Study on the Relationship between Energy Consumption and Economic Growth in Shandong Province

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Abstract

Energy is the basis of human socio-economic development, after the reform and opening up, in order to develop the economy rapidly, each province and city increase the exploitation and consumption of energy, and the energy storage of nature is decreasing, especially the exploitation and uncontrolled use of non-renewable energy, which is more detrimental to the sustainable development of the country. By analyzing the energy situation and GDP of Shandong province, we hope that each province and city can reasonably coordinate the endogenous relationship between energy consumption, economic development and ecological protection, and build a strong, beautiful and environmentally friendly socialist country. This paper selects the energy statistical data of Shandong Province from 2000 to 2020, analyzes the relationship between GDP and energy consumption in Shandong Province, and puts forward relevant policy suggestions. The article first briefly analyzes the current economic situation and energy consumption from the trend chart, and studies the mutual influence and causal relationship between energy and economy in Shandong Province from an empirical point of view. This paper uses methods such as co-integration analysis and large causality test to analyze the energy consumption and economic development of Shandong Province. According to the results, energy consumption and GDP are both changed from non-stationary to stationary by two differences, and since they are both second order single integer, thus cointegration test is performed, and it is found that there is a significant cointegration relationship between them, that is, they have a long term equilibrium relationship, and it can be determined that energy consumption is the one-way Granger cause of industrial GDP growth. Starting from the current situation of energy consumption in Shandong Province, this paper puts forward a series of countermeasures: reduce energy consumption, reduce the dependence of GDP on energy, change the energy-consuming economic development mode; improve energy utilization rate, promote green and low-carbon development; strengthen The promotion of energy conservation among residents will enhance the public's awareness of energy conservation and promote the conservation of the whole society.

Keywords

Energy Consumption; Economic Growth; Cointegration Analysis; Gergel and Causality Test.

1. Introduction

1.1. Background of the Study

Energy is an important driver of national economic growth. Since the industrial revolution, the economic value of energy has been discovered and increased, and the demand for coal, oil, natural gas and other energy sources has increased, which has facilitated the energy revolution, increased social productivity and promoted human society into industrial civilization, but at the same time, energy has also constrained the development of human society. On the one hand,

energy supply and demand has become a bottleneck for the development of many regions because of the scarcity of energy and the growth of energy supply to meet the needs of rapid social and economic development, and on the other hand, while energy promotes the development of human society, a large amount of waste is generated when human beings obtain and use energy, which causes incalculable damage to the ecological environment.

In the report of the 20th Party Congress, General Secretary Xi Jinping emphasized that "we should actively and steadily promote carbon neutralization, based on China's energy resource endowment, adhere to the first established and then broken, implement carbon peaking actions in a systematic and step-by-step manner, promote the energy revolution, strengthen the clean and efficient use of coal, accelerate the planning and construction of new energy systems, and actively participate in the global governance of climate change". China is a large country in terms of energy production and energy consumption; therefore, energy has a strategic and global position in the development of our national economy, which is related to the realization of our second century goal.

At the end of 2019, China broke out a new crown epidemic, the economy throughout China was affected to a certain extent, with the national epidemic prevention and control efforts to increase, China's epidemic has been effectively controlled, overall, China's industrial production gradually recovered, the economy began to recover, but the current part of the epidemic in foreign areas is still serious, the external environment there are many uncontrollable factors, so the situation of the epidemic in China exists Uncertainty, industrial safety production risks, industrial economic stability and recovery there are certain difficulties.

