, stock price, stock market system liquidity, CPI and industrial value added.

Let $W_{jt} = (x_{1,t-1}, x_{1,t-2}, ..., x_{1,t-k}, x_{2,t-1}, x_{2,t-2}, ..., x_{2,t-k}, x_{3,t-1}, ..., x_{6,t-2}, ..., x_{6,t-k})$ and z_{t-d} be the known threshold variable, then first calculate the variable vector:

$$x_{it} = \beta_{i0} = \sum_{j=1}^{6k} \beta_{ij} W_{jt} + u_{it} \qquad (6)$$

Calculate the residual term $\hat{u}_{it}$, set $SSR_0 = \sum \hat{u}_{it}^2$.

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Then calculate the random item:

$$\hat{u}_{it} = \alpha_0 + \sum_{j=1}^{6k} \alpha_{ij} W_{jt} + \sum_{j=1}^{6k} \delta_j z_{t-d} W_{jt} + \nu_{it} \quad (7)$$

Because $1 \le d \le k$, $G(z_{t-d})$ has k values, substituting k $G(z_{t-d})$ into equation (5) to carry out regression calculation regression calculation, and then calculate the relevant statistics:

$$LM = \frac{T \times (SSR_0 - SSR_1)}{SSR_0} \quad (8)$$

The number of samples is T. On the basis of the original hypothesis, the statistics LM follow the $\chi^2(36k)$ distribution approximately. Weise tests the overall system nonlinearity through log-likelihood ratio, that is H_0: for each equation, $\lambda = 0$ suppose:

$$\Omega_0 = \sum \hat{\varepsilon}_t \hat{\varepsilon}_t' / T \text{ , } \Omega_1 = \sum \hat{\mu}_t \hat{\mu}_t' / T \quad (9)$$

Then the likelihood ratio rejects the null hypothesis $LR = T\{\log|\Omega_0 - \Omega_1|\}$ and follows the $\chi^2(36k)$ distribution asymptotically. If the statistic is not significant, the linear null hypothesis is rejected, and the system model is considered non-linear. If there are multiple transfer variables, the linear null hypothesis is rejected. The variable with the smallest P value in the LR test is the most suitable transfer variable.

3.2 Selection of monetary policy transfer variables

Based on the LM test results, the model is non-linear and supports the setting of the LSTVAR model. Monetary policy has significant nonlinear impact on the real economy transmission system through the stock market. By further comparing the statistics when the monetary policy variable is used as the system transfer variable, it is found that when $DLM2_{t-2}$ is used as the transfer variable; the tested P value of LR is 0. According to the setting of Weise, this paper adopts the variable that can reject the linear hypothesis and has the smallest P value as the system transfer variable, that is, the second-order lag of the amount of currency should be regarded as the transfer variable when estimating the LSTVAR model.

3.3 The estimated result of the currency when its acts as a transfer variable

In this paper, the two-dimensional grid optimization search method $DLM2_{t-2}$ is used to estimate the velocity parameter γ and the position parameter c in the transfer function. According to the relevant value range, the different values used allow the model residuals have the smallest variance-covariance matrix. The range of c is [12.4, 25.5], and the value range of y is 0 to 25. Then take 50 values from large to small, construct 2500 combinations, and bring the 2500 combinations into the system model for OLS estimation respectively, calculate the sum of squared residuals, and the smallest value is the initial value in the system model. Take these initial values as the iterative initial values of the nonlinear OLS model, calculate the parameters γ and c , see equation (10), the simulation process is completed by Matlab.

$$(c,\gamma) = \min \det|\sum resid_i| \quad (10)$$

In the formula, $\det|\sum resid_i|$ is the determinant value of the variance-covariance matrix in formula (5).

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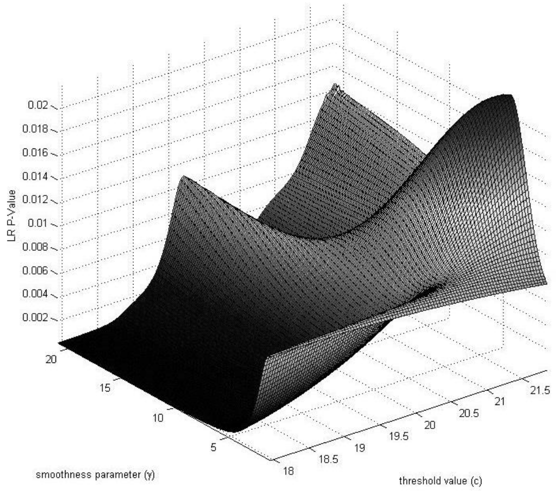

