

Using Computer Data Analysis Technology to Calculate International Crude Oil Price Fluctuations

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Abstract: When many scholars study the impact of international crude oil prices, they only consider it as an external shock. In fact, international crude oil prices are affected by a variety of internal and external factors. Therefore, it is necessary to verify the types and sources of price shocks from various aspects. Based on this, this paper uses computer data analysis technology to establish an SVAR shock decomposition model, and uses the Brent oil price from January 2009 to December 2020 as an example to identify and analyze its oil price data. The result of the study is that the trend of crude oil price has an extremely important impact on national economic development, scientific and reasonable risk control by enterprises and investors, and price risk management.

1. Introduction

Most scholars study the shock of international crude oil price as an external factor, while besides consideration of external factor, it is necessary to find out internal factors. Many scholars' studies show the movement of crude oil prices is caused by varieties of internal and external factors. For example, Hamilton (2003) identified the crude oil price shock was subject to underlying cause of multiple differences. Therefor only by differentiating these underlying causes can it be clearly determined the result that crude oil price shock impacts on the variates[1]. Luo Chen recognized among these three structural shocks, the specific crude oil demand refers to the speculation factors, preventive demand and other market requirements that cannot be explained by the basic crude oil supply to the demand[2]. And the market factor plays a powerful role under current macro-environment behind violent fluctuations in oil prices. But whether the market factor is the root cause of the crude oil price fluctuation is still to be examined.

Besides, scholar Kilian divided the international crude oil shocks into supply-side shocks and demand-side shocks, and further divided the supply-side shocks into special demand shocks in the oil market and comprehensive demand shocks, and thoroughly discussed the key impact of crude oil price shocks on the US stock market. The results show that: the special demand for crude oil has the most significant impact on the U.S. stock market, while the supply of the crude oil market has an insignificant impact on the U.S. stock market[3]. In addition, regarding SAVR research, domestic experts WU Xiang and others also investigated and analyzed the impact of fluctuations in international crude oil prices on China's oil prices[4]. Researchers such as FU Lianlian pointed out that after the outbreak of the international financial crisis and the rise of crude oil prices, the impact of international crude oil prices on the prices of agricultural products in our country has gradually expanded. International crude oil price fluctuations not only have a direct impact on domestic agricultural product prices, but also have an indirect transmission mechanism for domestic agricultural product prices[5].

This article selects Brent crude oil price and Shanghai Composite Index as the total index of the domestic stock market, mainly based on Kilian (2009) SVAR model to identify various shocks on international crude oil price. The conclusion of this article states: the international crude oil price

shocks are mainly related to global international crude oil supply, the aggregate demand of global economy, and special demand of global crude oil market [6-7].

2. Variables, Model and Method

2.1 Variables

This article mainly discusses the identification on international crude oil shock, mainly relevant variables and the source of variables detailed as below table 1.

Variable	Abbreviation	Data source	Detail formula
Global crude oil output	Prod	Crude oil statistics network from U.S. Energy information Administration	$\Delta prod_t = (prod_t - prod_{t-1})$
Global crude oil price	Rop	Brent crude oil	$\Delta rop_t = 100\% * (rop_t - rop_{t-1})$
Domestic stock market total index	SP	Shanghai composite index & wind first-tier industry index (Finance industry, medical care, energy, daily consumption, optional consumption, materials, information technology, public sector, telecommunication services)	$R_t = 100\% * (\ln SP_t - \ln SP_{t-1})$
Global real economic situation	Rea	Kilian economy index	Details as below
Domestic and foreign aggregate demand	OECD & domestic industrial value-added	OECD industrial production index	Details as below

Table 1 Main Variables And Source of Variables

It should be noted that when constructing Kilian economy index, it is required to search for the rate of delivery related with coal, iron stone, rice and other dry bulk goods among relevant maritime statistics and economic situation statistics monthly published by shipping company. In order to obtain accumulated average growth rate of shipping rate for all the dry bulk goods, it is also required to calculate comparative growth rate and uniform average of growth rate for different rate sequence, at last deflating accumulated average growth-rate sequence to actual shipping rate (mainly by CPI) and then linearize the actual shipping rate index in order to remove shipping-building techniques' mid-and-long term effects. Besides, since OECD industry production index excludes China and other Asia countries, this article choose industry added value as domestic aggregate demand. After OECD industry production index and domestic industry added value are deflated by CPI, choose natural log from the actual value, and use HP filtering to eliminate long-term trend, to get periodic cycle sequence which indicated short-term fluctuation.

2.2 SVAR Model Building

SVAR is the identification scheme by Sims (1980) innovatively different from large simultaneous equation model, that is to structurally identify perturbed variables and thereby factor out structural shock with relatively more specific economic implications[8]. The structure of vector autoregressive SVAR model can capture instant structural relationship between different variables within model system. The construction of SVAR is mainly based on economic theory, to introduce structural relationship within variables based on economic theory into VAR model[9].