1.2. Purpose of the Study

In the context of China's epidemic prevention and control situation is severe, Shandong has been China's strong energy industry, due to Shandong out of China's coastal areas in northern China, developed foreign trade, and Hebei, Henan, Anhui, Jiangsu 4 provinces bordering the epidemic, the impact of the epidemic is greater, so 2020 - 2021 Shandong industrial energy production operation is unstable, power generation and energy supply production is not stable, coupled with its own energy demand, Shandong Province, energy supply and demand contradictions are significant. On the one hand, from the main industrial energy production, electricity production fell year-on-year, coal and oil production and processing volume also fell year-on-year, on the other hand, from the total industrial energy consumption, comprehensive energy consumption continues to be at a high level, electricity consumption has increased substantially year-on-year, industrial coal and oil consumption has fallen, industrial product consumption has increased significantly.

1.3. Significance of the Study

In modern society, the development of social and economic development is inseparable from the development and utilization of energy, but the earth's agriculture is limited, and many international disputes and conflicts are caused by energy, so the development and utilization of energy has always been a focus of global attention. For thousands of years, people have been demanding nature without restraint, so that there are few resources left on the earth, therefore, China is committed to green energy and renewable energy to achieve the green concept of sustainable development. By studying the relationship between gross regional product and energy consumption in Shandong Province, we reveal the problems of energy consumption in the province and the dependence of the economy on energy consumption. Secondly, the suggestions and opinions on the rational use of energy can improve the material living standard of the people and promote the high speed, effective and sustainable development of Shandong province. Finally, energy is the driving force of China's social development, in order to get high quality and sustainable economic development, it is necessary to fully coordinate the inherent relationship between energy consumption, economic growth and ecological protection, with

the increasingly prominent role of science and technology in the energy market and consumption, we should Pay attention to the practical application of science and technology in energy utilization, improve energy utilization efficiency by means of science and technology, reasonably control energy consumption and energy intensity, and develop new clean energy; in order to reduce dependence on traditional energy and achieve sustainable economic and ecological development, Efficient and rational use of energy must be ensured.

2. Literature Review

2.1. Review of Foreign Literature

Due to the strategic importance of energy in the economic development of Western countries, foreign scholars have investigated the relationship between energy consumption and economic development from both qualitative and quantitative perspectives. Zamani Mehrzad (2007)Based on data from 1967-2003 for Iran an, found a bidirectional causality between GDP and consumption of natural gas and petroleum products and a single causality between GDP and overall energy [1].Mounir Ben Mbarek(2015) based on quarterly data for France from 2001 to 2012,using unit root test, incremental Dickey Fuller and Philips Perron, Granger causality test and variance decomposition to derive a unidirectional causal relationship from renewable energy production to primary production of all energy sources in the short run [2].Pala Aynur (2020) educated data for G20 countries from 1990 to 2016 to explore the energy consumption and economic development correlation, establish long-run equilibrium relationship by panel cointegration test, using full modified OLS (FMOLS) and dynamic OLS (DOLS) determined that energy consumption and economic growth have a long-run causal relationship [3].

2.2. Domestic Literature Review

China's research on the relationship between energy consumption and economic development has lagged relatively behind, and the research started after the reform and opening up, Wang Xuhui and Liu Yong (2007) analyzed the data of total energy consumption and GDP in China from 1978-2005, and the study found that the two showed some volatility in the short term, and in the long term the two had a better long-term and stable equilibrium relationship, and in a sense, energy consumption is an important factor affecting economic development [4]. Li Qin (2010) empirically tested the influence of energy consumption and economic development in various regions of Anhui Province based on time series model and using Granger causality analysis, and found that energy consumption and economic development in Anhui Province have a unidirectional causal link, and the increase of energy consumption in Anhui Province has a good contribution to the economic development [5]. Based on the panel data of energy consumption and GDP in China from 1978 to 2009, Yang, J. and Wang, Q. C. (2011) derived the pulling effect of electricity consumption, coal consumption and oil consumption on the national economy, with coal consumption having the largest impact on GDP, electricity consumption having a larger pulling effect on the national economy but still having a lag phase, and natural gas and oil consumption playing a positive role [6]. Using the time series data of China's renewable energy consumption and GDP from 1978 to 2017, Li, P. Y. and Xu, W. X. (2020) used cointegration analysis, and the results showed that there is a cointegration relationship between GDP and renewable energy consumption, renewable energy has a synergistic effect on GDP, i.e., the increase of renewable energy consumption can promote economic growth [7].

