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Analysis of the Economic Impact of International Crude Oil Price Fluctuations on China

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Abstract: This paper analyzes and examines the impact of international crude oil price fluctuations on China's economy. By constructing an SVAR model between crude oil prices and China's economy, prices and monetary policy, we study the impact of crude oil price fluctuations on some important economic indicators in China and explore their intrinsic relationships. The empirical results show that the increase in crude oil prices has a significant positive impact on the consumer price index and producer price index; it has a negative impact on industrial production in the short term, but fails to change its overall development trend. Overall, the economic system based on crude oil prices is stable, despite the fact that international crude oil prices are influenced by various complex and variable international factors.

Keywords: Crude oil price, SVAR model, Impulse response.

1. Introduction

In the context of today's technological and economic boom, energy has become an integral part of the society's development and progress. Although many ways to obtain energy have been developed, such as solar, hydrogen, tidal and nuclear energy, the majority of energy sources are still fossil fuels. Since 1867, when mankind entered the oil age, crude oil has played an important role in the energy sector of human society, and with the passage of time, it is now penetrating not only in the energy sector, but also in all areas of people's lives, from gasoline and diesel fuel, to asphalt on the road, to candles and lubricants used in everyday life, almost every industrial product can not be separated from crude oil and its related products.

As one of the most important raw materials for industrial production, crude oil prices have been closely monitored by various countries. The impact of crude oil price fluctuations on the economies of countries around the world is complex and far-reaching. What kind of impact does the fluctuation of crude oil prices have on a country's economy? And how is this impact transmitted? It is a hot topic of concern and research for scholars all over the world.

2. Variable Selection

(1) Economic growth (IAV): Industrial Added Value (IAV): IAV is chosen as a representative indicator of economic growth because, compared with real GDP, IAV is more closely related to the fluctuation of crude oil prices, because the impact of crude oil prices on industrial raw materials is the most direct and significant, which in turn has an impact on industrial production activities. In terms of data availability, GDP has only quarterly data, while IAV has monthly data, and for the missing values of IAV in January each year, this paper does not use the interpolation method to fill in the missing data, but uses the existing data to calculate the total growth of January and February based on the cumulative growth of January and February. In this paper, we calculate the sum of January and February based on the cumulative growth of January and February, and then subtract the February data to obtain the missing values for January. In this paper, the national industrial growth year-on-year rate of monthly growth is used and converted to a fixed base growth rate based on December 1999 to eliminate the limitations of the magnitude and other factors and match other variable indicators.

(2) Price level (CPI, PPI): Price index is an important economic indicator to measure the economic condition of a country, among which CPI (Consumer Price Index) and PPI (Producer Price Index) are the most widely used. It is the best representative of the price level. In order to maintain consistency in the type of variables, the PPI and CPI are calculated from the year-overyear and year-over-year growth of the CPI data, with 1999 as the base period (=100). consumer price index data. Considering the fact that there is a certain error in calculating the fixed-based price index by using year-over-year and year-over-year data only, the fixed-based price index is calculated by retaining four decimal places, and the calculated fixed-based quarterly CPI is adjusted and corrected by the available annual fixed-based CPI to obtain a more accurate fixed-based quarterly CPI (calculated by the same method as above). (the same method as above to obtain the fixed-base quarterly PPI).

(3) Crude oil price (Price): At this stage, the most traded crude oil futures in the world are North Sea Brent crude oil and US WTI crude oil futures, other than these two, other mainstream crude oil futures include Singapore crude oil, Oman crude oil, etc. At this stage, the largest single importer of crude oil in China is Russia, and the most imported crude oil by region is the Middle East. Therefore, both the actual domestic crude oil transaction price and the international oil price used as reference in the pricing mechanism of refined oil products are mainly priced using North Sea Brent crude oil and Middle East crude oil futures such as Dubai and Oman. Taking into account the representativeness to national oil prices and domestic imported crude oil costs, data availability, etc., this paper chooses North Sea Brent crude oil futures prices for analysis, and the original data obtained are dollar-denominated, multiplied by the corresponding dollar to RMB exchange rate to obtain crude oil prices in RMB.

