"Carbon-Water" Coupling and Conversion of New and Old Kinetic Energy

--Based on the Empirical Research of Jiangsu Province

XU Long

School of Business, Hohai University, Changzhou, 213022, China

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Abstract: The conversion of new and old kinetic energy is an important driving force to promote economic development. The carbon and water problems in Jiangsu Province have seriously affected the conversion of new and old kinetic energy in Jiangsu Province. This article innovatively uses the coupling coordination degree model to explore the coupling degree and coordination degree between the three systems of "carbon-water-new and old kinetic energy" in Jiangsu Province, and provide a basis for future policy recommendations. The conclusions of the article are as follows: (1) Coordination degree is consistent with the change trend of coupling degree, and the influence of coupling degree between systems is mostly benign. In the process of "water" restraint, carbon consumption and emissions are the main factors affecting economic development.

1. Introduction

With the gradual disappearance of factor endowments and other issues, the development method that uses technology and talents as production factors has become the focus of development. Promoting the transformation of old kinetic energy and speeding up the conversion of new and old kinetic energy are of great significance to my country's economic development. Jiangsu Province is a large industrial province with a large economic aggregate, but Jiangsu's industry still has problems such as unreasonable structure. At this stage, the contradiction between overcapacity and resources and environment in Jiangsu is more prominent. Based on this, this study will take Jiangsu Province as an example to explore the conversion of new and old kinetic energy in Jiangsu Province.

Based on the CREE-EIE analysis framework, Huang Jianhuan et al. [1] explored the source of coordination and incoordination of the complex system of resources, environment, and economy (REE); Jiang Lei et al. [2] expanded the three-system coupling formula and provided feedback to China's provinces. Coordinated analysis of the three systems of resources, environment, and economy in the region; Yuan Qingmin et al. [3] studied the decoupling relationship and rebound effect between the economic growth level of Tianjin and resources and the environment, and explored the relationship between economic growth, resource input, and environmental pressure. On the whole, the existing literature mostly focuses on the interaction between integrated systems, but does not make in-depth research on the coupling state and degree of influence of a single system at a more micro level. Based on this, this research will build on the existing research. Deepen, determine the coupling state and the degree of coordination between systems, and provide more reasonable, scientific, and detailed research for economic development.

The innovations of this research are: 1. In the existing research, the conversion of old and new kinetic energy is mostly based on theoretical research, and the impact of the conversion between new and old kinetic energy is relatively small with data. Therefore, this research will couple from "carbon-water" The angle data quantifies its impact on the conversion of new and old kinetic energy. 2. The existing literature only analyzes the impact of each system from a macro perspective. This study will use "carbon-water" as a specific indicator system to measure its specific impact on the new and old kinetic energy systems.

2. Materials and Methods

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2.1 Research Method

In this study, the coefficient of variation method was used to determine the weight indexes of the different indicators of the three systems, and the coupling coordination degree model was used to study “carbon system-old and new kinetic energy system”, “water system-old and new kinetic energy system”, and “carbon system-water system-new and old kinetic energy system” “The correlation between the three different systems, and finally summarize the conclusions and put forward relevant suggestions, laying a data foundation for the research on the conversion of new and old kinetic energy in Jiangsu Province.

2.2 Data Sources

This research is based on the relevant index data of Jiangsu Province from 2007 to 2017. The data comes from the “Statistical Yearbook of Jiangsu Province”, “China Energy Statistical Yearbook”, data from the National Bureau of Statistics and relevant data from the CEADs website of China's carbon emission database.

2.3 Construction of Indicator System

This study will construct a coupling index evaluation system from eight dimensions and twenty-four indicators of the new and old kinetic energy systems, water systems, and carbon systems, and use the comprehensive development index and coupling coordination degree analysis model to analyze the “carbon-water” coupling the impact of Jiangsu's conversion of new and old kinetic energy.

