The Influence of International Oil Price Fluctuations on Chinese Economy Based on VAR Model

Qingzhi Lv

1School of Economics and Management, Nanjing University of Science and Technology, Nanjing, Jiangsu Province, 210094, China
*Corresponding author’s e-mail: qingzhi0527@foxmail.com

Abstract. In this paper, the VAR model is used to construct the dynamic relationship between crude oil price and economic growth, price level and monetary policy. Granger causality analysis shows that oil price fluctuations are the Granger cause of economic growth rate, monetary policy and other economic indicators. Through VAR(2) model and impulse response analysis, the main impacts of oil price rise on China's economy are: it will increase the economic growth rate in a short time; through the aggregate demand to pull and increase the cost of such two ways to increase the price level; it makes it more difficult to implement monetary policy effectively. On the whole, although the international oil price and China's economic variables are complex and changeable, the economic system composed of international oil price, economic growth, price level and money supply is stable.

1. Introduction

The oil crisis of the 1970s gave birth to the establishment of oil futures markets in various countries, which indicates that it already has a certain degree of financial attributes. The OPEC annual report shows that in the 21st century, crude oil consumption increased rapidly, the supply and demand gap continued to expand, and international oil prices experienced multiple shocks. Between 2002 and 2008, international oil prices soared from $15/barrel to $157/barrel, reaching the peak of history. With the outbreak of the global financial crisis in 2008, oil prices have fallen more than 70% in half a year, and at the same time causing a serious decline in the real economy. After governments around the world used a number of measures to regulate the economy, oil prices finally recovered in 2009, and reached $18.1 per barrel in 2010. However, the global crude oil supply and demand pattern have undergone major changes in 2012. The maturity of oil and gas technology, the improvement of energy utilization rate and the continued economic downturn have caused the global crude oil supply and demand gap to shrink and eventually produce excess oil, which has led to a sharp drop in international oil prices. The macroeconomics of various countries are also affected to varying degrees.

Jiaqi Zhou (2010) adopted T-Y causality test and found that in the long run, oil price was the one-way Granger cause of China's economic growth, and there was an asymmetric co-integration relationship between oil price and China's economic growth, and the negative impact of oil price rise on economic activities was greater than the positive impact of oil price fall[1]. Yunshu Tang and Jianling Jiao (2012) used SVAR model, and after excluding the response of monetary policy to the disturbance of oil price fluctuations, they found that the output level did not decline with the rise of oil price in a short term[2]. Based on the SVAR model, Zhiguo Li and Jinggang Guo (2013) concluded that the increase of world oil price lead to a larger decline in output, and this effect had a strong sustainability and aggravates domestic inflation[3]. Based on state space model analysis, Min Wang et
al. (2016) found that international oil price fluctuation was the Granger cause of China's CPI index change, and its effect on CPI showed a significant asymmetry[4]. Ping Luo (2016) used the CGE model to conclude that a 10% drop in the international oil price would restrain inflation, reduce the output income of the oil sector, and demand for depreciation of RMB[5].

2. Variable selection
This paper analyzes the relationship between oil price fluctuations and economic growth, price level and money supply, and selects the following variables:

(1) Crude oil price. In the determination of international oil prices, the crude oil produced in the Americas is determined by WTI, the crude oil produced in Africa and the Caspian sea is determined by Brent, and the oil produced in Asia Pacific and the Middle East is determined by Dubai. In this paper, WTI (West Texas Intermediate crude oil) crude oil futures price is selected as the analysis variable.

(2) Economic growth rate. The economic growth rate is generally measured by gross domestic product (GDP) or industrial added value (IAV). GDP data are usually quarterly, while monthly IAV data are available. Moreover, the rising oil price in recent years does not seem to affect the strong momentum of China's economic growth. Even when the oil price continued to rise in 2008, China's economy still maintained strong growth and showed an overheating state. That is to say, no matter the oil price rises or falls, China's economy is always growing. For such a phenomenon, if the real value of industrial added value is adopted as the research object, many literature conclusions will be drawn, that is, the rise of oil price promotes the economy, while the decline of oil price inhibits the economy, which is inconsistent with China's current situation. Therefore, considering the special situation of our country, this paper adopts the growth rate of industrial added value as an indicator[6].