(4) Monetary policy (M2): M1 (narrow money supply) and

M2 (broad money supply) both meet the requirement of measurability, and M2 tends to better reflect the macroeconomic performance, so M2 is chosen here as the variable indicator representing monetary policy, and similarly, the data of M2 are converted into a fixed-base index with the current value of December 1999 as the benchmark.

When doing the empirical analysis, the data of the selected indicators are pre-processed by taking the natural logarithm, which has two advantages: first, it can reduce their absolute values and make the data more smooth; second, it can eliminate the problem of possible heteroskedasticity of the data (the above data are calculated based on the data from the National Bureau of Statistics and the website of Yingwei Finance).

3. Empirical Analysis

3.1. Test of Data Smoothness

Model building and the related empirical analysis usually require the series to be stationary, so testing the variables for stationarity is an indispensable step. The ADF test, which is the most common test for smoothness in the field of time series, was applied to all the original series, and it was found that only the lnM2 series was smooth at the 1% significance level; after the first-order difference was performed on the original series, they all passed the ADF test at the 1% significance level.

Table 1. Stability test results

Variables	Inspection Type (c,T,d)	ADF statistics	Threshold value (1%)	Stability
lnIAV	(c,0,1)	-1.303	-3.460	Unstable
lnM2	(c,0,1)	-3.685	-3.460	stable
lnCPI	(c,0,1)	-0.002	-3.460	Unstable
lnPPI	(c,0,1)	-1.680	-3.460	Unstable
lnPrice	(c,0,1)	-2.869	-3.460	Unstable
d_lnIAV	(c,0,1)	-16.331	-3.460	stable
d_lnM2	(c,0,1)	-11.784	-3.460	stable
d_lnCPI	(c,0,1)	-9.372	-3.460	stable
d_lnPPI	(c,0,1)	-9.260	-3.460	stable
d_lnPrice	(c,0,1)	-12.002	-3.460	stable

Note: (c,T,d) represent the equation tested contains intercept, time trend and lag order, respectively; lag order is determined by the SC minimum information criterion.

3.2. Johansen Co-integration Test

For the series with same order single integer, Johansen co-integration test is further performed to determine whether there is co-integration relationship between them. The following table gives the results of the test of the first-order differenced d_lnPrice series and the rest of the series such as d_lnIAV and d_lnM2. By comparing the test statistics with the critical values, the original hypothesis that there is no co-integration relationship is rejected in all cases at 5% confidence level, i.e., the original hypothesis that there is no cointegration relationship between d_lnIAV, d_lnM2, d_lnCPI, d_lnPPI and d_ lnPrice have co-integration relationships with each other.

Table 2. Johansen co-integration test results

Variables	Trace statistics	5% confidence level threshold
d_lnPrice and d_lnIAV	120.6041	3.76
d_lnPrice and d_lnM2	112.3144	3.76
d_lnPrice and d_lnCPI	76.1554	3.76
d_lnPrice and d_lnPPI	72.5577	3.76

3.3. Granger Causality Test

Since the premise of Granger causality test requires that the series is a smooth series, Granger causality test is done here for each series after the first-order difference. The output results are presented in the following table.

Table 3. Granger causality test results

Original hypothesis	F-statistic	Significance probability
The reason why d_lnPPI is not Granger of d_lnM2	13.534	0.009
The reason why d_lnPrice is not Granger of d_lnM2	8.3946	0.078
Granger reason why d_lnM2 is not d_lnCPI	7.066	0.132
Granger reason why d_lnIAV is not d_lnCPI	14.321	0.006
Granger reason why d_lnPrice is not d_lnCPI	7.5787	0.108
Granger reason why d_lnIAV is not d_lnPrice	3.8695	0.424
Granger reason why d_lnM2 is not d_lnPrice	5.3611	0.252
d_lnCPI is not d_lnPrice for Granger reasons	4.6309	0.327
Granger reason why d_lnPPI is not d_lnPrice	4.6512	0.325

From the results of the Granger causality test, it can be concluded that each variable is not a Granger cause of the change in crude oil prices at the 5% level of significance. The results of this test also show the following points: first, at the 5% significance level, d_lnPPI is the Granger cause of d_lnM2, indicating that the fluctuation of the producer exit price index will cause the change of monetary policy. Second, at 5% level of significance, d_lnIAV is the Granger cause of d_lnCPI, indicating that the change in the rate of change in the rate of increase of industrial value added will lead to the change in the price level. Third, at the 10% significance level, d_lnPrice is the Granger cause of d_lnM2, which means that the fluctuation of crude oil price will also have an effect on causing the change of our monetary policy.

