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The Structural Relationship between Chinese Money Supply and Inflation Based on VAR Model

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Abstract

With the development of economy, more and more attention is paid to the relationship between money supply and inflation in the economic field. This paper chooses consumer price index (CPI) as an important index to measure the level of inflation, by choosing between January 2008 and March 2019 money in circulation $M0$, narrow measure $M1$, broad measure $M2$, consumer price index CPI monthly data as sample, building a vector autoregressive (VAR) model and using econometric methods of impulse response function and variance decomposition, and finally characterizes money in circulation $M0$, narrow measure $M1$, broad measure $M2$ and the relationship between consumer price index CPI and different sizes of the impact of inflation in the money supply relationship.

Keywords

Money Supply, The VAR Model, Inflation

1. Introduction

With the continuous development of China's economy, indicators such as gross national product, consumer price index and money supply have been important indicators to judge the state of macroeconomic development. Consumer price index (cpi) [1] is an indicator to measure and judge deflation and inflation. And the control of money circulation has become particularly important, through the control of money circulation will directly affect inflation, affect the development of the whole economy. The influence of money supply on inflation is higher than that of fiscal deficit on inflation. The relationship between fiscal stimulus plan, money supply, public expectation and inflation, and finally the money

supply is the most important factor affecting inflation mainly in [2] [3]. There is a close relationship between money supply and inflation. There is no inflation in their short term, but we should also guard against the pressure brought by stagflation. Yang Zihui *et al.* [4] studied the directed acyclic graph and found that the fiscal deficit had a certain impact on inflation but was not the most important one. Somethings can be inspected in [4] [5]. And the money supply has a strong asymmetric influence on CPI and does not depend on the state of the economy. Inflation is closely related to China's monetary policy [6] and asset inflation. This paper is based on the VAR model to show that the impact of different money supply on inflation is different.

2. Materials and Methods

2.1. The VAR Model

Vector autoregression (VAR) [7] is to establish a model based on the statistical properties of data. The VAR model constructs the model by taking each endogenous variable in the system as the lagged value function of all endogenous variables in the system, thus extending the univariate autoregressive model to the "vector" autoregressive model composed of multivariate time series variables.

In 1980, C. A. Sims introduced VAR model into economics, promoting the wide application of dynamic analysis of economic system. The mathematical expression of VAR (P) model is:

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + H x_t + \varepsilon_t, \ t = 1, 2, \cdots, T \tag{1}$$

y_t is the column vector of endogenous variables in k dimension, x_t is the column vector of exogenous variables in d dimension, p is the lag order, and T is the number of samples. $k \times k$ dimensional matrix $\Phi_1, \cdots, \Phi_p$ and $k \times d$ dimensional matrix H are coefficient matrices to be estimated. ε_t is a k dimensional disturbance column vector, which can be correlated with each other synchronously, but not with its own lag value and not with the variables on the right-hand side of the equation.

2.2. Granger Causality Test

Proposed by Granger (1969) [7], another important application of VAR model is to analyze the causal relationship between economic time series variables. Granger solved the problem of whether x caused y, mainly looking at the extent to which the present y could be explained by the past x, and whether the addition of the lag value of x improved the explanation degree. If x is helpful in y prediction, or if the correlation coefficient between x and y is statistically significant, it can be said that "y is caused by x Granger".

Consider the mean square error (MSE) of the march period prediction:

$$\text{MSE} = \frac{1}{s} \sum_{i=1}^{s} \left(\hat{y}_{t+i} - y_{t+i} \right)^2 \tag{2}$$

This can be expressed as follows: if the mean square error obtained by pre-

dicting y_{t+s} based on $(y_t, y_{t-1}, \cdots)$ for all $s > 0$ is the same as the mean square error obtained by y_{t+s} based on both $(y_t, y_{t-1}, \cdots)$ and $(x_t, x_{t-1}, \cdots)$, then y is not caused by x Granger.