In short, many scholars at home and abroad have conducted in-depth discussions on the relationship between energy consumption and economic development; however, they have reached different conclusions on the title, length of time series, and application of models. Based on the research of scholars at home and abroad, this paper believes that there are four connections between energy consumption and economic development: one is the pull of

economic growth on energy consumption; the other is the impact of energy consumption on economic growth. Fourth, there is no necessary relationship between energy consumption and economic growth. Shandong Province is a province with a vast territory, rich resources and rapid economic development. The reform and opening up has brought huge development opportunities to the development of Shandong Province; in 2021, Shandong Province will rank among the top three in the province, with heavy industries as the mainstay, and heavy industries accounting for 68%, the economy of Shandong Province is heavily dependent on energy, and the energy consumption of Shandong Province has become an important reason restricting the economic development of Shandong Province; has important practical significance.

3. Research Content and Methodology

3.1. Research Content

Firstly, we use the literature analysis method to organize the research progress and results at home and abroad, summarize the analysis ideas, analysis.

Secondly, it defines the topic background, topic significance, research content and research methods.

We then proceed to identify the data. This paper takes the relationship between energy consumption and economic development in Shandong Province as the main line, and conducts a statistical analysis of the GDP and energy consumption of Shandong Province during 2000-2020.

Based on the panel data of various regions in Shandong Province, the quantitative and causal relationship between my country's energy consumption and economic growth is discussed by using cointegration analysis, Granger test and other methods.

According to the relationship between energy consumption and economic development in Shandong Province, and according to the current energy consumption situation in Shandong Province, some policy suggestions are put forward for the development of energy consumption in Shandong Province.

3.2. Research Methods

3.2.1. Literature Method

Through reading a large amount of relevant literature and searching relevant information on the Internet, we understand the main theories, contents and methods of energy consumption and economic growth.

The main theories, contents and methods of energy consumption and economic growth, so as to determine the research topic and the spatial and temporal scope of the research content, and lay the foundation for the subsequent thesis writing.

3.2.2. Co-integration Analysis

Cointegration analysis is the study of the long-term relationship of the variables, the smoothing and coordination of the variables is its prerequisite, if the data are non-stationary, the data need to be differenced; if the variable data can be smooth after differencing of the same order (usually first-order and second-order differencing), cointegration analysis can be conducted; then the cointegration rank test, through the analysis of the cointegrating series, according to the results of the cointegration rank test to establish The co-integration analysis is followed by the co-integration rank test, through the analysis of the co-integrated series, according to the results of the co-integration rank test to establish the co-integration equation, to obtain the long-term equilibrium relationship between the variables; if short-term fluctuations are

considered, the error correction of the fitted co-integration equation is also required; after the co-integration analysis, the Granger causality test can be conducted.

4. Empirical Analysis

4.1. Data Source and Pre-processing

For the study of the cointegration and causality of energy consumption and economic growth in Shandong Province, the data of total energy consumption and real GDP of Shandong Province from 2000 to 2020 were selected. The data of this period are selected because China is in the 21st century and has distinctive economic development stages, the economic development gradually shifts from high speed development to high quality development stage, and the economic data of this period has distinctive characteristics and stages because it is highly influenced by economic globalization, the global financial crisis in 2008 and the new crown epidemic in late 2019, and the economic decline is serious. We study the relationship between energy consumption and economic growth in Shandong Province during 2000-2020