Figure 1 Grid optimization search process with the amount of currency as a transfer variable

Figure 1 shows the grid search process of the amount of currency as a system transfer variable. It can be found that the value of all transfer equations LR P-Values in the whole process is far less than the critical value of 5%. The simulation results confirm that the entire transfer process in different states is extremely smooth; the regression coefficients of all equations have a higher significance level. Through the two-dimensional grid optimization search method, the smoothness parameter γ (smoothness parameter) of the transition function is 0.1, the threshold c (threshold value) is 18.97, and the optimal position parameter c divides the transition variable $DLM2_{t-2}$ into two intervals: Currency high growth range and currency low growth range. That is, when the year-on-year growth rate of the currency is greater than 18.97%, the system belongs to mechanism 1, which means that the system is in a mechanism with high currency growth rate; when the year-on-year growth rate of currency is less than 18.97%, the system belongs to mechanism 0, which represents that the system is in a mechanism with low currency growth rate. .

4 Generalized impulse response functions with the amount of currency as the transfer variable

4.1 Generalized impulse response function

This paper examines the asymmetric effect of the stock market's impact on the real economy by estimating the LSTVAR model from two different perspectives: first, whether the positive and negative shocks of the stock market are asymmetric; second, whether the impact of high currency growth rate and low currency growth rate under the different monetary policy cycle states have different effects. Therefore, the generalized impulse response function proposed by Koop (2012) is used to examine the dynamic response process of the LSTVAR model [17]. The traditional impulse response function (IRF) can be expressed as:

$$IRF_x(n, v_t, w_{t-1}) = E[x_{t+n} \mid v_t = \delta, v_{t+1} = 0, ..., v_{t+n} = 0, w_{t-1}] - E[x_{t+n} \mid v_t = 0, v_{t+1} = 0, ..., v_{t+n} = 0, w_{t-1}], \quad n = 0, 1, ..., n \qquad (11)$$

The generalized impulse response function (GRIF) has been improved. For the impact $v_t = \delta$ in any direction and magnitude and the previous period response function w_{t-1}, GRIF can be expressed as:

$$GIRF_x(n, v_t, w_{t-1}) = E[x_{t+n} \mid v_t, w_{t-1}] - E[x_{t+n} \mid w_{t-1}], \quad n = 0, 1, ..., n \qquad (12)$$

GRIF improves the estimation method through the following points:

1) Let w_{t-1}^r be a lagging exogenous variable of the actual value at a certain time.

2) Let the sequence (dimensional) impact be v_{t+n}^b, $n = 0, ..., q$.

3) Use w_{t-1}^r and v_{t+n}^b to simulate the change of

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x_{t+n} in period $q+1$, $x_{t+n}(w^r_{t-1}, v^b_{t+n})$, $n = 0,...,q$.

4) Replace the element with index i, 0 in v^b_{t+n} phase with $v_{i,0}$ to simulate the change of x_{t+n} in phase $q+1$, $x_{t+n}(v_{i,0}, w^r_{t-1}, v^b_{t+n})$, $n = 0,...,q$.

5) Repeat the step 2 to step 4 500 times.

Repeat step 1 to step 5 R times. Calculate $[x_{t+n}(v_{i,0}, w^r_{t-1}, v^b_{t+n}) - x_{t+n}(w^r_{t-1}, v^b_{t+n})]/BR$ as the average impulse response function; or $X^{rn}_{t+n}(v_{i,0}) = median[x_{t+n}(v_{i,0}, w^r_{t-1}, v^b_{t+n}) - x_{t+n}(w^r_{t-1}, v^b_{t+n})]$ as the median response number.

$$GI_{\gamma}(n, v_t, \omega_{t-1}) = E[Y_{t+n} \mid v_t, \omega_{t-1}] - E[Y_{t+n} \mid \omega_{t-1}], n = 0,1,...... \quad (13)$$

Where GI_{γ} is the generalized impulse response function of Y, $E[\bullet]$ is the expected operator, and n is the forecast period

4.2 The generalized impulse response of the price level affected by the stock market under different mechanisms in the system

Figure 2 depicts the generalized impulse response function of the CPI impacted by stock market variables under the system's threshold mechanism (high currency growth rate), where the first line represents a unit of positive shock (+ 1SD shock), the second line The figure represents a unit of negative shock (-1SD shock), the dotted line is the standard deviation of a positive and negative unit, which has the same meaning below.