2.3. Impulse Response Function

Vector autoregression model (VAR) [8] is a non-theoretical model, so it is not necessary to analyze the mutual influence between its variables when it is analyzed, but the impact on the explained variable when it is impacted by an error term. Therefore, for the VAR model, it is difficult to explain the economic value of a single parameter estimate. In addition to prediction, an important aspect of its application is the dynamic characteristics of the system, that is, the response of an endogenous variable to residual shock (response). The impulse response function can be used to describe the impact of the random error on the current and future values of endogenous variables.

First i endogenous variable of an impact not only directly affect the first i variable, and pass through the dynamic structure of the VAR model to other endogenous variables, impulse response function attempts to depict the influence of trajectory, shows how an arbitrary variable disturbance affect all other variables through model, finally and feedback to the process itself.

2.4. Variance Decomposition

In 1980 [8], Sims proposed the variance decomposition method according to the expression of VAR (∞), and provided the influencing relationship between variables in the VAR model:

$$y_{it} = \sum_{j=1}^{k} \left(\theta_{ij}^{(0)} \varepsilon_{jt} + \theta_{ij}^{(1)} \varepsilon_{jt-1} + \theta_{ij}^{(2)} \varepsilon_{jt-2} + \theta_{ij}^{(3)} \varepsilon_{jt-3} + \cdots \right), i = 1, 2, \cdots, k; t = 1, 2, \cdots, T \quad (3)$$

$$Var(y_i) = \sum_{j=1}^{k} \left\{ \sum_{q=0}^{\infty} \left(\theta_{ij}^{(q)} \right)^2 \sigma_{jj} \right\}, i = 1, 2, \cdots, k \quad (4)$$

We know that the contents of the brackets are the sum of the influences of the j disturbance term ε_j from the infinite past to the present time point on y_i.

In this paper, the consumer price index (CPI) cover 8 types of goods and services consumed nationwide, and the calculation formula of CPI is

$$CPI = \sum_{i=1}^{n} CPI_i \times Weight_i$$

3. Empirical Analysis

3.1. Data Preprocessing

Data are derived from Wind database. **Figures 1-4** are the sequential trend charts of *CPI*, *M*0, *M*1 and *M*2 from January 2008 to March 2019. As the observed trend charts are not stable, the stationarity of unit root test series is further adopted.
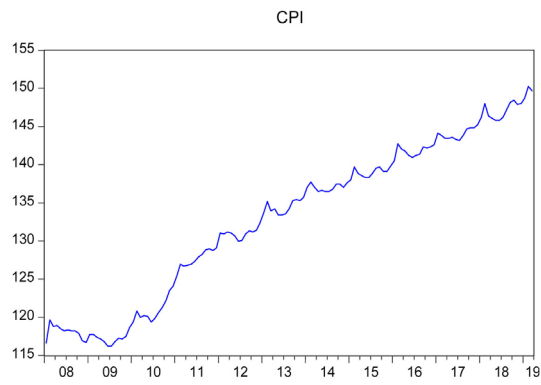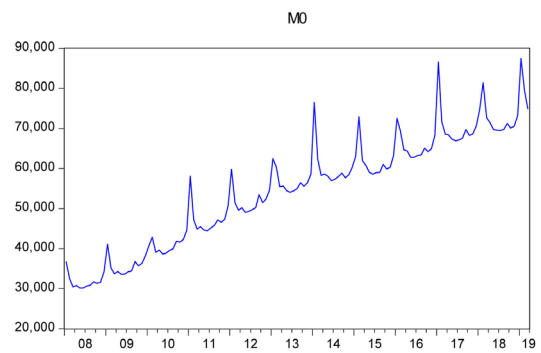
Figure 1. *CPI* trend chart.
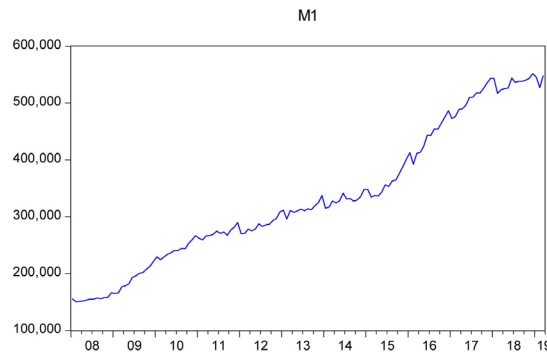

