

The Study of the Impact of Traditional Energy and New Energy Development on Economic Growth

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Abstract: Energy is a key driver of economic development. Given the dual pressures of the depletion of traditional energy and environmental issues, it is particularly important to explore the impact of energy and new energy on economic growth. This paper uses a univariate linear regression model, based on data from the National Bureau of Statistics of China from 2000 to 2022, to examine the effects of energy and new energy on economic growth. Robustness tests are conducted using per capita Gross Domestic Product (GDP) and the GDP index, while heterogeneity analysis is carried out by considering different time periods and methods of economic growth calculation. The findings of this study are as follows: 1. There is a positive correlation between energy, new energy, and economic growth. 2. The contribution of traditional energy to economic growth is more significant after the outbreak of the subprime mortgage crisis, while new energy had a greater impact on economic growth before the crisis. 3. Both traditional energy and new energy have the greatest impact on investment, followed by consumption, with the lowest impact on imports and exports. 4. Both traditional energy and new energy have the greatest influence on the service sector, followed by industry, with the least impact on agriculture. In every time period, and for every component of economic growth and every industry, the driving force of traditional energy exceeds that of new energy.

Keywords: Traditional energy development, new energy development, economic growth, linear regression

1. Introduction

Energy is the cornerstone of modern society, essential for driving urbanization, promoting commercial prosperity, and ensuring the normal functioning of basic social services. Without a stable and reliable energy supply, modern society would be paralyzed, and people's quality of life would plummet. However, in today's world, energy issues have become a global focus. As traditional energy sources gradually deplete and environmental problems become increasingly severe, new energy, with its sustainability, cleanliness, and immense development potential, has become a critical part of the future energy landscape, making its development and utilization especially vital. Forms of new energy such as solar, wind, water, and biomass energy not only help reduce dependence on fossil fuels, lower carbon emissions, and alleviate climate change pressure, but also inject new vitality into economic growth.

As outlined above, this paper will empirically analyze the impact of traditional energy and new energy on economic growth. With a clear understanding of China's current situation, the study uses

macroeconomic data from 2000 to 2022 and applies a univariate linear regression model, supplemented by robustness tests and heterogeneity analysis, to derive more comprehensive conclusions.

2. Literature review

The first stream of literature relevant to this study explores the relationship between regional energy and economic development. Chen Junhua and Zeng Qihong [1] empirically analyzed the dynamic equilibrium relationship between carbon emissions, energy consumption, and economic growth in Sichuan Province since the 21st century. Shao Minlan [2] used grey correlation analysis to examine the relationship between economic growth and energy consumption. Li Peng and Wang Lei [3] found that, overall, China's renewable energy exhibits a clear U-shaped relationship with industrial economic growth.

The second stream of literature relevant to this study examines the relationship between the new energy industry and economic development. Li Yanfeng [4] discussed the changes brought about by new energy development in energy intensity and economic growth. Tan Shan [5] delved into the direct and indirect impacts of the new energy industry on regional economic growth. Zhang Lingyun [6] explored the synergistic development strategies of new energy and coal power in regional economies. Wang Kai [7] revealed the advantages of new energy power generation in regional economic diversification and environmental sustainability. Zhao Yanli [8] pointed out that economic growth is more greatly influenced by new energy consumption. Gao Yuan [9] conducted empirical research showing that the development of new energy systems contributes to carbon reduction, alleviates environmental pressure, and promotes the advancement of the green economy.

The third stream of literature relevant to this study focuses on the relationship between energy transformation and economic development. Zhao Xinyu and Li Ningnan [10] proposed that changing the energy supply structure is key to transformation and will also affect economic growth. Zhang Jia [11] discussed the roles of old and new energy in China's economic transformation, emphasizing the importance of their integration.