Table 1 System Index Evaluation System

Subsystem	Dimension	Evaluation index	Unit	Weights
New and old kinetic energy	Economic strength	GDP	100 million yuan	0.171
		GDP per capita	Yuan / person	0.171
		The total retail sales of social consumer goods	100 million yuan	0.176
	Economic structure	Proportion of primary industry	%	0.127
		Proportion of secondary industry	%	0.184
		The proportion of tertiary industry	%	0.170
Water	Water supply	Total water supply	One hundred million cubic meters	0.099
		Total surface water supply	One hundred million cubic meters	0.099
		Total groundwater supply	One hundred million cubic meters	0.070
	Water utilization	Total water consumption	One hundred million cubic meters	0.073
		Total agricultural water	One hundred million cubic meters	0.010
		Total industrial water	One hundred million cubic meters	0.083
		Total domestic water	One hundred million cubic meters	0.055
		Total ecological water consumption	One hundred million cubic meters	0.047
		Water consumption per capita	Cubic meter/person	0.076
	Water pollution	Total industrial wastewater discharge	Ten thousand tons	0.097
		Total wastewater discharge	Ten thousand tons	0.097
	Water treatment	Completed investment in wastewater treatment project	Ten thousand yuan	0.106
Carbon	Carbon consumption	Total coal consumption	Ten thousand tons	0.219
		Total oil consumption	Ten thousand tons	0.153

		Total natural gas consumption	One hundred million cubic meters	0.094
	Carbon emission	Total carbon emissions	million tons	0.209
		Carbon dioxide emissions per unit of GDP	Tons/million yuan	0.112
		CO2 emissions per capita	Tons/person	0.214

3. Comprehensive Evaluation Index

3.1 Index Calculation

The comprehensive evaluation index is to calculate and transform multiple indicators into an indicator that can correct the overall development status anyway. First, the range standardization method is applied to the original data.

$$y_{ij} = \begin{cases} \dfrac{x_{ij} - min(x_{ij})}{max(x_{ij}) - min(x_{ij})} & (1) \\ \dfrac{max(x_{ij}) - x_{ij}}{max(x_{ij}) - min(x_{ij})} & (2) \end{cases}$$

(1) and (2) respectively represent the range standardization method for positive indicators and negative indicators. x_{ij} represents the original value of the j-th index in the i-th area, $min(x_{ij})$represents the minimum value of the index, and $max(x_{ij})$ represents the maximum value of the index value. Third, the index weight is determined by the coefficient of variation method. The specific formula of the coefficient of variation method is as follows:

$$V_{ij} = \frac{\sigma_{ij}}{\overline{y_{ij}}} \quad (3)$$

$$\mathrm{w_{ij}} = \frac{\mathrm{V_{ij}}}{\sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{V_{ij}}} \quad (4)$$

V_{ij} is the coefficient of variation, σ_{ij} is the standard deviation of the index value after standardization, $\overline{y_{ij}}$ is the average value of the index value after standardization, and w_{ij} is the weight corresponding to the index. The comprehensive evaluation index is calculated as formula (5).

$$S = \sum_{i=1}^{n} w_{ij} y_{ij} \ , \mathrm{i} = 1,2, \dots, \mathrm{n} \quad (5)$$

3.2 Result Analysis

Use the coefficient of variation method to obtain the comprehensive development index of each system in Jiangsu Province, as shown in Table 2.

Table 2 2007-2017 Comprehensive Development Index of Various Systems

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Kinetic energy	0.311	0.337	0.366	0.399	0.453	0.500	0.521	0.555	0.610	0.649	0.693
Water	0.441	0.512	0.461	0.379	0.474	0.434	0.451	0.424	0.367	0.435	0.403
Carbon	0.889	0.822	0.734	0.577	0.325	0.238	0.224	0.257	0.250	0.132	0.178

