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Study on the Impact of Oil Price Fluctuations on the Structure of Energy Consumption

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Abstract

As an important disposable energy source in China, oil has an important impact on the development of China's macro economy, as well as on the daily life of clothing, food, housing and transportation. In order to explore the fluctuation of oil prices, the impact on the change of China's energy consumption structure. In this paper, we construct a fixed-effects model with provincial panel data on oil price fluctuations and energy consumption structure for 30 provinces and municipalities directly under the central government from 2008 to 2019, draw conclusions, and propose targeted opinions based on the final results to promote the transformation and upgrading of China's energy consumption structure.

Keywords

Fixed Effects; Energy Consumption Structure; Oil Prices.

1. Introduction

As an important primary energy source, oil is widely used in our daily life and enterprise production for its processing and derivative products, and its price changes also affect the consumption level of residents and the scale of investment of enterprises from multiple angles. 2021, China produces 198.98 million tonnes of crude oil, an increase of 2.4% over the previous year and 4.0% over 2019, representing an average growth of 2.0% over two years. Although China's crude oil production is increasing, China's external dependence on oil and gas resources demand is still high at present, so changes in international oil prices will affect China's GDP and have a corresponding change on the energy consumption structure. At the same time, oil will continue to play a major role in China's energy consumption structure. This paper focuses on the specific direction of China's overall energy consumption structure in the light of changes in oil prices.

2. Review of the Literature

In recent years, China's oil consumption has been increasing, and it accounts for a large proportion of the energy consumption structure. Oil price fluctuations have an inseparable and mutually influential relationship with the macro economy, for example, its price fluctuations are closely linked to inflation and economic consumption; specifically, oil prices can influence the overall structure of energy consumption, which has been the focus of attention of scholars at home and abroad.

In terms of the impact of oil price fluctuations on the domestic macroeconomy. As an important raw material for production and processing in the industrial sector, oil price changes also chain affect the production costs of upstream and downstream enterprises, which in turn indirectly

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affects economic variables such as enterprise sector output, investment scale and residents' consumption, and has an inestimable impact effect on China's macroeconomy Yu (2022) Based on the CGE model,[1] found that by analyzing the change trend of WTI annual data: oil price Changes in oil prices cause different strengths of shocks to different industrial sectors, and the more the sectoral production chain is linked to the oil sector, the greater the intensity of the impact of oil price changes. At the same time, the direction of oil price changes is negatively correlated with the consumption of the population and has a negative impact on the scale of investment. Wu Shanshan (2020), using the DSGE model [2], found that a rise in international oil prices would be an increase in production costs for enterprises and cause inflation, while a large fall in international oil prices would lead to deflation, as evidenced by the negative impact on domestic output and investment.

In terms of the impact of oil price fluctuations on the consumption of residents. Due to the continuous improvement of oil refining technology and its processing derivatives range, oil is affecting the daily consumption situation of residents more deeply, Liu Zhuochen (2016) [3] mentioned that oil prices that are more volatile will change residents' demand for essential goods to a greater extent, and also have a deeper impact on the structure of consumption expenditure, with low oil prices having a strong supporting effect on the structure of consumption expenditure, while high oil prices will lead to an increase in production costs, promote inflation and hinder economic growth. Zheng Minzhao and Xiao Chunlai (2009) measured the impact of oil prices on the price index by building a model [4]: for every 1% increase in oil prices, the price index increases by 0.0624. It can be seen that the current structure of China's economy is still dominated by oil-based traditional energy sources, which affects residents' consumption to a greater extent.

Aspects of the impact of oil price fluctuations on the structure of energy consumption. As the main energy source today, oil occupies a pivotal position in the energy mix, and the impact of its price fluctuations on the energy mix is an issue of concern to many scholars. [5] Wang Luxin and Cao Yan (2019) used input-output price models to find that energy prices can optimize the energy mix, with oil price changes having a stronger impact than coal. Using the person correlation coefficient method [6], Wang Chen Guangsheng (2012) found that there is a strong negative correlation between the price of refined oil products and the share of oil consumption in China at this stage. Tang Jochu and Tang Yaojia (2010) confirmed that there is a long-term equilibrium relationship between oil prices and new energy consumption, and the coefficient of the oil price variable is positive, but the impact of oil prices on new energy is not significant because of factors such as the higher cost of development of new energy, which accounts for a smaller energy mix. [7]

In summary, there have been more systematic and comprehensive studies on the impact mechanism of oil price changes on national macroeconomics, but fewer studies have been conducted on energy consumption structure. Therefore, this paper uses a fixed-effects model to analyse provincial panel data of 30 provinces and municipalities directly under the central government from 2008 to 2019 to study in depth the impact of oil prices on energy consumption structure.