Figure 2. *M*0 trend chart.
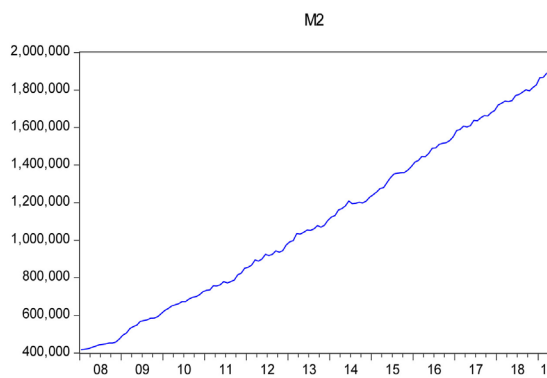

Figure 3. *M*1 trend chart.

Figure 4. *M*2 trend chart.

3.2. Stationarity Test

In this paper, ADF unit root test was adopted to test the stationarity of the original sequence. The test results are shown in Table 1. By observing Table 1, *CPI*, *M*0, *M*1 and *M*2 sequences failed the stationarity test.

Therefore, the first-order difference is carried out for the above sequences, and then the unit root test is carried out for the new sequences. The obtained results are shown in Table 2, and the new sequences after the first-order difference have been stabilized.

3.3. Order Determination and Stability Test of the Model

As can be seen from Table 3, the likelihood ratio (LR) is an indicator reflecting authenticity, which is a compound indicator reflecting both sensitivity and specificity. The final prediction error statistic (FPE) is a tool that provides prediction accuracy and high imitation, as well as a more general prediction checking capability. *DCPI*, *DM*0, *DM*1 and *DM*2 are first-order integral sequences, so they can be judged according to the results of LR test statistics, final prediction error (FPE), AIC information criterion, SC information criterion and HQ information criterion, and there are enough lag terms and enough degrees of freedom at the same time. According to the results in Table 3, the optimal order of the VAR model is finally selected as order 2. By using EViews7.2 to establish the VAR (2) model, the vector autoregression expression about *CPI* can be obtained as follows:

$$DCPI = 6.4339e{-}05 * DM\,0(-1) + 3.4488e{-}05 * DM\,0(-2)$$
$$+ 0.1177 * DCPI(-1) + 0.080 * DCPI(-2)$$
$$+ 4.9877e{-}05 * DM\,1(-1) + 1.9733e{-}05 * DM\,1(-2)$$
$$- 3.8129e{-}07 * DM\,2(-1) - 3.6004e{-}06 * DM\,2(-2) - 0.0062$$

Table 1. ADF test results of *CPI*, *M*0, *M*1 and *M*2 sequences.

Variable	ADF test value	The critical value at the 1% level	The critical value at the 5% level	The critical value at the 10% level	P values	Conclusion
CPI	−320194	−3.479656	−2.883073	−2.578331	0.9177	Non-stationary
M0	−2.488793	−3.484653	−2.885249	−2.579491	0.1207	Non-stationary
M1	0.225702	−3,480038	−2.883239	−2.578402	0.9733	Non-stationary
M2	2.070928	−3.484653	−2.885249	−2.579491	0.9999	Non-stationary

Table 2. ADF test results of *DCPI*, *DM*0, *DM*1 and *DM*2 sequences.

Variable	ADF test value	The critical value at the 1% level	The critical value at the 5% level	The critical value at the 10% level	P values	Conclusion
CPI	−11.21752	−3.480038	−2.883239	−2.578420	0.0000	Non-stationary
M0	−9.797663	−3.484653	−2.885249	−2.579491	0.0000	Non-stationary
M1	−13.92312	−3.480038	−2.578420	−2.578420	0.0000	Non-stationary
M2	−3.258272	−3.484653	−2.885249	−2.579491	0.0191	Non-stationary

Table 3. Delay order judgment results.

	LogL	LR	FPE	AIC	SC	HQ
0	−4152.109	NA	2.62e+22	62.97134	63.05870	63.00684
1	−4076.024	146.4052	1.05e+22	62.06097	62.49776*	62.23846
2	−4048.308	51.65193*	8.83e+21*	61.88346*	62.66968	62.20294*

Note: *represents the optimal lag order of the corresponding criterion; LR represents likelihood ratio statistic; FPE represents the final prediction error statistic; AIC represents the chi information criterion statistics; SC represents Schwartz statistic; HQ represents the hannan-quinn information statistic.

