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Research on the comprehensive Efficiency Evaluation and Spatial Effect of New Green Dynamic Energy in China

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Abstract: Due to regional differences, different parts of the country attach different importance to green development, resulting in different measures and effects. In order to comprehensively and directly evaluate the benefits of new green kinetic energy and compare and analyze between different regions, this paper studies the measurement and influencing factors of new green kinetic energy. Based on the panel data of 31 provinces in China from 2010 to 2019, this paper first uses the entropy weight method to measure the score of new green kinetic energy and discusses its spatio-temporal evolution; Then, the spatial econometric panel model is used to explore the influencing factors of the new kinetic energy effect of green development in China's provinces. The results show that: (1) The amount of comprehensive utilization of industrial solid waste per unit and the amount of completed investment in industrial pollution control per unit played an important role in the new momentum of development;(2) Different provinces have different grades of green scores, which leads to regional differences. Most of the lower scores are in northwest China;(3) The number of research and test developers per unit of GDP, the number of high-tech enterprises per unit of GDP, and the reduction rate of energy consumption per unit of GDP play a negative role in the development of new green kinetic energy scores, while the increase rate of the secondary industry plays a positive role. This paper measures the new green kinetic energy from the aspects of environmental protection and green production and consumption. On this basis, the spatial effect is included in the analysis framework of the influencing factors of the new green kinetic energy, and the spatial econometric model is used to explore the mechanism of the new green kinetic energy. There is some innovation in research perspectives and methods.

Keywords: Green new kinetic energy score, Statistical measure, Influencing factors, Spatial econometric model.

1. Introduction

1.1. Background and significance of the study

New green kinetic energy is the main driving force to stimulate and maintain green development. Cultivating new green development momentum is an effective grip to crack the main social contradiction in the new era, and a driving force to stimulate and maintain green development. In 2016-2021, Nanchong County, Sichuan Province has implemented a total of 143 green low-carbon projects with a total investment of over 100 billion yuan; while the Yangtze River Delta region accounted for 25% of the increase in national industrial capacity in 2018, of which the market share of new energy vehicles accounted for 1/3 of the country.

China's vast territory, the development of new green dynamic energy varies from region to region, and it becomes our concern how to evaluate the effect of developing new green dynamic energy and timely adjust the measures according to the effect to increase the development speed. Therefore, it is of theoretical and practical significance to study the scoring system for the development of new green dynamic energy in China. On the one hand, it is important to establish a preliminary green new kinetic energy evaluation system to explore different development methods and promote the development of green new kinetic energy in green development; on the other hand, after the initial test of this evaluation system in all parts of the country, it can put forward targeted suggestions according to the differences of resource endowment of regions, which is important to promote the development of green new kinetic energy in China and achieve common prosperity.

1.2. Current status of domestic and international research

1.2.1. Research on the development perspective of new green dynamic energy

Most scholars take the green economic effect as the research direction, the essence of which is the development effect of new green kinetic energy. Tu Zhengge proposed in 1998-2005 that China's accelerated growth of green productivity is the core driving force of industrial growth and pollution reduction. China issued some green standards, but the evaluation standards mainly in pollution prevention and control, resource conservation and green consumption, the green development system has more room for soundness. Yuan Xi and Wu Lihua et al. compare and judge the changes in green efficiency of 285 prefecture-level cities in China, and then assess the impact of the three national regional development strategies on them.

1.2.2. The development of new green dynamic energy lacks a unified standard evaluation system

Some foreign countries attach great importance to green development standards, such as the German Manufacturing 4.0 program, the U.S. National Strategic Plan for Advanced Manufacturing, and the U.K. Industry 2050 strategy. Zhang Yunshu et al. (2019) constructed a green governance capacity evaluation index system from three perspectives: green governance input, green governance efficiency, environmental rule of law and regulatory status. In summary, most scholars base their research on green economic effects, mainly including its influencing factors and evaluation indicators. And there are few researches on new green dynamic energy and its influencing factors and so on.

