Empirical Study on Oil and Gas Price and Economic Growth Based on Time Series

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Abstract: This paper selects the main statistical data of China 's oil and natural gas production and consumption and macroeconomic from 2003 to 2020, and carries out unit root test, cointegration test and Granger causality test on the growth rate of China 's GDP and the actual price of oil and natural gas. Based on the perspective of time series empirical analysis, this paper analyzes the relationship between economic growth and oil and natural gas consumption in various stages of industrialization in China, and the impact of China's GDP growth on oil and natural gas prices. The results show that the change of GDP growth rate directly affects the market price level of oil and natural gas.

1. Introduction

Oil is the black gold, is the ' blood ' of China's modern manufacturing industry, not only a kind of human non-renewable products, but also an indispensable strategic resource for the survival and development of the country. It is of immeasurable significance to maintain China's economic and social development and national defense security. And oil and natural gas as the basic industrial raw materials of China's national economy, its price changes and macroeconomic operation are closely linked.[1]

Many scholars have done a lot of research and analysis on the relationship between energy demand, consumption and price changes and economic growth. Shi Jun (2017) makes an empirical analysis of the relationship between China's industrial structure and the corresponding oil demand and national economic development through the vector autoregressive model. It is concluded that China's oil demand has a relatively obvious inertia in the short term, and various industries have different influencing factors on the development of oil demand. And China's oil supply and demand relationship and the reverse adjustment between the three industrial structure, only in the long-term equilibrium relationship[2]; Li Hongxun (2017) constructed a ternary interaction structure of ' petrochemical industry investment-carbon intensity-economic growth ', and selected the historical data of 27 provinces, prefecture-level cities and autonomous regions in China to analyze. It is concluded that the reduction of carbon intensity of petrochemical industry has a significant role in promoting investment in petrochemical industry. The increase of petrochemical industry investment will promote economic growth, and economic growth will also promote the reduction of carbon intensity of petrochemical industry[3]; Zhou Rui (2021) uses TVP-SV-VAR model to study the time-varying impact of global oil price change on China 's economic growth and inflation level. From the perspective of time-varying dynamics, the rise of global oil price and the change of

China's economic growth determine the level of inflation. Global oil price is positively correlated with China's economic growth, and the effect of inflation on global oil price change is completely opposite in the short-term and medium-term[4]; Suzina (2021) empirical research based on multivariate vector regression analysis shows that China's oil price may change under the influence of macroeconomic, and the price is also determined from the supply and demand[5].

The above research results show that due to the effectiveness of the research on the impact of oil price volatility on the macro level, the research involves a wide range of research fields, and the above research results lay a solid foundation for further improving the understanding of the impact of energy price volatility. However, there are relatively few studies on the analysis based on time sequence. Therefore, this paper mainly carries out the unit root test, co-integration test, Granger causality test and other tests from the two indicators of GDP growth rate and the actual price of oil and natural gas. Based on the perspective of time series empirical analysis, this paper clarifies the impact of China's GDP growth rate on oil and natural gas prices.