Based on the above literature, this paper may contribute in the following four ways: First, the research topic includes new energy development, making it highly timely. It also covers energy development, thereby conducting a systematic and comprehensive study that enriches academic research on the relationship between China's energy development and economic growth. Second, in terms of research methodology, statistical tools are used to empirically analyze the hypothesis, with robustness tests discussing the baseline regression results, and heterogeneity analysis based on different time periods and methods of economic growth calculation, providing deeper insights into the impact of traditional energy and new energy on economic growth. Third, the study uses comprehensive and novel data, with a long time span covering China. Fourth, against the backdrop of China's rapid development in the 21st century, this paper analyzes the specific phenomena of China's energy and economic development, particularly focusing on China's unique domestic demand structure, which has important theoretical and practical significance and is likely to provide valuable experience for other developing countries in the world.

3. Key facts

Figure 1 shows the average daily coal consumption in China from 2000 to 2022. From Figure 1, it can be observed that: First, the average daily coal consumption increased from 2000 to 2013, with a sharp rise between 2009 and 2013. The main reason for this could be the increase in population and energy consumption. Second, after reaching a small peak around 2013, the average daily coal consumption started to decline, which may be due to China's energy structure adjustment,

environmental protection policies, and the promotion of clean energy. Third, the average daily coal consumption increased slowly from 2016 to 2022, likely due to the substitution of some coal usage by new energy sources.

Figure 2 shows the average daily natural gas consumption in China from 2000 to 2022. From Figure 2, it can be seen that the average daily natural gas consumption increased from 2000 to 2022, with a sharp rise between 2016 and 2022. This is likely due to China's energy structure adjustment, environmental protection policies, and the promotion of clean energy.

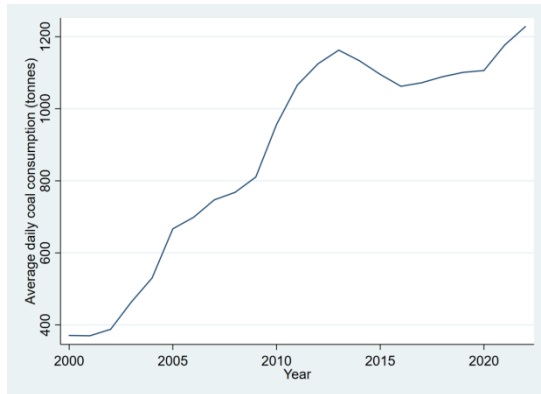


Figure 1: Average daily coal consumption in China

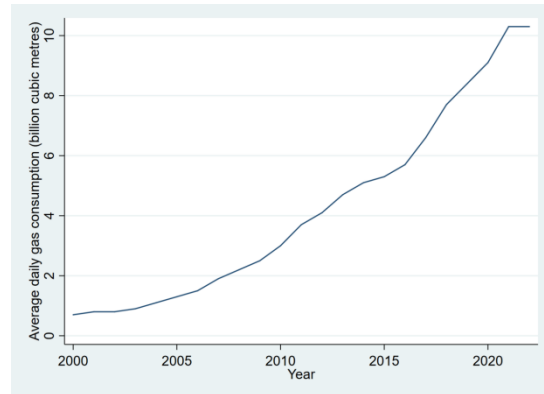


Figure 2: Average daily natural gas consumption in China

4. Research design

4.1. Variable selection

The dependent variable in this study is economic growth, with Gross Domestic Product (GDP) used as a proxy. The key independent variables are energy development level and new energy development level, measured by the national average daily coal consumption and the national average daily natural gas consumption, respectively. This study will use per capita GDP and the GDP index for robustness tests. Additionally, this study will conduct heterogeneity analysis of economic growth based on the expenditure approach, using final consumption, total capital formation, and net exports of goods and services. Heterogeneity analysis of economic growth based on the three industries will also be performed using the value added of the primary, secondary, and tertiary industries.

4.2. Data sources

The empirical analysis in this study focuses on China, with the observation period from 2000 to 2022. The sample data used in this study comes from the National Bureau of Statistics of China. The descriptive statistics of the data are presented in Table 1 below.

Table 1: Descriptive statistics analysis

Variable	Obs	Mean	Std.Dev.	Min	Max
Average Daily Coal Consumption (10,000 tons)	23	877.7	292.7	369.9	1228
Average Daily Natural Gas Consumption (billion cubic meters)	23	4.248	3.191	0.700	10.30
Gross Domestic Product (billion RMB)	23	540152	365051	101309	1.234e+06
Per Capita GDP (RMB)	23	39243	25511	8024	87385

Table 1: (continued).