3.4. Determination of the Lag Order

In order to determine the optimal lag order of the SVAR model, this paper refers to both LL (log-likelihood function), LR (likelihood ratio test), FPE (Akaike's Final Prediction Error), AIC criterion, HQIC criterion and SBIC criterion, and finally determines the lag period to be 4th order. The results of the tests are presented in the following table.

Table 4. Hysteresis order detection results

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	3084.31	NA	NA	NA	1.0e-17	-24.9337	-24.9051	-24.8627
1	3228.1	287.57	25	0.000	3.9e-18	-25.8955	-25.7239	-25.4693
2	3350.03	243.87	25	0.000	1.8e-18	-26.6804	-26.3658	-25.899
3	3461.52	222.98	25	0.000	8.8e-19	-27.3807	-26.9231	-26.2441
4	3534.18	145.33*	25	0.000	6.0e-19*	-27.7667*	-27.166*	-26.2748*

3.5. Construction and Analysis of SAVR Model

In order to construct and identify the SVAR model, at least [2n2 -n(n+1)/2] constraints are imposed on the elements in the A and B matrices. n=5 in this paper, therefore, at least 35 constraints need to be imposed to make the model identifiable. Combining the actual situation of the studied problem and the results of Granger causality test, based on the actual problem studied, the specific form of A matrix and B matrix set up in this paper study is as follows.

$$A=\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ a_1 & 1 & 0 & 0 & 0 \\ a_2 & a_3 & 1 & 0 & 0 \\ a_4 & a_5 & a_6 & 1 & 0 \\ a_7 & a_8 & a_9 & a_{10} & 1 \end{pmatrix} \quad B=\begin{pmatrix} b_1 & 0 & 0 & 0 & 0 \\ 0 & b_2 & 0 & 0 & 0 \\ 0 & 0 & b_3 & 0 & 0 \\ 0 & 0 & 0 & b_4 & 0 \\ 0 & 0 & 0 & 0 & b_5 \end{pmatrix}$$

The estimated values of all the parameters to be estimated in the SVAR model, subject to the identifiable conditions, are shown in the following table.

For the established SVAR model, the test of smoothness, i.e., the test of AR unit circle, is performed. The results are shown in the following figure (Figure 1), and it can be seen that the absolute values of all the characteristic roots fall within the unit circle of mode 1, according to which the established SVAR model is stable.

Table 5. Results of the estimated parameters of the SAVR model

Parameters to be estimated	Coefficient	Standard deviation	Z-statistic	P-value
a1	0.0013	0.0118	0.11	0.911
a2	-0.0068	0.0065	-1.04	0.299
a3	-0.0381	0.0353	-1.08	0.281
a4	-0.0315	0.0068	-4.58	0.000
a5	0.5563	0.0372	1.49	0.135
a6	-0.2436	0.0668	-3.64	0.000
a7	0.0015	0.0704	0.02	0.983
a8	-0.1933	0.3670	-0.53	0.599
a9	0.0975	0.6732	0.14	0.885
a10	-2.6288	0.6243	-4.21	0.000
b1	0.0471	0.0021	22.23	0.000
b2	0.0087	0.0003	22.23	0.000
b3	0.0048	0.0002	22.23	0.000
b4	0.0051	0.0002	22.23	0.000
b5	0.0499	0.0022	22.23	0.000