3. Theoretical Studies

Oil is not only closely related to our daily lives, such as fuel used in cars, planes and ships, but it can also be used as a raw material for many chemical products, such as plastics, asphalt and synthetic rubber. Oil is a very important source of energy, looking back at the history of World War II, the battle for resources around oil has been a hidden battle line to determine the fate of victory and defeat, the history of the crude oil market has experienced three oil crises and four price wars, the world has also always attached great importance to the development and use of

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oil. The Organization of the Petroleum Exporting Countries (OPEC) is the main supplier of oil, and was established in September 1960 by 13 oil-producing countries, with Saudi Arabia as the leading country. In the course of rapid industrialisation and urbanisation, China's demand for oil is increasing day by day. At the same time, as China's map is a patchwork of many small geological plates, while the large oil fields in the Middle East and Russia are mostly formed on large stable plates, the overall quality of China's oil and gas reservoirs is poorer and more expensive to extract than major oil-producing regions such as the Middle East, resulting in China's major dependence on oil imports. Currently, China has become the largest importer and consumer of oil and gas in the world market, with apparent consumption reaching 660 million tonnes in 2019, up 70% from 388 million tonnes in 2009, ranking second in the world, according to the National Bureau of Statistics, while at the same time, China imports 505 million tonnes of crude oil from more than 40 countries around the world, with a 72% foreign oil dependency [8].

Related studies have concluded that the main factors affecting oil price volatility are supply and demand, political and economic factors, new technology development and oil stocks, and these macro uncertainties significantly affect oil prices [9]. In addition to this, the new coronavirus epidemic has also enhanced the uncertainty of oil prices. on 21 January 2020, international oil prices started to fall, and the reason behind this round of decline was attributed to the spread and spread of the new coronavirus epidemic. wti and brent fell from US$58.54 and 64.85 per barrel on the 17th to US$53.14 and 59.32 per barrel on the 27th, a drop of 9.22% and 8.53%. The reason for this plunge in oil prices is that the epidemic has led to economic stagnation in countries around the world, factory shutdowns, suspension of international flights and a significant drop in transport demand, which have led to a significant reduction in demand for oil and contributed to the fall in oil prices. The Newcastle pneumonia outbreak is now gradually being brought under control, the easing of preventive and control measures, and the steady recovery of international geopolitics and economies will stimulate oil and gas demand in the short term. Demand for oil and gas will rebound as economies around the world recover and the transport sector, for example, recovers. However, reduced investment in oil and gas development due to the previous New Crown epidemic and low oil prices on the oil market may affect oil and gas supply, while green energy policies such as sustainable development will also pose challenges to the long-term development of the oil and gas industry.

The volatility of oil prices not only affects the development of China's economy: rising oil prices hinder macroeconomic growth and increase inflationary pressure, oil price fluctuations cause instability in the operation of related industries, crude oil prices affect the futures market, etc. [10], but also affects the structure of energy consumption. Global primary energy is based on oil, coal and natural gas as the three pillars, while China is highly dependent on coal and oil [11]. In 2021, the structure of primary energy consumption in China will be 56% for coal, 18.5% for oil, 8.9% for natural gas and 16.6% for non-fossil energy [12]. The fluctuation of oil prices affects the production costs and industrial structure of the chemical industry, the consumption of the population in terms of transportation and living, etc. On this basis, it affects our choice of energy types and the amount of each type of energy used, which in turn affects the structure of energy consumption in China.

At present, with the country accelerating its energy security strategy, optimising the energy consumption structure, continuously increasing the proportion of new energy consumption and reducing the use of fossil energy can not only save social costs, promote economic growth and improve people's livelihood, but also reduce greenhouse gas and other emissions, reduce environmental pollution and promote green development. The Strategic Action Plan for Energy Development (2014-2020), published by China, specifies the target for restructuring energy consumption, i.e., adjusting the proportion of non-fossil energy in energy consumption to 15% by 2020 and 20% by 2030. Under this target, it is extremely important to study the factors

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affecting the energy consumption structure and explore the optimization path of the energy consumption structure. This paper will analyse the impact of oil price fluctuations on the energy consumption structure by constructing a panel data fixed effects model.