GDP Index (1978 = 100%)	23	2399	1223	765.1	4525
Final Consumption (billion RMB)	23	293325	201957	64569	671804
Total Capital Formation (billion RMB)	23	232187	158128	34073	522679
Net Exports of Goods and Services (billion RMB)	23	14625	9453	2325	38931
Value Added of Primary Industry (billion RMB)	23	44729	23313	14717	88207
Value Added of Secondary Industry (billion RMB)	23	220345	133990	45664	467630
Value Added of Tertiary Industry (billion RMB)	23	275078	208928	40928	678193

4.3. Model design

The research model in this study is a univariate linear regression, as follows:

$$Y = \alpha X + \beta + \varepsilon \quad (1)$$

Where, Y is the dependent variable representing economic growth, X represents the core independent variables (energy development level and new energy development level), and ε is the random error term.

5. Empirical analysis

5.1. Correlation analysis

Figure 3 illustrates the relationship between economic growth and traditional energy. From Figure 3, it is clear that GDP increases with average daily coal consumption, indicating a positive correlation between the two. Specifically, when GDP is at a relatively low level, the growth rate of GDP increases slowly with the rise in coal consumption. As coal consumption continues to grow, the GDP growth rate accelerates, especially after coal consumption reaches a certain level, after which a slight decrease in coal consumption still results in GDP growth. Of course, the relationship between economic growth and traditional energy will be further confirmed through regression analysis in this study.

Figure 4 shows the relationship between economic growth and new energy. From Figure 4, it can be observed that GDP increases with the average daily natural gas consumption, indicating a positive correlation between the two. Specifically, when GDP is at a relatively low level, GDP grows at a faster rate with the increase in natural gas consumption. However, at higher GDP levels, the growth rate of GDP slows as natural gas consumption increases. As with traditional energy, the relationship between economic growth and new energy will also be further examined through regression analysis in this study.

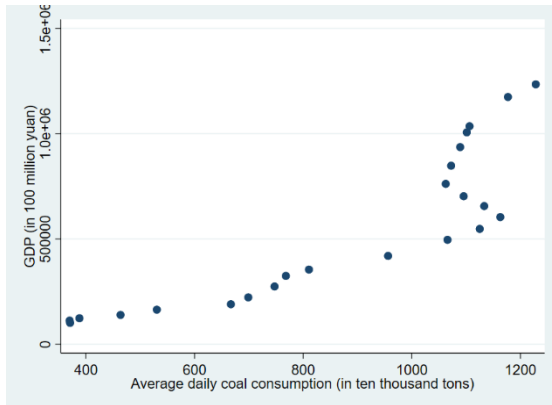


Figure 3: Correlation between economic growth and average daily coal consumption

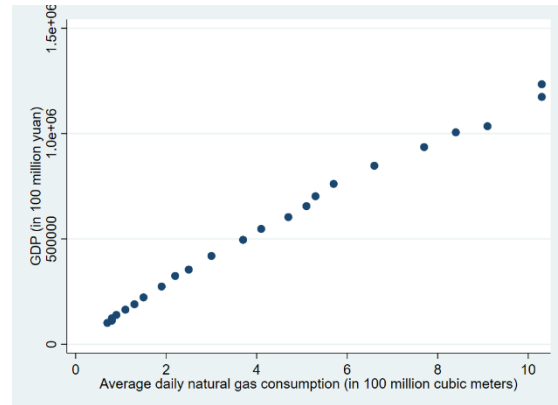


Figure 4: Correlation between economic growth and average daily natural gas consumption

5.2. Baseline regression

Table 2, Models (1) and (2) report the primary regression results regarding the impact of average daily coal consumption and average daily natural gas consumption on economic growth. Specifically, the estimated coefficients of the core explanatory variables in the models are 1.9124 and 0.9061, both significantly positive at the 1% significance level. The regression results preliminarily indicate that, in terms of economic growth, both traditional and new energy sources have a generally positive impact. However, traditional energy exerts a stronger driving effect on economic growth.