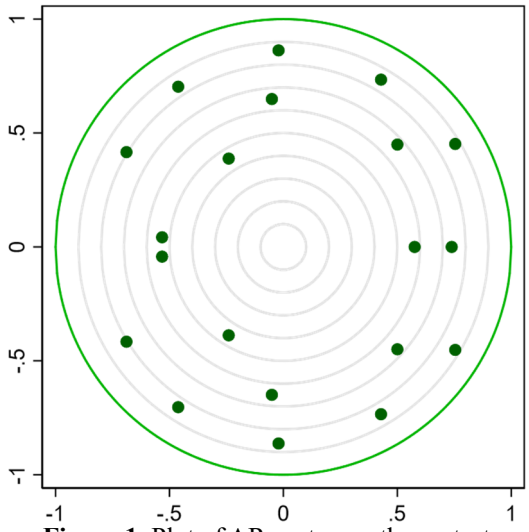

Figure 1. Plot of AR root smoothness test

3.6. Impulse Response Function Analysis

The responses of the four macro variables to shocks in crude oil price volatility are observed by building an SVAR model and plotting a series of response functions in which the vertical axis represents the logarithmic value of the rate of change of the variable to be analyzed, the horizontal axis represents the observation period, which is ten months, and the imposed shock is one standard deviation of the rate of change in crude oil prices. The solid line in the figure represents the impulse response function of each indicator subjected to a crude oil price shock, and the shaded part is the deviation range of the given 95% confidence interval.

According to the impulse response function plots, the results of the impulse responses of crude oil price changes on each variable indicator are analyzed in turn.

First, the response of IAV to the positive shock of rising crude oil prices is complex, with the impact of rising oil prices being significantly negative in the first three periods, then showing a positive response in the fourth period, alternating with a negative positive impact after the fourth period, and the impact largely disappearing starting after the sixteenth period. Overall, the impact of the increase in crude oil prices on IAV is complex, with a significant negative impact in the short term, and alternating positive and negative impacts after the fourth period. For this phenomenon, since crude oil is an important raw material essential for industrial production, its price increase will directly lead to an increase in production costs in the industrial sector, resulting in a short term decrease in the growth rate of IAV; after a short period of decrease, the industrial production sector will increase the inflow of capital to cope with the increase in raw material prices, and thus the growth rate of IAV will increase in that period. After that, there is a brief rebound in the growth of industrial value added at a faster rate. With the passage of time and the gradual stabilization of crude oil prices, the impact of crude oil prices on the growth rate of industrial value added will become smaller and smaller and gradually disappear.