From 2007 to 2017, the old and new kinetic energy systems of Jiangsu Province were in a stage of steady growth, indicating that Jiangsu's economic development is in good shape; from 2007 to 2017, the overall development trend of the water system was relatively stable; from 2007 to 2017, the range of changes in Jiangsu's carbon emission system was relatively large Its development trend can be roughly divided into two stages: (1) From 2007 to 2012, the comprehensive development index of Jiangsu’s carbon system fell sharply. The reason is that Jiangsu’s industrial development is mainly based on the supply structure of energy such as carbon, and China’s industrial structure is heavy. The trend of globalization is obvious, which brings great pressure to the carbon system, resources and environment; (2) From 2012 to 2017, the carbon system was found to be relatively stable, which has a lot to do with the formulation of national economic policies. However, due to the constraints of the industrial structure, the growth of the carbon system index is not steadily advancing, but constantly improving in fluctuations. The overall trend shows that the problem of Jiangsu carbon emissions in the province has gradually improved.

It is worth noting that the changing trends among the three systems are not synchronized, and there is a certain degree of disorderly development in the development of the entire social system, which will limit the new and old kinetic energy systems, water resources, carbon emissions, and even the entire social system to achieve a higher degree of development. Based on this, this research explores the coupling state of the different systems between the three systems, reveals the main obstacles and contradictions in the conversion of new and old kinetic energy, and proposes more reasonable and feasible suggestions for the subsequent conversion of new and old kinetic energy, and speeds up the conversion of new and old kinetic energy in Jiangsu.

4. Coupling Coordination Degree Analysis

4.1 Coupling Coordination Degree Model

This study uses the research of Jiang Lei et al. [2] to calculate the coupling degree of three different systems: “carbon-new and old kinetic energy”, “water-new and old kinetic energy”, and “carbon-water-new and old kinetic energy”. The coupling degree model formula is as follows:

$$C_n = \left[\frac{U_1 \times U_2 \times \ldots \times U_n}{\left(\frac{U_1+U_2+\ldots+U_n}{n}\right)^n}\right]^{\frac{1}{n}} \quad (6)$$

C_n represents the coupling degree between systems, and U represents the comprehensive development index of each system. The larger the value of the coupling degree C_n, the better the coupling effect between systems. The expression formula of coupling coordination degree is as follows:

$$D = \sqrt{C \times T} \quad (7)$$

$$T = \alpha U_1 + \beta U_2 + \gamma U_3 \quad (8)$$

D is the degree of coupling coordination, T is the comprehensive development evaluation index of the composite system, α, β, γ are undetermined coefficients, and $+\beta + \gamma = 1$, When the systems are coupled in pairs, the two systems can be considered equally important, so $\alpha = \beta = 1/2$ when the three systems are coupled, the three can be considered to be equally important, so $\alpha = \beta = \gamma = 1/3$,The calculation results are shown in Table 3.

Table 3 Calculation Results Of Coupling Degree and Coordination Degree

Year		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
carbon-new and old kinetic energy	C_1	0.876	0.908	0.942	0.983	0.986	0.935	0.917	0.930	0.908	0.750	0.806
	T_1	0.725	0.725	0.720	0.693	0.619	0.587	0.584	0.615	0.625	0.541	0.593
water-new and old kinetic energy	C_2	0.985	0.979	0.993	0.999	0.999	0.998	0.997	0.991	0.969	0.980	0.964
	T_2	0.609	0.645	0.641	0.624	0.681	0.683	0.696	0.696	0.688	0.729	0.727
carbon-water-new and old kinetic energy	C_3	0.907	0.936	0.958	0.982	0.987	0.953	0.940	0.953	0.935	0.824	0.866
	T_3	0.704	0.722	0.706	0.666	0.642	0.610	0.612	0.627	0.618	0.578	0.606

4.2 Analysis of Coupling Degree

Coupling degree analysis is used to reveal the degree of interaction between systems. The better the degree of coupling between systems, the higher the operating efficiency will be. On the contrary, the low degree of coupling between systems may cause the system to stagnate and regress.