5.3. Robustness tests

To test the stability and reliability of the baseline regression results, this study replaces the measurement indicators for economic growth. Specifically, per capita GDP and the GDP index are used as substitutes for the core dependent variable GDP in the robustness analysis. The empirical results of Models (3), (4), (5), and (6) in Table 2 show that the impacts of traditional and new energy sources on economic growth remain significantly positive, confirming the robustness of the baseline model's conclusions.

Table 2: Baseline regression and robustness tests

	(1) Y	(2) Y	(3) Y	(4) Y	(5) Y	(6) Y
X	1.9124*** (13.9647)	0.9061*** (96.7857)	1.8292*** (14.1478)	0.8655*** (92.7264)	25.8843*** (7.6442)	13.3064*** (21.6392)
_cons	0.0940 (0.1021)	3.5720*** (36.8352)	-1.9470** (-2.2408)	1.3917*** (14.3951)	-149.6615*** (-6.5769)	-113.3432*** (-17.7953)
N	23	23	23	23	23	23
R2	0.9977	0.9978	0.9050	0.7356	0.9976	0.9571

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.4. Heterogeneity analysis

5.4.1. Temporal heterogeneity analysis

Based on data availability, this study selects the 2009 subprime mortgage crisis as a time node and divides the sample period into two time intervals for temporal heterogeneity analysis. Table 3, Models (1) and (2) report the regression results on the impact of traditional energy on economic growth from 2000–2009 and 2009–2022, with estimated coefficients of 1.2751 and 2.8101, respectively. Models (3) and (4) report the regression results on the impact of new energy on economic growth during the same periods, with estimated coefficients of 0.9913 and 0.8540, respectively. The results show that, at a 1% significance level, both traditional and new energy sources positively affect economic growth in both periods. The findings suggest that the growth-promoting effect of traditional energy was strongest in 2009–2022, slightly lower before the subprime mortgage crisis, while the impact of new energy was highest in 2000–2009 and slightly lower post-crisis. Regardless of the time period, traditional energy consistently had a greater impact on economic growth than new energy.

Table 3: Temporal heterogeneity analysis

	(1) 2000-2009	(2) 2009-2022	(3) 2000-2009	(4) 2009-2022
X	1.2751*** (10.0785)	2.8101*** (3.7833)	0.9913*** (34.0405)	0.8540*** (53.4356)
_cons	4.0389*** (5.0787)	-6.1388 (-1.1832)	2.7737*** (10.1749)	4.1432*** (23.6728)
N	9	14	9	14
R2	0.9355	0.5440	0.9940	0.9958

5.4.2. Heterogeneity analysis based on the expenditure approach

Using the expenditure approach, this study classifies economic growth into consumption, investment, and net exports for heterogeneity analysis. Table 4, Models (1), (2), and (3) report the effects of traditional energy on consumption, investment, and net exports, with estimated coefficients of 1.8046, 2.0906, and 1.6576, respectively. Models (4), (5), and (6) report the corresponding effects of new energy, with estimated coefficients of 0.8763, 0.9712, and 0.6625, respectively. All regression results are significantly positive at the 1% significance level. The findings indicate that both traditional and new energy sources have the strongest impact on investment, followed by consumption, with the lowest impact on net exports. However, traditional energy consistently exerts a greater effect than new energy across all economic growth components.

Table 4: Heterogeneity analysis based on the expenditure approach

	(1) Consumption	(2) Investment	(3) Import and Export	(4) Consumption	(5) Investment	(6) Import and Export
X	1.8046*** (11.2920)	2.0906*** (16.9155)	1.6576*** (6.3181)	0.8763*** (78.9232)	0.9712*** (44.9669)	0.6625*** (4.7248)
_cons	0.2136 (0.1989)	-1.9747** (-2.3776)	-1.7951 (-1.0182)	3.2764*** (28.4900)	2.0275*** (9.0634)	2.4878 (1.7131)
N	23	23	23	23	23	23
R2	0.8586	0.9316	0.6553	0.9966	0.9897	0.5153