The construction of SVAR model adopt Kilian (2009) SVAR model construction method expounded as above, detailed as formula (1):

$$A_0 Z_t = \alpha + \sum_{i=1}^{12} A_i Z_{t-i} + u_t \quad (1)$$

$z_t=(\Delta \text{prodt}, \text{reat}, \Delta \text{ropt})$: 1. global crude oil output represented as prodt ; 2. global economy aggregate demand (global economy activity level) represented as reat ; 3. actual crude oil price represented as ropt ; 4. first-order difference represented as Δ ; 5. Two no sequence-related structural impact vector represented as ut . Specific covariance matrix as below formula (2):

$$E(utut') = \begin{bmatrix} \sigma_1^2 & 0 & 0 \\ 0 & \sigma_2^2 & 0 \\ 0 & 0 & \sigma_3^2 \end{bmatrix} \quad (2)$$

SVAR model include current terms of variables, while VAR only include lagged terms of variables. Therefore, before composing SVAR model, it is required to simplify SVAR into VAR model, followed by related constraint conditions. Formula (1) is simplified to VAR model as below formula (3):

$$z_t = \theta + \sum_{i=1}^{12} B_i z_{t-i} + et \quad (3)$$

Among it, simplified VAR represented as et , so simplified model has significant linear correlation with international crude oil structure shock, therefore formula (4) as below:

$$et = A_0 - I ut \quad (4)$$

The simplified random error term in formula (4) is the linear combination of international oil price structural shock which reflects the composite impact.

Kilian (2009) states the shock terms of international oil price can be identified as the shocks from international crude oil supply, special demand of international crude oil market and the aggregate demand of global economy only if the condition of matrix is limited [10-11]. The detailed formula of three different structural shock terms as below formula (5). Among it, international crude oil supply shock represented as ut^{ss} , special demand shock of international crude oil market represented as ut^{sd} , aggregate demand of global economy represented as ut^{ad} :

$$et = \begin{pmatrix} e_t & \Delta \text{prod} \\ e_t & \text{rea} \\ e_t & \Delta \text{rop} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} ut^{ss} \\ ut^{ad} \\ ut^{sd} \end{pmatrix} \quad (5)$$

If the matrix is given recursive constraints, the supply curve and demand curve in international crude oil market will arouse demand shock which makes supply curve and demand curve have a certain offset [12].

Kilian (2009) points out recursive constraint condition need be processed by according procedures: firstly, for international crude oil output, generally the production cost of international crude oil is very high and the dynamic instability of the whole international crude oil market and global economy environment will have significant influence on international crude oil. So the change of international crude oil is unstable and wildly fluctuated with the change external environment. Normally to the less sensitive crude oil producer, the production scale of it will not change much, which means in short term the international crude oil supply lacks a certain flexibility. That is to say, the international crude oil output in current month will not be easily influenced by special demand shock of international crude oil and global economy aggregated demand; Secondly, as to actual price of international crude oil, the special demand shock of international crude oil market mainly manifest that at a certain time in the future, the uncertainty of crude oil supply will cause preventive demand, which cannot be explained by global economy aggregate demand and international crude oil supply; thirdly, as to the index for global economy aggregate demand, special demand index of global economy market doesn't show very strong and significant change, which means the general fluctuation will not be so rapid, that indicates special demand shock will not have great impact on global economy activity level.

Besides, this article separate global aggregate demand into foreign economy aggregate demand and domestic aggregate demand, according to relevant research, to divide global international oil price shock into two different types of impacts separately caused by foreign economy aggregate demand and domestic aggregate demand. Formula (6) is created on Formula (5) as below:

$$et \equiv \begin{pmatrix} e_t & \Delta prod \\ e_t & OECD \\ e_t & CH \\ e_t & \Delta drop \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{12} & a_{22} & 0 & 0 \\ a_{13} & a_{23} & a_{33} & 0 \\ a_{14} & a_{24} & a_{34} & a_{44} \end{bmatrix} \begin{pmatrix} u_t^{ss} \\ u_t^{OD} \\ u_t^{cD} \\ u_t^{sd} \end{pmatrix} \quad (6)$$

In order to specify the sources which cause the change of international crude oil in different segment, this article on the basis of formula (5) and formula (6), adopting historical decomposition method to recognize the structural shock of international crude oil from supply side and demand side. The historical decomposition method can decompose the historical route of all the variables based on fitted trend of historical data and the accumulated historical plus current effects of each conflict item which cause the change of international crude oil. The historical decomposition method mainly separately decomposes the crude oil change rate per each segment or point into three types of oil price fluctuation impacted by special demand shock, foreign and domestic aggregate demand shock, supply shock, detailed formula (7) as below:

$$y_{t+j} = [\sum_{s=j}^{\infty} \phi_{sut+j-s}] + \sum_{s=0}^{j-1} \phi_{sut+j-s} \quad (7)$$

In formula (7), multidimensional structural impact vector represented as U_t ; the forecast fitted by all the historical data based on t period represented that the fluctuation of international crude oil market is caused by complicated factors.

3. Conclusion

This article based on SVAR model with constrained conditions, attributes the source of international oil price fluctuation to the supply shock of international crude oil, aggregate demand shock of global economy, special demand of international crude oil market. To further deeply investigate the significant role of domestic economy aggregate demand in international crude oil market, this article decomposes aggregate demand of international crude oil into foreign aggregate demand represented by OECD and domestic aggregate demand, and by analyzing the source of international crude oil fluctuation, concludes that the fluctuation of international crude oil market is caused by complicated factors.

Our findings suggest: firstly, to speed up the transformation and upgrading of domestic crude oil industry, vigorously improving the advantage of crude oil productivity and accelerate the internalization progress of crude oil; Secondly, to accelerate the overall innovation and construction of crude oil industry, with scientific planning and rational distribution, continuously developing current crude oil pillar industry; thirdly, continuously exploiting diversified market and domestic market, to strengthen the introduction of crude oil personnel; fourthly, to provide the policy support for crude oil, stabilizing crude oil production, to effectively avoid the market deterioration; finally, both enterprises and investors should choose suitable financial derivatives or cross-industry stocks to scientifically and rationally avoid risks and make relevant price control management.

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