The statistical data of energy consumption (EC) in 2000-20020 are obtained from China Energy Statistical Yearbook (2005, 2010, 2015, 2020), which is a physical indicator, and the unit is million tons of standard coal; the statistical data of GDP are obtained from China Statistical Yearbook, and the data of GDP in this period are the real GDP in constant price in 2000, The unit is billion RMB. Figure 1 reflects the trend of energy consumption and real GDP in Shandong Province from 2000 to 2020. The empirical analysis data analysis and modeling were done with the help of econometric software Stata.
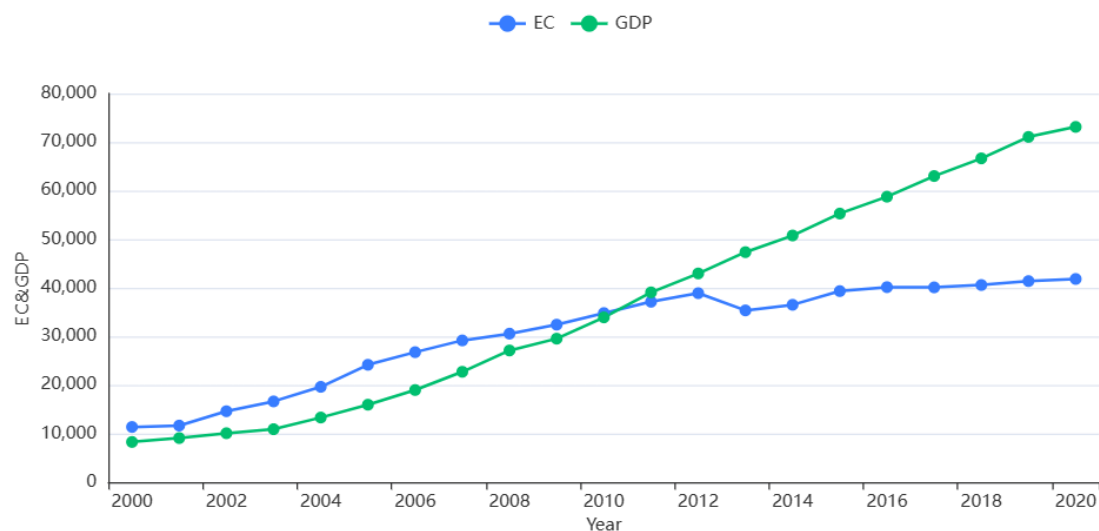
Figure 1. Trend of energy consumption and economic growth in Shandong Province

4.2. The Smoothness Test of the Series

From Figure 1, we can see the trend between energy consumption and economic growth in Shandong Province from 2000 to 2020, and we can initially determine that both are unstable. The reason for this phenomenon is mainly due to economic fluctuations in GDP, while energy consumption is mainly due to changes in energy supply and demand, national policies, science and technology.

In order to make this determination more accurate, we selected the more strongly conditioned drift model from the three ADF models, i.e., the model with both constant and trend terms, and used the critical values of the ADF of this model to determine the smoothness of energy consumption and GDP, respectively.

Original hypothesis: there is a unit root Alternative   hypothesis: there is no unit root.

Table 1. ADF test

Time series	ADF value	1% critical	5% critical	10% critical
EC	-2.312	-3.809	-3.022	-2.651
GDP	-1.669	-4.138	-3.155	-2.714

From the above results, the ADF value for energy consumption is -2.312<0.05, which means that there is a unit root for GDP, and the ADF value for GDP is -1.669<0.05, which means that there is a unit root for energy consumption, so both are not smooth.

The single integer order of energy consumption and GDP is obtained by the quadratic difference method. The first-order difference and second-order difference time-varying curves between energy consumption and GDP in Shandong Province, the first-order and second-order second-order differences are the first-order and second-order second-order, second-order and second-order second stage.
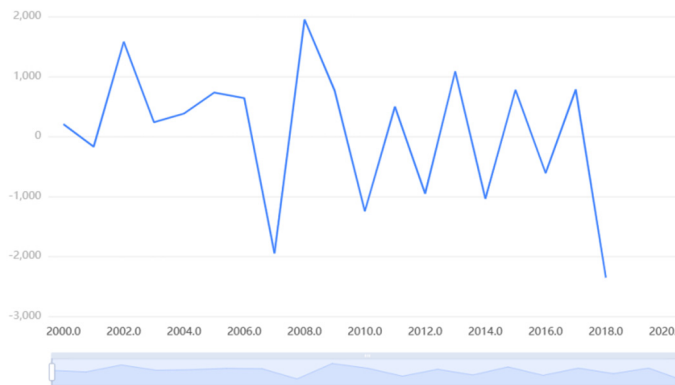