5.4.3. Heterogeneity analysis of economic growth based on the three major industries

This study categorizes economic growth into agriculture, industry, and services, and conducts a heterogeneity analysis based on the three industries. Table 5 models (1), (2), and (3) report the impact of traditional energy on agriculture, industry, and services, with estimated coefficients for the explanatory variables being 1.3753, 1.7994, and 2.1287, respectively. Models (4), (5), and (6) report the impact of new energy on agriculture, industry, and services, with estimated coefficients for the explanatory variables being 0.6526, 0.8339, and 1.0217, respectively. The regression results are all significantly positive at the 1% level. The results indicate that both traditional and new energy have the greatest impact on the service sector, followed by industry, with the lowest impact on agriculture. Regardless of the industry type, the impact of traditional energy is always greater than that of new energy.

Table 5: Heterogeneity analysis of economic growth based on the three major industries

	(1) Agriculture	(2) Industry	(3) Service Industry	(4) Agriculture	(5) Industry	(6) Service Industry
X	1.3753*** (13.6357)	1.7994*** (17.5197)	2.1287*** (12.3875)	0.6526*** (71.9323)	0.8339*** (44.6085)	1.0217*** (95.6052)
_cons	1.3306* (1.9631)	0.0000 (0.0000)	-2.1050* (-1.8229)	3.8220*** (40.6729)	3.4654*** (17.8981)	1.6304*** (14.7286)
N	23	23	23	23	23	23
R2	0.8985	0.9360	0.8796	0.9960	0.9896	0.9977

6. Conclusion

Based on the empirical results above, this study concludes that both traditional and new energy exhibit a positive relationship with economic growth. In terms of different time periods, the contribution of traditional energy to economic growth is greater after the outbreak of the subprime mortgage crisis, while the contribution of new energy to economic growth was greater before the crisis. In terms of different methods of calculating economic growth, traditional and new energy have the greatest impact on investment, followed by consumption, with the lowest impact on imports and exports. Regarding economic growth based on the three major industries, traditional and new energy have the greatest impact on the service sector, followed by industry, with the lowest impact on agriculture. For any period of time and for any component of economic growth or industry, the impact of traditional energy is always greater than that of new energy.

The implications of the above conclusions are as follows: (1) Positive Relationship Between Traditional and New Energy and Economic Growth: Both traditional and new energy are important drivers of economic growth. The government should formulate a long-term and stable energy development strategy. On one hand, it should reasonably plan the extraction and use of traditional energy, increase support for the research and development of efficient and clean utilization technologies for traditional energy, improve the efficiency of traditional energy use, and ensure that it continues to play a stable role in economic growth. On the other hand, strong support should be given to the development of the new energy industry, including tax incentives, R&D subsidies, and other policy support, to accelerate the industrialization and popularization of new energy, increase its share in the energy structure, and promote green and sustainable economic growth. (2) Differences in the Contribution of Traditional and New Energy During Different Periods: Since the contributions of traditional and new energy to economic growth differ during different periods, the government should establish a dynamic energy monitoring and evaluation mechanism. During special periods, such as economic crises, energy policies should be flexibly adjusted according to the different impacts

of energy on economic growth. For example, after the subprime mortgage crisis, it is appropriate to increase policy support for the traditional energy sector to ensure its strong support for economic growth. Before the crisis, more focus could be placed on the innovative development of the new energy sector to maximize its contribution to economic growth at that time. (3) Industry Differences Based on Different Methods of Calculating Economic Growth: Given the differences in the impacts of traditional and new energy on industries depending on the method of calculating economic growth, the government should formulate targeted energy policies for specific industries. For economic growth based on the expenditure approach, traditional and new energy enterprises should be guided to increase their participation in investment, encourage them to develop innovative products and services in the consumer sector, and enhance the added value of energy products. (4) Promotion of Efficient Energy Use in the Service Sector and Other Industries: For economic growth based on the three major industries, efforts should be made to promote the efficient use of energy in the service sector, support technological innovation in energy within the industrial sector, and provide moderate support for energy applications in agriculture to promote balanced development across all industries.

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