(3) Price level. The consumer price index (CPI) is the best representative of the price level as it reflects the purchasing power of consumers and the overall economic prosperity. Therefore, this paper chooses CPI as the price measurement index.

(4) Monetary policy. Some scholars tested the stability of M1 and M2 by calculating the standard deviation and variation coefficient of their respective multipliers and circulation velocity. The Granger causality test is used to study whether the base money and money multiplier can change M1 and M2. Therefore, this paper selects M1 as the measure index of monetary policy[7].

In the empirical analysis, the natural logarithm was taken for all the above indicators, LIAV was used to represent the growth rate of industrial added value, LOP was used to represent the price of crude oil, DLM was used to represent the rate of change of money supply: \( DLM = (\ln(M1) - \ln(M1_{t-1})) \), LCPI was used to represent the price level. The investigation period of this paper was from January 2002 to February 2019, with 206 monthly data.

3. The empirical analysis

3.1. Stability test
We use ADF method to test the stationarity of variables. The results are shown in the following table:

| Test Form | ADF test value | 1%critical value | 5%critical value | 10%critical value | conclusion |
|-----------|----------------|------------------|------------------|------------------|------------|
| LOP (C,T,1) | -2.913626 | -3.462412 | -2.875538 | -2.574309 | stationary |
| LIAV (C,T,1) | -2.242131 | -3.462574 | -2.875608 | -2.574346 | Non-stationary |
| LCPI (C,T,1) | -11.15491 | -3.462253 | -2.875468 | -2.574271 | stationary |
| DLM (C,T,1) | -2.214432 | -3.464101 | -2.876277 | -2.574704 | Non-stationary |

As can be seen from the test results in table 1, LIAV, LOP, LCPI and DLM are not all stable at the significance level of 0.05, while their difference sequences are all stable at the significance level of 0.05. Therefore, in the following analysis, the first order difference sequence of these four variables is used for research.
### Table 2. ADF test results of first-order difference

| Test Form | ADF test value | 1% critical value | 5% critical value | 10% critical value | conclusion |
|-----------|----------------|------------------|------------------|-------------------|------------|
| DLOP     | (C,T,1) -10.31967 | -3.462412         | -2.875538        | -2.574309         | stationary |
| DLIAV    | (C,T,1) -16.00252 | -3.462901         | -2.875752        | -2.574423         | stationary |
| DLCPI    | (C,T,1) -11.67756 | -3.464101         | -2.876277        | -2.574704         | stationary |
| DDLM     | (C,T,1) -8.821297 | -3.464101         | -2.876277        | -2.574704         | stationary |

### 3.2. Granger causality test

In order to determine the correlation between variables, Granger causality test was carried out for variables in the VAR model before the VAR model was established. According to the current situation of China's crude oil market, the lag period here is 12, that is, one year[7]. In the test results, the parts showing Granger causality are shown in table 3.

#### Table 3. results of Granger causality test

| Null Hypothesis | Obs | F-Statistic | Prob. |
|-----------------|-----|-------------|-------|
| DLI A V does not Granger Cause DLOP | 179 | 1.71539 | 0.0683 |
| DLOP does not Granger Cause DL IA V | 3.64299 | 8.E-05 |
| DLCPI does not Granger Cause DLOP | 193 | 0.75952 | 0.6912 |
| DLOP does not Granger Cause DLCPI | 1.17945 | 0.3015 |
| DLCPI does not Granger Cause DLIAV | 179 | 1.85911 | 0.0435 |
| DLCPI does not Granger Cause DDLM | 1.76485 | 0.0577 |
| DLOP does not Granger Cause DLI A V | 0.96639 | 0.4830 |
| DLOP does not Granger Cause DD LM | 2.79250 | 0.0017 |

(1) At a significant level of 5%, DLOP is the Granger cause of DLIAV, which means that oil price fluctuations will lead to changes in the growth rate of industrial added value.