2. Relationship between Oil and Gas Demand and Economic Growth in China

Because the change of supply and demand of oil and natural gas is closely related to the increase of China's national economy, and in various periods of China's industrial development, the dependence on oil and natural gas in national economic development is also different. According to the development experience of other developed countries, in the early stage of industrial development, heavy industrial enterprises rely more on a large number of chemical products resources to achieve the effect of rapidly stimulating productivity and expanding industrial scale, but at the same time the demand for high energy-consuming industries has increased sharply, which has promoted the rapid growth of demand for chemical products resources ; in the late stage of industrial development, capacity structure from the original high energy consumption, low output to low energy consumption, high output optimization of industrial structure development. The change trend of total consumption of oil and natural gas and GDP growth rate is shown in Figure 1.
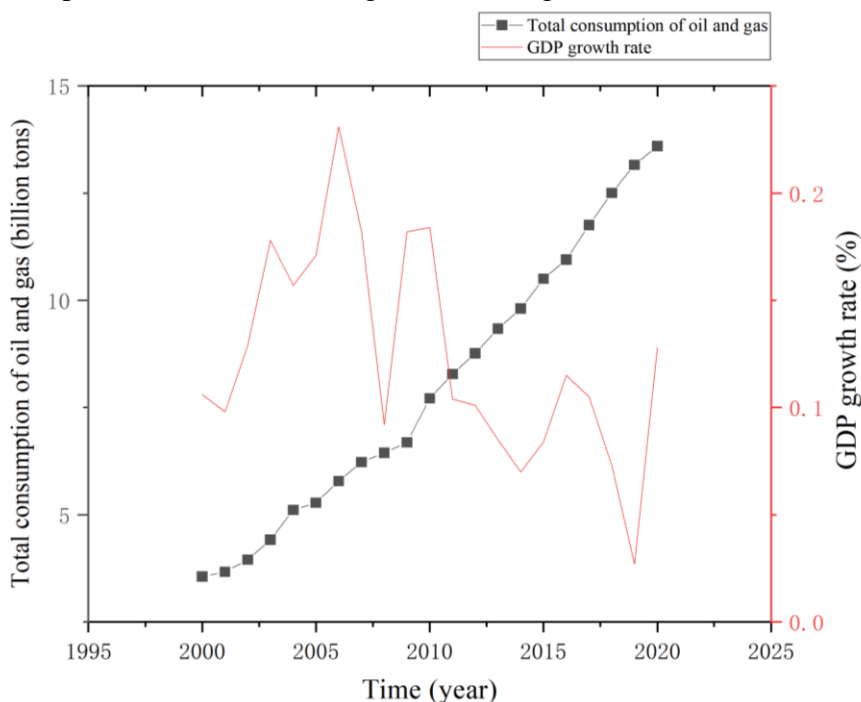

Figure 1: Trends in consumption of oil and gas and GDP growth

In the early stage of industrialization, there is a strong proportional relationship between China's oil and gas consumption and national economic growth rate. Since China entered the WTO in 2001, China's economy has begun to flourish. In the early stage of industrialization, China has entered a stage of high development of heavy industrialization. The development of science and technology and the huge demand for production have promoted the huge increase in China's demand for oil and natural gas. In this stage, the total consumption of oil and natural gas nationwide has also doubled, and its consumption level has also increased almost synchronously with the development of national economy. Therefore, on the surface, the development of national economy in this stage is highly dependent on oil and natural gas.

However, in the middle and late stages of industrialization, due to the gradual shift of China's economy from high-speed development to high-quality development, as well as the popularization and universal application of new energy, the dependence of China's national economic development on crude oil production and urban gas consumption has become increasingly weak.

In recent years, due to the invasion of the new coronavirus, the spread of the worldwide epidemic, China's economic growth has fallen sharply, and the consumption of oil and natural gas has continued to decline. Although in the current situation of normal management of the epidemic, social production and residents ' life began to normalize, the demand for oil and natural gas is increasing, even under the regulation of the national counter-cyclical policy, there is a short rebound, but in the long run, with the proposal and use of green energy, the depth of China's energy structure adjustment, the continuous change of industrial structure, the future economic growth will continue to weaken the demand for oil and natural gas.

3. Impact of macroeconomic growth on oil and gas prices

3.1. Impact of Supply - Demand Relationship on Oil and Gas Prices

In the market economy, changes in supply and demand determine changes in oil and natural gas prices.
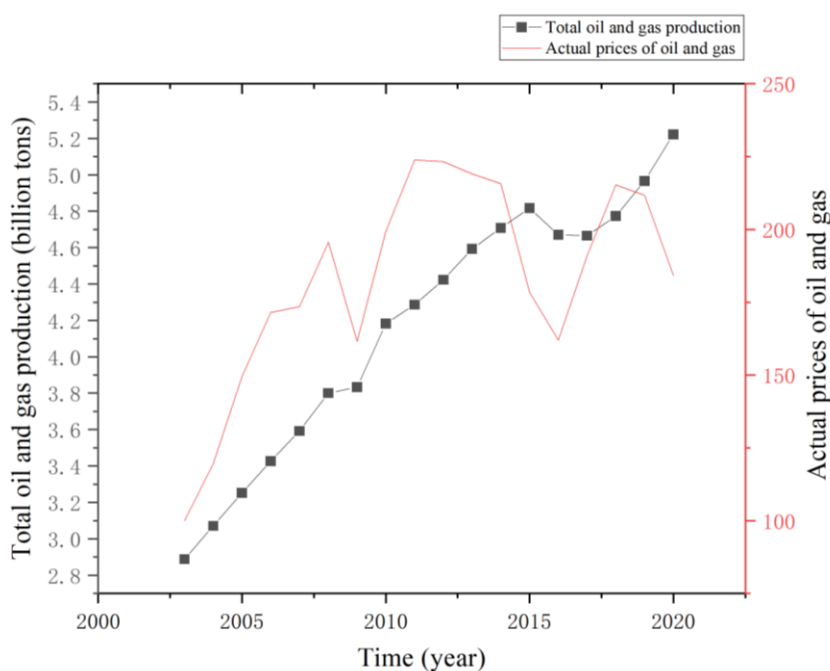