Figure 2. First-order differential of energy consumption
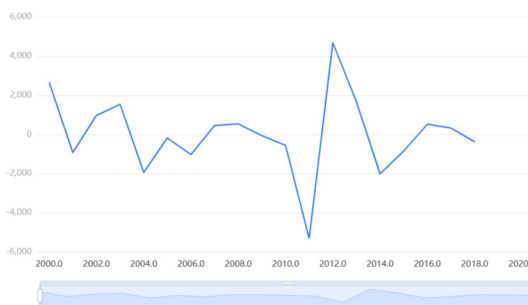
Figure 3. Second-order differential of energy consumption
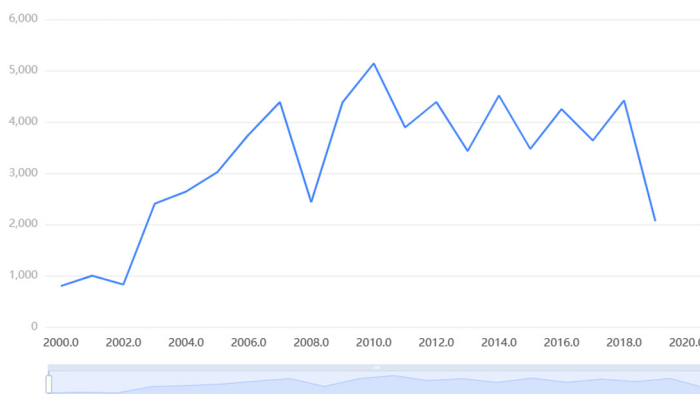
Figure 4. First-order differential of GDP

Figure 5. Second-order difference of GDP

From the above four figures, we can see that the second-order difference between energy consumption and GDP is relatively smooth, and the initial judgment is that the two are second-order single integer.

Table 2. ADF test after differencing

Time series	ADF value	1% critical value	5% critical value	10% critical value
EC first-order differential	-2.533	-4.223	-3.189	-2.73
EC second order difference	0.513	-4.223	-3.189	-2.73
GDP first order difference	-2.562	-3.833	-3.031	-2.656
GDP second order difference	-6.465	-3.859	-3.042	-2.661

From the results, it can be seen that both first-order differences cannot reject the original hypothesis at the 1% significance level, and both can reject the original hypothesis at the second-order differences, i.e., both energy consumption and GDP are second-order single integers.

4.3.   Co-integration Test

From the results of the ADF unit root test of the difference between energy consumption and economic growth in Table 2, it can be seen that energy consumption and GDP are cointegrated and meet the prerequisites for the cointegration test, so we can determine whether there is a long-run equilibrium relationship between them by doing the cointegration test.

First of all, we can examine whether there is a cointegration relationship from the graph, and we can see that the growth rates of energy consumption and GDP are different, but the time trends are relatively close, so we can simply assume that there is probably a long-term equilibrium relationship.

In order to establish the cointegration equation, first determine the cointegration rank and lag order in the data, we pass the cointegration rank test result of stata software shows that there is only one linearly independent cointegration vector, and most of the criteria from the lag order results indicate that the lag fourth order should be chosen.Then the great likelihood estimation (MLE) was used to estimate the error correction model for the vectors, resulting in the cointegration test results shown in Table 3, which in turn led to the cointegration equation as

$$EC = 2974.308 - 0.410 * det(GDP) - 0.006 * ECM(-1)$$

This cointegrating equation represents the long-run equilibrium relationship.