4. Empirical Analysis

4.1. Construction of the Model

The factors influencing the structure of energy consumption are not only affected by oil price fluctuations, but also by external macro factors such as technological factors, institutional factors and China's economic growth. Therefore, in order to fully exclude the interference of other factors to explore the impact of oil price fluctuations on the structure of energy consumption, in the choice of model, it is found that there is a significant individual area effect and insignificant time effect, after HAUSMAN test, this paper uses the panel data fixed effects model. The specific model is shown below.

$$\mathbf{lnYit = \beta 0 + \beta 1 lnXit + \beta 2 Zit + Ei + \alpha i + \partial\ it}$$

where i represents the province, t is the year, the explanatory variable Y is the structure of energy consumption denoted by jp, Xit is the core explanatory variable, i.e., the price change of oil in each province from 2008-2019 denoted by rg, and Z is a series of control variables, including institutional, technological and economic factors, denoted by pf, kj and zd respectively. Ei denotes regional fixed effects and αi denotes time fixed effects.

4.2. Selection of Indicators

4.2.1. Explanatory Variables

The explanatory variable in this paper is the structure of energy consumption (jg). Referring to previous studies, regarding the measurement of this indicator of energy consumption structure, this paper uses carbon emissions as a proportion of total energy consumption to be measured, which is estimated according to the estimation methodology of the PICC Guidelines for National Greenhouse Gas Emissions Inventories 2019, as follows.

$$C = \sum_{i=1}^{n} MiFi$$

Where: C denotes energy carbon emissions, i denotes energy type, M denotes energy consumption and F denotes the carbon emission factor for that type of energy. The t-standard coal conversion factor for each energy source is based on PICC, and because carbon emission factors are complex to measure and do not vary significantly from year to year, they are assumed to remain constant from year to year.

Table 1. Standard coal carbon conversion factors and carbon emission factors

Types of energy	Conversion factor	Carbon emission factor	Types of energy	Conversion factor	Carbon emission factor
Raw charcoal	0.7143	0.7559	**Vegetable oil**	1.4571	0.5919
Coke	0.9714	0.885	**Fuel oil**	1.4286	0.6185
Crude Oil	1.4286	0.5857	**Liquefied Petroleum Gas**	1.7143	0.5042
Petrol	1.4714	0.5538	**Liquefied natural gas**	1.7572	0.4483
Paraffin	1.4714	0.5714			

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4.2.2. Explanatory Variables

The explanatory variable in this paper is oil price volatility (rg). Drawing on the approach of Li Hongkai et al. for oil price volatility, the national average retail price of 90# unleaded petrol is chosen to represent oil price volatility in this paper, and the natural logarithm of the data is taken in order to eliminate heteroskedasticity in the time series.

4.2.3. Control Variables

(1) Technological progress (jp). Calculated as the share of internal expenditure on R&D funding in the regional GDP. Over the past 20 years, with technological advances, China's energy efficiency has improved and the consumption structure has been further optimised. Theoretically, technological progress is an important influencing factor in the change of the energy consumption structure.

(2) Institutional factors (kj). This paper uses the number of employees in state-owned units as a proportion of the total number of employees to represent the influence of institutional factors. Our country has always maintained a strict attitude towards the energy sector and state-owned enterprises have an important influence on the energy mix.

(3) GDP per capita (zd). GDP per capita represents the growth of our economy, which is always in a mutually constraining relationship with energy consumption and cannot be ignored.

4.3. Selection of Data and Descriptive Statistics

Due to the serious lack of data on Tibet and Hong Kong, Macao and Taiwan, this paper should instead select the provincial panel data of 30 provinces and municipalities directly under the Central Government of China from 2008-2019 as the relevant sample, based on the exclusion of that said sentence. The data related to energy consumption structure and GDP per capita are obtained from the EBS database and the China Energy Statistics Yearbook, while the institutional factors and technological progress factors are sourced from the WIEGO database and the China Statistical Yearbook. The descriptive statistics are shown in Figure 1 below, from which the distribution pattern of individual variables can be initially explored.