(2) At a significant level of 10%, DLIAV is the Granger cause of DLOP, that is, the change in the growth rate of industrial value added will lead to the fluctuations of oil price.

(3) DLOP is the non-significant Granger cause of DLCPI, that is, the fluctuations of oil price are not obvious to the price level.

### 3.3. Determination of optimal lag order

In order to further analyze the dynamic relationship between oil price fluctuations and economic variables, a 2-dimensional vector autoregression model (VAR model) is established to determine the optimal lag order. SC test is used in this paper. The following results are obtained to determine the lag order of 2.

#### Table 4. SC test of optimal lag order

| Lag | SC    |
|-----|-------|
| 0   | -14.57478 |
| 1   | -14.75112 |
| 2   | -14.76456* |
| 3   | -14.60532 |
| 4   | -14.38570 |
| 5   | -14.18630 |
| 6   | -14.13139 |
| 7   | -13.79410 |
| 8   | -13.47713 |

### 3.4. Construction of VAR model

VAR (2) is constructed, expressed as follows:

\[
egin{bmatrix}
DLIAV_t \\
DLOP_t \\
DLCPI_t \\
DDLM_t
\end{bmatrix} = \begin{bmatrix}
-0.007345 \\
0.001357 \\
0.000168 \\
-0.000202
\end{bmatrix} + \begin{bmatrix}
-0.151925 & 0.111595 & -0.370149 & -0.164281 \\
-0.027294 & 0.298154 & 0.829709 & -0.147747 \\
0.006540 & -0.000644 & -0.223585 & 0.102218 \\
-0.016000 & -0.005809 & -0.682781 & -0.902700
\end{bmatrix} \begin{bmatrix}
DLIAV_{t-1} \\
DLOP_{t-1} \\
DLCPI_{t-1} \\
DDLM_{t-1}
\end{bmatrix}
\]
Meanwhile, by calculating the AR characteristic polynomial of the model, it is found that the inverse of the roots of the characteristic polynomial are all located in the unit circle, which indicates that the VAR(2) model established is stable.

According to the established VAR(2) model, the following conclusions can be drawn:

(1) The impact of oil price fluctuations on the growth rate of industrial added value. In VAR(2) model, the influence coefficients of oil price lag period 1 and lag period 2 on the growth rate of industrial added value are 0.111595 and 0.378390 respectively, and their values are between 0 and 1. This suggests that higher oil prices do not reduce GDP, contrary to popular conclusion. The main reasons are as follows: On the one hand, China's strict control over the price of refined oil has cut off the transmission path of crude oil price to some extent; On the other hand, due to overheating and demand pull, automobile manufacturing, durable goods manufacturing and construction departments are in rapid expansion in recent years, such as offset the rise in the price of crude oil of demand reduction effect, making the crude oil prices will not be a negative impact on industrial production and GDP. Its impact on the economy more mainly displays in industrial added value growth rate, namely on the volatility of economic growth.

(2) The impact of oil price fluctuations on the price level. In the VAR(2) model, the influence coefficients of oil price lag of stage 1 and stage 2 on current price level are -0.000644 and -0.009131 respectively, showing slight negative correlation. It may be that the domestic government usually adopts a tight monetary policy in order to alleviate the inflation caused by the increase of industry costs caused by the rising oil price, and there may be an overreaction in the process.

(3) The impact of oil price fluctuations on monetary policy. In VAR(2) model, the influence coefficients of oil price lag period 1 and lag period 2 on current monetary policy are -0.005809 and 0.032246 respectively. This shows that the rise of oil price after the first period will lead the central bank to tighten monetary policy, while the rise of oil price after the second period will lead the central bank to adopt a looser monetary policy. The main reasons are as follows: on the one hand, as a big oil importer, China needs to pay more foreign exchange for the rise of oil price, which leads to the imbalance of international payments; on the other hand, higher oil prices slow economic growth, putting pressure on central Banks to adopt expansionary monetary policies.
3.5. Impulse response analysis

(1) The impulse response of DLIAV to oil price fluctuations.