Therefore, this paper explores the new green dynamics score and its influencing factors in China based on entropy value method and spatial econometric model.

1.3. Research ideas

Part I: Determining factors and finding data. According to the relevant literature such as Zhiwang and Baidu Academic, specific indicators were selected from two aspects of green production and consumption and environmental protection: the amount of wastewater generated per unit of GDP, the forest coverage rate, and the intensity of completed investment in industrial pollution control. Then, the data of each province from 2010-2019 were standardized by finding accurate data from the National Bureau of Statistics and other websites, excluding the data in years with abnormal fluctuations due to the impact of epidemics.

The second part: the entropy method was applied to obtain the weighting scores. The entropy value method is used to assign weights to them with a certain proportion to get the scores of each province in the last ten years. And the temporal and spatial descriptive analysis is performed based on their scores.

Part III: Conducting spatial exploratory analysis. Because traditional measurement methods require elements to be independent of each other and cannot be used, this paper adopts spatial measurement methods and conducts spatial exploratory analysis.

Part IV: Model building. The model is established according to the least squares method, and the paper conducts Hausman test and LM test on the selected indicators to ensure that the results of the model are correct. After the model establishment is completed, the model robustness test is conducted again for prudence reasons.

Part V: Drawing conclusions and recommendations. Based on the above analysis, it is found that different provinces have different green new dynamics score levels and thus regional variability.

1.4. Innovations and shortcomings

1.4.1. Innovation point

1. Starting from the perspective of green production and consumption and environmental protection, we evaluate the development of new green dynamic energy in China in a more comprehensive way.

2. The measurement of new green dynamics is comprehensive. This paper measures and measures the new green dynamic energy in terms of environmental protection and green production and consumption, and the indicators are reasonably chosen and the data are scientific.

3. The application of the theoretical principles of the panel model to the practice of energy conservation and emission reduction is logically clear.

1.4.2. Shortcomings

This study only measures air pollution equivalence emissions based on total sulfur dioxide emissions, total nitrogen oxide emissions, and total smoke (dust) emissions in the air, and includes them in the analytical framework of green new dynamics to analyze the impact of environmental pollution and green new dynamics development, which has certain shortcomings. For example, emissions from burning coal or oil from major contemporary means of transportation, such as automobiles, trains, airplanes, and ships, are also important pollutants. In particular, the exhaust gases emitted by cars in cities are mainly carbon monoxide, sulfur dioxide, and nitrogen oxides and hydrocarbons etc., which become one of the main sources of air pollution in large cities.

2. Description of Symbols

Table 1. Description of symbols

Symbols	Symbol Description
X1	Research and experimental development (R&D) personnel per unit of GDP (persons/billion yuan)
X2	Education Expenditure Rate
X3	Number of high-tech enterprises per unit GDP (pcs/billion yuan)
X4	Research and experimental development investment intensity rate
X5	Energy consumption reduction rate per unit of GDP
X6	Secondary industry increase ratio
Y	New Green Momentum Score
x'_{ij}	Value of normalized index
y_{ij}	Proportion of the jth option for the i-th factor
m	Number of influencing factors considered
S_i	Score of the i-th influencing factor

3. Research Methodology and Data Sources

3.1. Research Methodology

3.1.1. Literature analysis method

The research progress of green new kinetic energy measurement at home and abroad is sorted out from statistical measurement of green new kinetic energy, factors affecting green new kinetic energy, and spatial measurement research of green new kinetic energy efficiency, in an attempt to map out the current research status of scholars on green new kinetic energy efficiency and provide scientific basis and lay theoretical foundation for the construction of national green new kinetic energy evaluation system.