Table 2. Descriptive statistics Summary Statistics

VarName	Obs	Mean	SD	Min	Median	Median	Max
jg	360	0.79	0.304	.27995	.72296	.72296	1.8152
pf	246	6.47	0.953	3.23	6.46	6.46	8.24
kj	360	0.01	0.006	0	.00916	.00916	.03242
zd	360	0.20	0.113	.03114	.17526	.17526	.79325
rg	360	4.87	2.660	.8824	4.22845	4.22845	16.4222

4.4. Results and Analysis of the Regression

Table 3. Results of the base regression with fixed effects

lnjg	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnpf	-.0496501	.0357742	-1.39	0.167	-.1201707	.0208706
lnkj	.1299972	.0357679	3.63	0.000	.059489	.2005055
lnzd	-.0306472	.0369946	-0.83	0.408	-.1035737	.0422792
lnrg	-.1614444	.0416909	-3.87	0.000	-.2436284	-.0792603
_cons	.5338998	.1879935	2.84	0.005	.1633136	.9044859
Time						
year	.07817379					
rho	.96012563	(fraction of variance due to u_i)				

Note: 000, 00 and 0 denote 1%, 5% and 10% significance levels respectively.

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In order to eliminate heteroskedasticity, all variables in this paper are calculated in natural logarithms. The impact of each explanatory variable on the structure of energy consumption was analysed by adding the core variable rg as a benchmark and gradually adding the technological factor (technological progress) and the institutional factor, as well as the macroeconomic factor (GDP per capita), while controlling for time and regional effects, and carrying out the regression analysis again. The results are shown in Table 3.

4.4.1. Oil Price Factors

From the regression results, it can be seen that for the core explanatory variables, the oil price factor has a high significance and a good fit on the energy consumption structure. the Err results show that the standard error of this data is small and the data is reliable, and the change in the correlation coefficient is 1.614, showing a high positive correlation, implying that with the increase in oil prices, the consumption structure of energy will face greater difficulties.

4.4.2. Controlling Variable Factors

As far as the results are concerned, the control variables technological progress factor and energy consumption structure have a statistically high significance and their correlation coefficient value is positive 1.2, showing a high positive correlation, while the significance presented by institutional factors and external economic factors is not high and the correlation coefficient is negative, the results show that with the progress of technology, China's energy consumption structure will be further optimised, but due to the GDP per capita up and other factors will have an inhibiting effect on the optimisation of the energy consumption structure. The reason for this is likely to be due to the increase in the level of consumption of residents with the policy input, leading to an increase in the pinning down and waste of energy.

4.5. Robustness Analysis

To test the robustness of the regression analysis, this paper replaces the use of carbon emissions as a proportion of total energy consumption with the amount of each type of energy consumed by each sector of the national economy and its share of total energy consumption for robustness testing (see Table 4). The results show that the structure of my energy consumption becomes more significant with the key explanatory and control variables after the replacement, and the sign of the coefficients is largely consistent with the original levels. This indicates that the regression results of this paper are robust.

Table 4. Robustness tests

lnfg	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnrg	-.2083438	.0400455	-5.20	0.000	-.2872954	-.1293922
lnpf	-.0608744	.0358178	-1.70	0.091	-.1314909	.0097422
lnkj	.1456974	.0351773	4.14	0.000	.0763437	.2150512
lnzd	-.0856225	.0391034	-2.19	0.030	-.1627166	-.0085283
_cons	2.288332	.4350418	5.26	0.000	1.430627	3.146037
sigma_u	.40063896					
sigma_e	.07688101					
rho	.96448378	(fraction of variance due to u_i)				

Note: 000, 00 and 0 denote 1%, 5% and 10% significance levels respectively.

5. Conclusion and Recommendations

Firstly, the price of oil is an important factor in the structure of energy consumption in China. The volatility of oil prices is positively correlated with the structure of energy consumption. This may be due to the fact that, as oil prices continue to fluctuate, the public's trust in oil

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products decreases and their purchasing preference falls, leading to a short-term tendency to "push" companies towards new energy production. Therefore, we should prepare and reserve for high fossil energy prices in advance of oil price fluctuations. With green development as a guide, we should take the opportunity to develop new energy sources and improve the efficiency of energy use.

Secondly, external macro-economic and policies also have a positive influence on the structure of energy consumption. The reason for this is probably due to the increasing awareness of environmental protection as the standard of living of the population continues to improve. In this regard we should all the more invest in new energy sources, combine them with the population, vigorously carry out green production reforms and strictly check the waste energy emissions of energy companies.

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