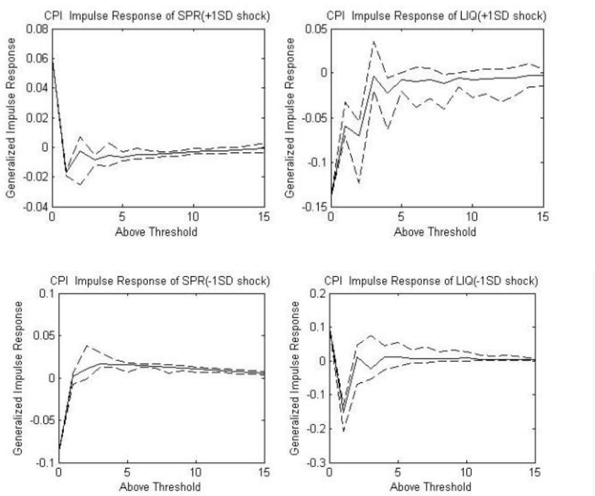
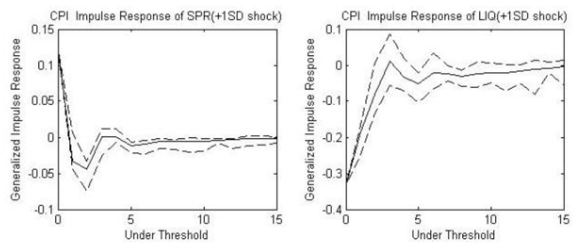


Figure 2 The generalized impulse response function of CPI on the threshold value impacted by stock market variables

From the sub-graph (CPI Impulse Responds of SPR), we can see that in the short term, an increase in the stock price will increase the CPI, and the impulse response value is 0.06, but the shock effect will quickly decline within a lag period, and there will be fluctuations in the second lag period. After the second lag period, it converges and tends to zero value. It can be seen that the rise in stock prices will have a relatively small positive impact on CPI in the short term. From the sub-graph (CPI Impulse Responds of LIQ), we can see that the increase in the liquidity index of the stock market system will bring a negative impact on CPI, with a response coefficient of -0.13. It can be seen that the continuous rise of stock prices can attract a large amount of speculative capital inflows, especially during the period of high currency growth. The stock market usually exhibits excessive speculation. The rise of the stock market causes a large amount of speculative capital inflows, which makes the systemic liquidity impact caused by the stock price rise shows a negative value, which has a greater negative impact on general commodity prices.



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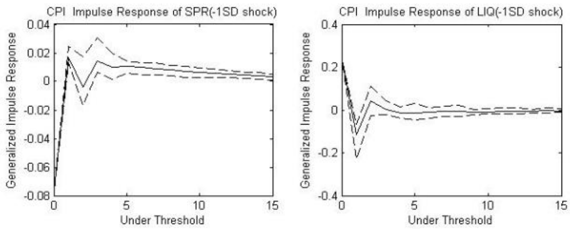

Figure 3 The generalized impulse response function of CPI under the threshold value impacted by stock market variables

Figure 3 depicts the generalized impulse response values of CPI affected by positive and negative shocks in one unit standard deviation of stock market variables when the system is under the threshold (low currency growth rate) mechanism. Similarly, it shows that in the mechanism of low currency growth, the liquidity of the stock market system has a more significant impact on CPI. Empirical evidence shows that changes in China's stock prices can cause the same trend of CPI changes, and the effect is more pronounced in the mechanism of low currency growth. When the currency growth rate is low, the stock market has stronger funds allocation, which has increased the inflation effect caused by the changes in stock price and price level in the same direction, indicating that the stock price has played the role of indicator of financial asset price to a certain extent.