After the estimation of the model, the inverse roots of the AR characteristic polynomial of the model should be tested, and the AR root diagram and tables can be obtained, as shown in Figure 4 and Figure 5.

According to Figure 5 and Table 4, the inverse roots of AR characteristic roots are all within the unit circle, and the overall stability of the model indicates that the VAR model composed of these indicators is effective, that is, there is a stable relationship between the money supply index and the inflation index.

3.4. Granger Causality Test

Granger causality test can further determine the causal relationship between each variable. The Granger causality test is conducted below, and the test results are shown in Table 5.

According to the data in Table 5, at the significant level of 10%, there is a causal relationship between *CPI* and $M0$, $M1$ and $M2$, but it is not mutual. Instead, there is a one-way granger causal relationship, and the change of money supply is the cause of inflation.

3.5. Impulse Response Function

According to the impulse response diagram in Figure 6 and Figure 7, when $M0$ increases, the *CPI* changes very little, indicating that $M0$ has a lag effect on *CPI*. In the 6th, 7th and 8th phases, *CPI* has a negative effect on $M0$, and reaches its maximum in the 9th phase.

By observing the impulse response diagram in Figure 8, it can be concluded that the maximum value reached in the second phase produced a positive boost, and the negative effect was generated in the fifth phase, and the amplitude fluctuation decreased and tended to be near the 0 value in the end.

By observing the impulse response diagram in Figure 9, it can be concluded that in the first period, $M2$ had no effect on *CPI*, and the impulse response value was 0. After that, there was a negative impact in the fourth period, and then the fluctuation was gradually reduced until the response value approached 0.

Variance Decomposition

Figure 10 is the variance decomposition graph of *CPI*, which is used in the VAR model to analyze the contribution to the change of endogenous variables. In this paper, the contribution of $M0$, $M1$ and $M2$ to *CPI* is adopted in anova. In
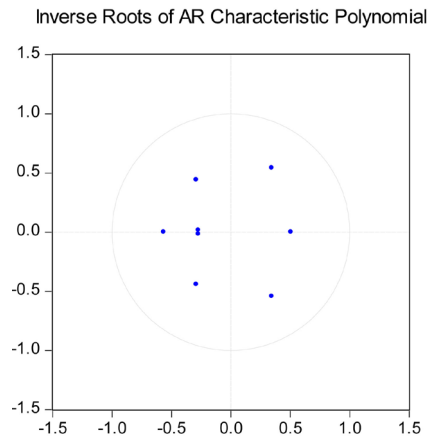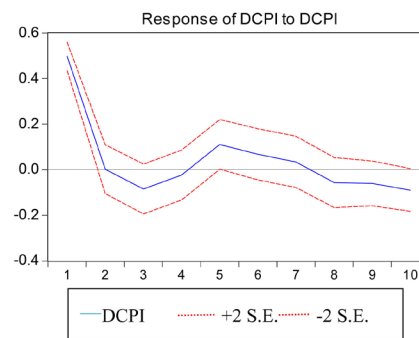
Inverse Roots of AR Characteristic Polynomial

Figure 5. AR root diagram of VAR (2) model.

Response of DCPI to DCPI

Figure 6. Impulse response of DCPI to DCPI.