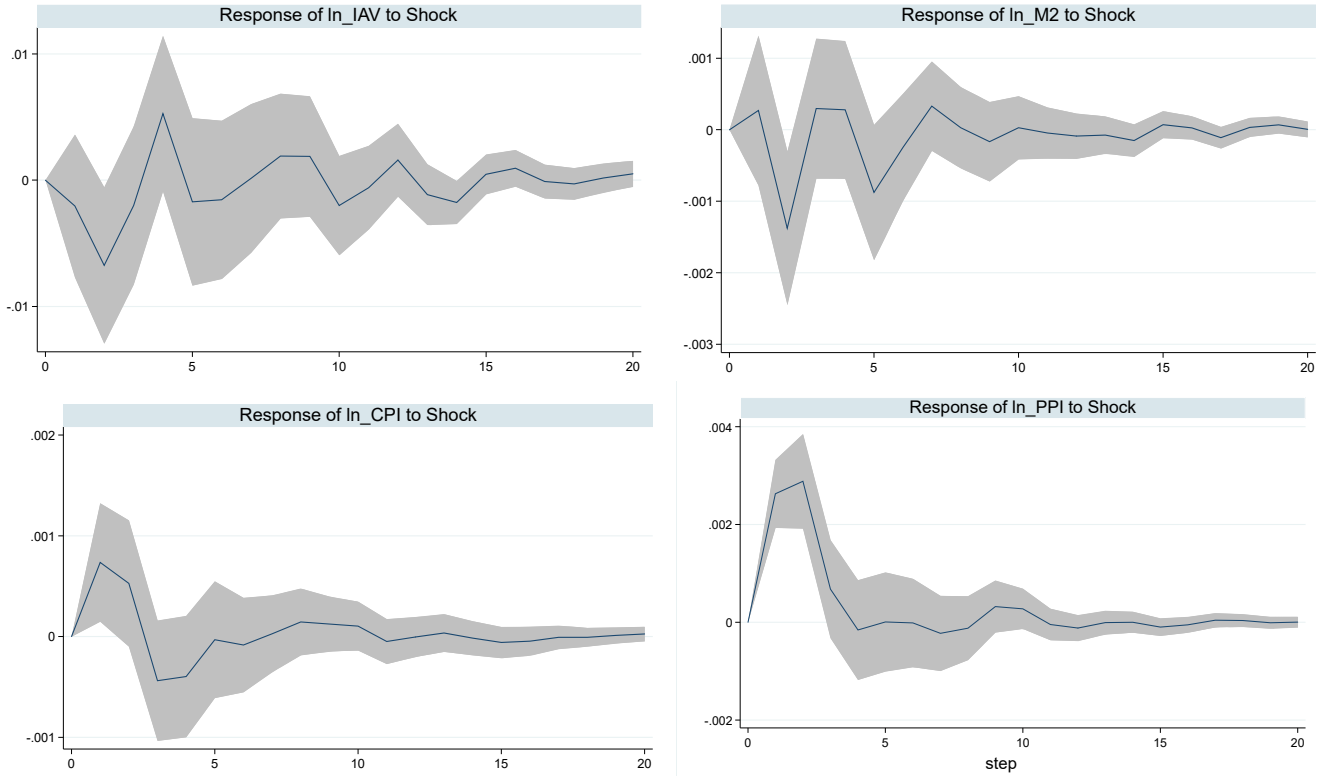

Figure 2. Impulse response function diagram

Second, the response of broad money supply M2 to crude oil price shocks is slightly positive in the first period, rapidly turns negative and unusually significant in the second period, and is basically negative, with the effect on it gradually going to zero after ten periods. The broad money supply M2, as a proxy for macro monetary policy, actually represents the government's choice in monetary policy. In the face of rising crude oil prices, the price index will tend to rise, and the government will tend to adopt a tighter monetary policy to maintain economic stability in this case.

Third, the consumer price index CPI responds very quickly to the increase in crude oil prices, and the positive crude oil price shock makes the CPI have an obvious positive response, and the positive impact is most significant in the first period, and slightly weaker in the second period than the first period, which is mainly because the increase in crude oil prices will directly cause the increase in production costs of crude oil-related industries, which in turn will pull up the costs of other related industries and eventually The negative response from the third to the fifth period is probably due to the excessive monetary tightening policy adopted by the government, which leads to a decrease in CPI.

Fourth, the response of PPI to the shock of crude oil price fluctuation is similar to that of CPI, and the response of PPI, the industrial output price index, to the positive shock of crude oil price is also a significant positive fluctuation, which increases slightly in the second period to reach the peak on the basis of a significant increase in the first period, and after reaching the peak, the impact drops rapidly to about zero in the fourth period and the impact gradually disappears. Compared to CPI, the response of PPI is stronger because the most direct impact of crude oil price changes is the production cost of industrial goods, which in turn affects PPI.

4. Conclusion

By constructing an SVAR model between crude oil prices and China's economy, prices, and monetary policy, we focus on the pattern of crude oil price fluctuations on some important economic indicators in China and explore their intrinsic dynamic relationships. An empirical analysis is also conducted based on 254 monthly data from January 2000 to December 2020.

When analyzing the impact of crude oil prices on China's economy, one of the important steps is the selection of indicators, and after repeated deliberation, we finally choose to use IAV instead of GDP indicators in the light of China's actual situation. In the face of the problem of missing data of IAV data in January every year, many scholars will use the interpolation method to supplement the research analysis. In this paper, we do not use the interpolation method, but use the existing data to calculate the sum of January and February growth based on the cumulative growth data, and then subtract the February data to arrive at the missing value for January, which is more accurate than the interpolation method.

In the empirical analysis, the effect of crude oil price increase on some important economic indicators in China is studied and analyzed through the constructed SVAR model. The results show that the increase in crude oil prices has a significant positive impact on China's consumer price index and producer price index in the short term, while it has a certain negative impact on China's industrial production in the short term, but fails to change its overall development trend. This study also finds that government departments, when faced with the problem of rising crude oil prices, tend to adopt a tight monetary policy to deal with the problem, but the transmission of monetary policy often takes some time, so the CPI and PPI will fall in the period after the rise of crude oil prices due to the tight monetary policy. Overall, the economic

system based on crude oil prices is stable, despite the fact that international crude oil prices are complicated and variable by various international factors. In other words, our market self-regulation and government macro-control have enabled our economy to develop quickly and steadily.

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