4.3 The generalized impulse response of the output level affected by the stock market under different mechanisms of the system

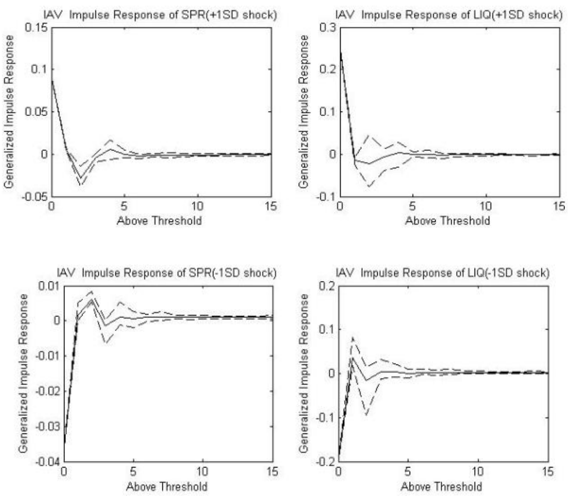

Figure 4 The generalized impulse response function of output impacted by stock market variables on the threshold

Figure 4 depicts the generalized impulse response of positive shocks and negative shocks in one unit standard deviation of industrial added value to the stock market variables when the system is under the threshold (high currency growth rate) mechanism. Sub-graphs (IAV Impulse Responds of SPR) and (IAV Impulse Responds of LIQ) describe the generalized impulse response functions of industrial value added affected by stock price and liquidity of the stock market system, as can be seen from the figure. The impact of the positive deviation (+ 1SD shock) and negative shock (-1SD shock) in one unit of the standard deviation also shows asymmetry, especially the positive impact value of the stock price on industrial added value is much greater than the negative impact value of the stock price on industrial added value, which means that when the currency growth rate is high, the impact of rising stock prices on the output level is greater than the negative impact of falling stock prices. The positive impact of a standard deviation of the stock price and the liquidity of the stock market system has a positive impact on industrial added value. The positive impulse response values are 0.08 and 0.25, respectively.

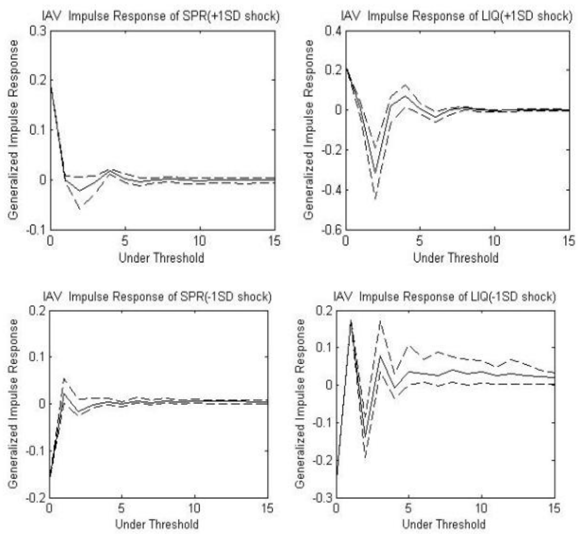

Figure 5 Generalized impulse response function of

output impacted by stock market variables under the threshold

Stock prices will also have a greater impact on investment. In the mechanism of low currency growth, the balance sheet effect and the effect of Tobin q have increased. In theory, it is also consistent with Tobin q theory that when the growth rate of currency is low, the stock market has a large allocation effect on capital [18]. It shows that China's stock market shows good inflation effects, wealth effects and systemic liquidity effects.

5 Conclusions

Studies have shown that changes in China's stock prices can cause the CPI change in the same trend, and this effect is more pronounced in the mechanism of low growth in currency amount. When the currency growth rate is low, the stock market has stronger funds allocation, which increases the inflation effect of the stock price and price level changes in the same direction; similarly, when the stock price decreases, the currency will flow from the stock market into the real economy, resulting in CPI rising, this systemic liquidity effect is more significant when the growth rate of the currency is low. It shows that there is a significant systemic liquidity effect in China's stock market, at the same time; stock prices will also have a greater impact on investment. In the mechanism of low currency growth, the balance sheet effect and the Tobin effect are enhanced.

This paper uses the generalized impulse response function to study and finds that when the currency growth rate is in different mechanisms, the stock price has a positive impact on the price level and output level, and the liquidity of the stock market system shows a negative impact on the price level. At the same time, the study found that during the process of currency growth rate changes, stock market variables have different impacts on the real economy. It not only confirms that China's stock market has good inflation effects, wealth effects, and systemic liquidity effects. At the same time, it found that the stock market has a relatively high maturity and excellent ability to allocate currency, which further shows that the stock market has become an important component in China's economic system. In the long run, the stock market has also become a "barometer" for measuring the development of the national economy.

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