Table 3. Co-integration test

Johansen cointegration test (trace statistic Trace)					
Original hypothesis H0	Characteristic root eigenvalue	Trace Trace	10% critical value	5% critical value	1% critical value
None(no co-integration)	0.346	10.859	13.429	15.494	19.935
None(no co-integration)	0.224	4.062	2.705	3.841	6.635

4.4. Granger Causality Test

Through the above co-integration test, it has been shown that there is a long-run equilibrium relationship between energy consumption and GDP, and then we use Granger test to determine the change of causality between the two.

Table 4. Granger causality test

Original hypothesis H0	F value	P value	df 1	df 2
Granger reasons why 'energy consumption' is not 'GDP'	12.739	0.001**	2	14
Granger reasons why 'GDP' is not 'energy consumption'	0.430	0.659	2	14

The results from the Granger causality test show that the P-value is 0.001 < 12.739, so the original hypothesis that energy consumption is not the Granger cause of GDP is rejected, and since the P-value is 0.659 > 0.430, the original hypothesis that GDP is not the Granger cause of energy consumption cannot be rejected, so industrial energy consumption is the one-way Granger cause of industrial GDP, that is There is a causal relationship between them both and it is not a pseudo-regression relationship.

5. Policy Recommendations

Energy not only serves as the driving force of economic development, but also restricts the development of the economy, energy production and consumption is related to national security and economic security, before the twenty-first century, the main source of people's production and life consumption is coal, oil, natural gas and other traditional energy sources, and the pollution gas generated by these consumption of these energy sources has also brought serious harm to the environment, greenhouse gases, extreme weather, acid rain, sea level Greenhouse gases, extreme weather, acid rain, sea level rise and many other problems seriously affect the quality of life of our human beings. To achieve harmony between human and nature, sustainable economic development, environmental protection and economic development have become a priority in the 21st century.

5.1. Low Energy Consumption Intensity, Change the Economic Growth Model

Since 2000, Shandong Province's consumption of energy demand accelerated, the province's energy consumption is highly increased, there is an imbalance between supply and demand contradiction, resulting in economic development and ecological environment pressure increased, the social development of Shandong Province has caused a great threat. Although Shandong province province is rich in hydropower resources, but oil, natural gas and other resources are extremely scarce, if the GDP growth depends on the consumption of energy, it will certainly be at the cost of the environment, social development will certainly not last, so we

now urgently need to change this mode of economic growth, reduce the consumption of energy, reduce the pollution of the ecological environment, the development of new industries, reduce the use of energy. Implement macro energy control policies, adjust the structure of industrial industries as soon as possible, and change the current status quo of over-reliance on the development of heavy industry.

5.2. Improve Energy Utilization and Develop New Energy Sources

Coal, oil, and natural gas are non-renewable energy sources, and as mining technology improves, the amount of storage is decreasing. In order to alleviate the economic pressure caused by the scarcity of energy, we must improve the energy utilization rate so that each unit of energy can create the economic benefits of maximum profit. While improving the energy utilization rate, we must also devote ourselves to the development of new energy sources, which is not only a requirement of the international situation, but also a test made by the ecological environment to human beings.

5.3. Carry out Energy Conservation Campaigns to Raise National Awareness of Energy Conservation and Environmental Protection

With the progress of science and technology, people's quality of life is also improving, the demand for energy is also increasing, from 2000-2020 this twenty-one year period, the province's residential energy consumption from 4,940,900 tons of standard coal to 42,663,300 tons of standard coal, a linear growth, energy consumption is huge, therefore, we should call on residents to save energy, Therefore, we should call on residents to save energy, protect the environment, enhance residents' awareness of energy saving and environmental protection, vigorously promote the concept of energy saving, and carry out various energy saving activities to make the concept of energy saving and environmental protection deeply rooted in people's hearts.

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