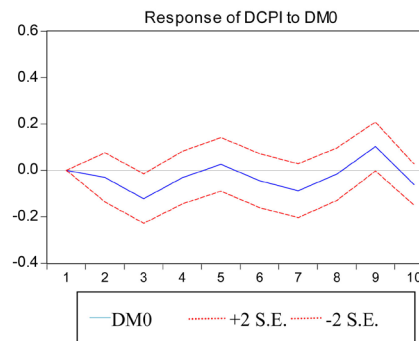Response of DCPI to DM0

Figure 7. Pulse response of DCPI to DM0.
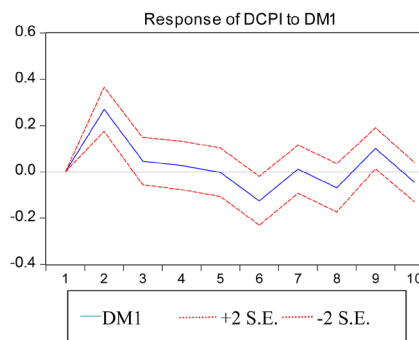
Response of DCPI to DM1
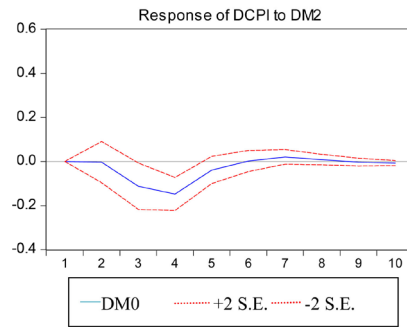
Figure 8. DCPI impulse response to DM1.

Figure 9. Impulse response of DCPI to DM2.

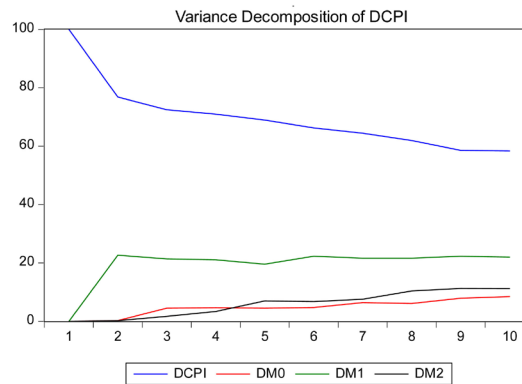**Figure 10.** Variance decomposition.

Table 4. AR root table of VAR model.

Root	Modulus
0.343647 − 0.543592i	0.643106
0.343647 + 0.543592i	0.643106
−0.564894	0.564894
−0.290970 − 0.442758i	0.529809
−0.290970 + 0.442758i	0.529809
0.505074	0.505074
−0.272000 − 0.017187i	0.272543
−0.272000 + 0.017187i	0.272543

Table 5. Results of Granger causality test.

The null hypothesis	The F value	Probability (P value)	Conclusion
DCPI is not the granger cause of DM0	0.810061	0.6670	Accept
DCPI is not the granger cause of DM0	17.99314	0.0001	Refuse
DCPI is not the granger cause of DM0	0.029371	0.9854	Accept
DCPI is not the granger cause of DM0	40.54574	0.0000	Refuse
DCPI is not the granger cause of DM0	3.940281	0.1394	Accept
DCPI is not the granger cause of DM0	0.394868	0.0008	Refuse

the first period, *CPI* was only affected by itself. With the passage of time, the contribution rate of *CPI* itself is gradually decreasing and the contribution rate of money supply variance is steadily rising.

4. Conclusions and Recommendations

Through correlation analysis such as impulse response function and variance as impulse response function and variance decomposition, the following conclusions can be drawn.

It is observed that the cumulative effect values of the corresponding impulse response functions *M*0, *M*1 and *M*2 are greater than 0, and it can be concluded that the increase of *M*0, *M*1 and *M*2 will increase *CPI*. From the variance decomposition, it can be concluded that contribution rate of different money supply to *CPI* is different.

The impact of *CPI* is a certain lag, and the lag index *M*1 is the leading indicator. Therefore, from the perspective of money supply, we should pay more attention to the change of *M*1 indicator, and then pay attention to the change of *M*2 indicator.

However, there is a significant short-term relationship between China's inflation and money supply, and money supply has a significant impact on inflation. This relationship is very obvious in the short run. In the long run, the influence of money supply on inflation will gradually weaken and stabilize at a relative level, and the volatility will gradually stabilize.

Therefore, it can be concluded that there is no inflation in China's economy in a short time, but it does not mean that the economy will develop steadily in the future, and stagflation may occur. At the same time, the monetary policy also has some lag and limitations. Therefore, we should establish a preventive mechanism in advance, and constantly improve some fiscal policies, formulate relevant systems, laws and regulations, so as to avoid some adverse impacts brought by inflation.

Fund

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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