Figure 2: Trends in real prices and capacity of oil and gas

From the perspective of supply and demand, the supply and demand of oil and natural gas are closely related to macroeconomic growth, and there are seasonal shocks in the short term. For China, the supply and demand of oil and natural gas are still in a relatively balanced stage. Although the price of products fluctuates with demand, the price elasticity of supply and demand is small.

From the perspective of market supply and demand, the long-term supply capacity of China's oil and natural gas market is determined by its total production capacity, and in the short term it may be quite different from its total production. However, according to the analysis of the production status of China's oil and natural gas market in recent years, it has changed greatly and thus has a greater impact on its product price. If we take production capacity as potential supply, we can find that there is a reverse trend between the actual price of crude oil and natural gas and production capacity. The change trend of the actual prices of crude oil and natural gas and their production capacity is shown in Figure 2.

3.2. Empirical Analysis of Economic Growth and Real Price of Oil and Gas

This paper selects China's oil and gas price index from 2003 to 2020, and the actual price (2003=100) and annual GDP growth rate calculated by GDP reduction are used as variables to represent the actual price of oil and gas (CP_R) and the actual GDP growth rate (GDP_R). In this paper, the empirical analysis is based on the National Bureau of Statistics of oil and gas prices and annual GDP, in SAS and Eviews software for empirical analysis.
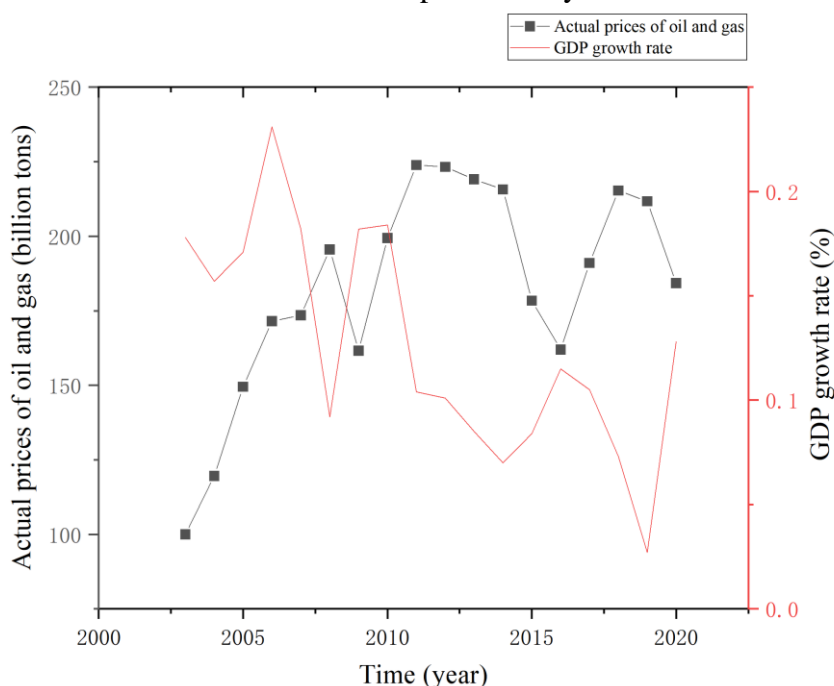

Figure 3: GDP growth and real price trends for oil and gas

Analysis of 2003-2020 data, oil and natural price changes and economic growth rate is closely linked. Therefore, time series analysis is adopted to study and analyze the specific relationship between economic and social development and oil and natural gas prices. In order to remove the negative impact of potential inflation factors, this chapter calculates the prices of oil and natural gas by GDP deflator and obtains its real value. At the same time, it introduces the annual GDP growth rate measured by constant prices to carry out theoretical analysis. The real value changes of crude oil and natural gas in GDP growth are shown in Figure 3.