The positive impact of one unit standard deviation of crude oil price will first cause the economic growth rate to accelerate, and the acceleration degree will slow down. After half a year, the economic growth rate will stabilize at the equilibrium level of zero growth rate. In other words, the impact of oil price shock on economic growth gradually disappears. The explanation is that China’s regulation of refined oil products makes the transmission of oil price fluctuations somewhat obstructed, so the rise of oil price does not immediately reduce the output level.

(2) The impulse response of DLCPI to oil price fluctuations.

The positive impact of one unit standard deviation of the price of crude oil. The price of crude oil rose by a small margin, then fell, then rose again. After the 6th period, the price tended to be stable. It may be that the domestic government usually adopts a tight monetary policy in order to alleviate the inflation caused by the increase of industry costs caused by the rising oil price, and there may be an overreaction in the process. It then reverts to a normal ascending response.

(3) The impulse response of DDLM to oil price fluctuations.

The positive impact of one unit standard deviation of the crude oil price causes the amount of money to fall by a small margin, then rise and then fall. After half a year, monetary quantity tends to stabilize. This shows that the domestic monetary authorities have adopted a tight monetary policy in the face of rising international oil prices, reducing the money supply to recover liquidity, so as to hedge against the negative impact of price rise and inflation. With the effect of monetary policy, the influence of oil price is weakened, and the economic shock gradually disappears, the monetary authorities adjust to loose monetary policy again to stimulate economic growth.

3.6. Variance decomposition

In order to determine the role of oil price fluctuations in various variables, a variance decomposition analysis can be performed. This paper only takes the variance decomposition of economic growth rate as an example.

| Period | S.E.   | DLIAV  | DLOP   | DLCPI  | DDLM   |
|--------|--------|--------|--------|--------|--------|
| 1      | 0.125121| 100.0000| 0.000000| 0.000000| 0.000000|
| 2      | 0.126822| 99.36449 | 0.553369 | 0.004010 | 0.078132|
| 3      | 0.131789| 92.92241 | 6.993309 | 0.004123 | 0.080163|
| 4      | 0.131991| 92.74440 | 7.080455 | 0.075570 | 0.099578|
| 5      | 0.131995| 92.73950 | 7.081684 | 0.076240 | 0.102576|
| 6      | 0.132004| 92.73231 | 7.084448 | 0.080071 | 0.103167|
| 7      | 0.132004| 92.73140 | 7.084370 | 0.081028 | 0.103205|
|   |     |        |         |         |          |
|---|-----|--------|---------|---------|----------|
| 8 | 0.132005 | 92.73124 | 7.084391 | 0.081040 | 0.103329  |
| 9 | 0.132005 | 92.73095 | 7.084377 | 0.081051 | 0.103622  |
|10 | 0.132005 | 92.73086 | 7.084370 | 0.081060 | 0.103709  |

The contribution of crude oil price rise to output growth rate appeared after the third period and leveled off after the sixth period. On the whole, the oil price fluctuations have a great contribution to the economic growth rate fluctuations.

4. Conclusions
(1) Granger causality analysis shows that oil price volatility is the Granger cause of economic growth rate and monetary policy, and the price level is not significant.
(2) The stationarity analysis of the model shows that, although the international oil price and China's economic variables are complex and changeable, the economic system composed of the four variables of international oil price, economic growth, price level and money supply is stable on the whole.
(3) VAR(2) model and impulse response analysis show that:
The rise of oil price will not only reduce the GDP, but also make the economic growth speed faster, which will slow down in the later period; The price level rises as the oil price rises, then falls, and then rises normally; The influence of oil price fluctuations on monetary policy is more complex, on the one hand, the oil trade deficit caused by rising oil prices and rising prices, the need to tighten monetary policy, but late slowing economic growth, and need expansionary monetary policy. As a result, oil price fluctuations make the effective implementation of monetary policy caused the difficulty in our country.
(4) Variance decomposition analysis shows that the influence of oil price fluctuations on economic indicators has a lag effect of about 3 months, which reaches a stable level after about half a year.

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