From 2007 to 2017, at this time the “carbon-new and old kinetic energy” system was in the running-in stage and the high-level coupling stage [4], indicating that carbon is highly correlated with economic development at this stage. The degree of coupling can be significantly divided into three changing cycles. From 2007 to 2011, the trend of coupling degree showed an upward trend; from 2012 to 2015, the trend of coupling degree declined slowly, but it was still in a high level of coupling; from 2016 to 2017, the degree of coupling Realize the transition from high-level coupling to the running-in stage. In recent years, my country’s development and utilization of clean energy will have a certain degree of influence on the coupling degree of “carbon-new and old kinetic energy”, and with the requirements of high-quality sustainable development, the impact of carbon emissions on the economy will be gradually reduced.

From 2007 to 2017, the fluctuation range of the coupling degree of the “water-new and old kinetic energy” system in Jiangsu Province was relatively small, and the interaction between the two was relatively stable, and it was in a high-level coupling stage.

From 2007 to 2017, the coupling degree of the “carbon-water-new and old kinetic energy” system in Jiangsu Province was in a high-level coupling stage, indicating that the degree of interaction between the “carbon-water” and the economic development of Jiangsu Province is relatively high. The coupling of the three systems and the two systems Comparing the degrees, it can be found that the economic development of Jiangsu Province is more affected by carbon.

4.3 Coordination Analysis

Since coupling analysis can only prove the degree of interaction between systems, but cannot reveal the size of benign coupling between systems, therefore, the concept of coordination analysis is introduced. Through coordination analysis, it can be known that different systems are at a high level. Mutual promotion state or low-level mutual restraint state [5].

From 2007 to 2017, the “carbon-new and old kinetic energy” system in Jiangsu Province was in a highly coordinated stage, [4] and it realized the transition from intermediate coordinated development to barely coordinated development. [6] The main reason is that with the upgrading of the industrial structure, the utilization of resources such as coal and crude oil by enterprises will decrease to a certain extent, and the proportion of energy such as coal in the economic development trend will decrease.

From 2007 to 2017, the “water-new and old kinetic energy” system in Jiangsu Province was in a highly coordinated stage, realizing the transition from primary coordinated development to intermediate coordinated development, that is, water resources have more positive effects on economic development. With the improvement of the utilization rate of water resources and the maturity and popularization of water pollution treatment technologies, the positive impact of water resources on the entire new and old kinetic energy system continues to increase. Therefore, Jiangsu Province can continue to continue the original water resources related policies and increase water pollution. The degree of protection of resources promotes its benign contributions.

From 2007 to 2017, the “carbon-water-new and old kinetic energy” system in Jiangsu Province was in a highly coordinated stage, achieving the transition from intermediate-primary-reluctantly coordinated development, and the benign coupling continued to decrease. Moreover, the development trend of the “carbon-water-new and old kinetic energy” system is similar to that of the “carbon-new and old kinetic energy” system, indicating that carbon emissions have a greater impact in the system, but the trend is even more developed when the positive impact of water resources is reconciled. gentle.

5. Summary and Discussion

The paper uses the data of the three systems of carbon, water, new and old kinetic energy in Jiangsu Province from 2007 to 2017 to carry out coupling and coordination calculations to study the overall state of coupling and coordination between systems. The conclusions are as follows:

(1) The change trend of coordination degree and coupling degree is consistent, and the influence of coupling degree between systems is mostly benign. And when the two systems are coupled, the values are relatively close. The reason is that when the factors in the system increase, the degree of its comprehensive negative impact will also increase. Therefore, for large industrial enterprises and manufacturing enterprises, the carbon and water balance should be done well. Promote the transformation and upgrading of the industry.

(2) The coupling and coordination degree of “water-new and old kinetic energy” system is on an upward development trend, and the coupling and coordination trends of “carbon-new and old kinetic energy” and “carbon-water-new and old kinetic energy” are consistent, and taking 2016 as

the turning point, the degree of coupling has shown an upward trend, indicating that carbon consumption and emissions are the main factors affecting economic development. In the subsequent phase of the conversion of new and old kinetic energy, the government and enterprises should pay more their attention to carbon emissions and ecosystem, and take more stringent governance measures.

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