The correlation coefficient between the actual price of oil and natural gas and the actual GDP growth rate from 2003 to 2020 is-0.62, indicating that they have a strong negative correlation. In order to avoid the false regression caused by the different order of time series, it is necessary to gradually carry out the stability test between the actual price and the actual GDP growth rate. The specific test conclusions are shown in table 1.

Table 1: Test results of real oil and natural gas prices and real GDP growth stability

Variable	ADF-statistics	Possibility	Conclusion
CP_R	-2.83	0.0751	Non-Stationary
CP_R First difference	-3.22	0.0380	Stationary
GDP_R	-2.29	0.1863	Non-Stationary
GDP_R First difference	-4.27	0.0052	Stationary

Through the unit root test of the horizontal value and the first-order difference of the two variables, it can be seen that the real oil and natural gas prices and the real GDP growth rate are both stable after the first-order difference, that is, both are first-order monolithic sequences. There is also a continuous and stable cointegration relationship between the real oil and natural gas prices and the real GDP growth rate. Granger causality test is used to test the causal relationship between the two, the results are shown in table 2.

Table 2: Granger Test Parameters of Actual Oil and Gas Prices and Real GDP Growth Rate

Null Hypothesis	Sample Number	F-statistics	Possibility
CP_R is not Granger Cause of GDP_R	17	3.39464	0.0867
GDP_R is not Granger Cause of CP_R		4.76050	0.0467

The test shows that the real GDP growth rate has a one-way impact on the real oil and natural gas prices. Changes in the real GDP growth rate will cause changes in the real oil and natural gas prices, while changes in the real oil and natural gas prices will not cause changes in the real GDP growth rate.

Through the above analysis of the data, we can find the long-term correlation between the actual price of oil and natural gas and the actual GDP growth rate. Considering the long-term pricing inertia of oil and natural gas, we can take the actual GDP growth rate and the one-stage lag of the actual price as the main explanatory variable of the actual price, so as to establish the regression model. The regression results are shown in Table 3.

Table 3: Regression results of correlation between real oil and natural gas prices and real GDP growth rate

Variable	Coefficient	Standard-Error	t-statistics	Possibility
CP_R Phase I Delay	1.003920	0.000298	3363.460	0.0000
GDP_R	2.173783	0.405750	5.357439	0.0001
Adjusted R2	0.999989		D.W. statistics	0.802864

From Table 3, the regression equation is
$CP\_R_t=1.003920CP\_R_{t-1}+2.173783GDP\_R_t$.

The test results show that the regression models of the real price with respect to the real GDP growth and the one-period lag of the real price can pass the test, and the goodness of fit is perfect. The two explanatory variables have passed the significant indigenity test, and there is no heteroscedasticity and sequence correlation. The explanations of the one-period lag of the real oil and natural gas price and the real GDP growth on the oil and natural gas price are significant indigenity.

4. Conclusion

In summary, China's economic growth is closely related to the consumption of oil and natural gas products. The change of economic growth directly affects the price level of oil and natural gas products, and the fluctuation of oil and natural gas product prices also directly determines the profitability level of China's oil and natural gas enterprises and industries. Affected by the new coronavirus disease, China's GDP growth rate in 2019 was 2.7 %, which became the worst year since the reform and opening up. At present, due to the slowdown in economic growth, the demand for oil and natural gas products has begun to decline. Under the new normal of overcapacity, the price level of China's oil and natural gas has begun a new round of decline. Some oil and gas companies have gradually approached the break-even point, and the profitability of China's oil and gas industry has also suffered a great blow. If the prices of oil and natural gas products are further lowered, more losses will be caused to oil and natural gas enterprises, and the profit margins of oil and natural gas industries will also be further reduced, affecting the progress of structural reform on the supply side of oil and natural gas. Therefore, in the current trend of oil and natural gas product prices, in order to prevent further expansion of the loss of oil and natural gas plate, the relevant government departments should timely introduce macro-control of oil and natural gas product prices, in order to ensure the stable operation of oil and natural gas companies, to prevent rapid reduction of industrial profit margins, in order to promote the healthy development of oil and natural gas industry.

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