3.1.2. Spatial econometric model

Traditional econometrics ignores the geospatial element, which can cause bias and unscientific model calculation results. Since the development of new green dynamics is strongly dependent on natural conditions and the neighboring urban areas are highly similar, the development of new green dynamics is not only influenced by the influencing factors within its own region, but also by the spatial spillover effects of neighboring areas. In this study, based on the full consideration of the spatial effects of new green dynamics at the national scale, a spatial econometric model is used to analyze its influencing factors.

3.2. Data sources

The data used in this study mainly include: statistical data related to green development in each province, data from domestic and foreign journal literature, and its data sources mainly include the following two aspects.

3.2.1. 2010-2019 panel data related to green development by province

The data are obtained from China Environment Database, China Energy Database, Beijing Statistical Yearbook, Shanghai Statistical Yearbook, Poyang Lake Ecological Economic Zone Statistical Yearbook, Hebei Statistical Yearbook, Anhui Statistical Yearbook, Jiangsu Statistical Yearbook, Zhejiang Statistical Yearbook, and other publicly available statistics in China in the relevant years, and some data are calculated based on the yearbook data. The spatial data are derived from the 1:1.5 million vector data provided by the National Basic Geographic Information Data Center.

3.2.2. Domestic and international journal literature data

We provide reference information for this study by downloading relevant authoritative journals and academic papers through websites such as China Knowledge Network, Baidu Academic, and Veep Journals.

3.3. Green New Dynamic Score Data Detection and Processing

3.3.1. Vacancy data processing

In this paper, we mainly use mean and time series models to fill in the missing data. For the data of the few missing years in the middle, the method of finding the mean value is used to take the data of the indicator of the two adjacent years and find the mean value to fill the vacant data; for the data of the more backward and missing years, this paper uses the time series model to predict the vacant data, and the general form of the model is shown in the following equation:

$$Y_t = c + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \epsilon_t + \beta_1 \epsilon_{t-1} + \ldots + \beta_q \epsilon_{t-p}$$

A smoothness test is performed to transform the time series that do not satisfy the smoothness of the time series by differential variation or log-differential variation into a smooth series, followed by the construction of an ARIMA model for the smooth time series and forecasting.

3.3.2. Data normalization process

For positive indicators:

$$x'_{ij} = \frac{\max(X_{1j}, X_{nj}, \ldots, X_{nj}) - X_{ij}}{\max(X_{1j}, X_{nj}, \ldots, X_{nj}) - \min(X_{1j}, X_{nj}, \ldots, X_{nj})}$$

For negative indicators:

$$x'_{ij} = \frac{\max(X_{1j}, X_{nj}, \ldots, X_{nj}) - X_{ij}}{\max(X_{1j}, X_{nj}, \ldots, X_{nj}) - \min(X_{1j}, X_{nj}, \ldots, X_{nj})}$$

4. Quantitative Study of The New Green Dynamics Score

4.1. The selection of new green dynamic energy indicators

In his study on the distinctive features and connotations of new green development dynamics compared with traditional development paths, Shao Mingzhen selected greening coverage of built-up areas, energy consumption per unit GDP, industrial wastewater emissions per billion GDP, industrial carbon dioxide emissions per billion GDP, and industrial dust emissions per billion GDP as indicators of green development. Yuan Xi evaluated the impact of three national regional development strategies on the green growth of urban economy and found that the "Belt and Road" and Yangtze River Economic Belt development strategies showed significant growth effects on green GDP. Wang Wanjing et al. constructed a green city construction evaluation index system by selecting 26 indicators from four aspects: transformation development, social construction, resource utilization and environmental protection, and evaluated Nanjing's urban development and proposed improvement methods for the 12th Five-Year Plan construction.

In this chapter, based on the data envelopment analysis and combined with the relevant studies of current domestic and foreign scholars, ten categories of indicators are to be selected: centralized treatment of sewage treatment plants (%), per capita park green area (m2), forest coverage rate (%), comprehensive utilization of industrial solid waste per unit (10,000 tons/billion yuan), completed investment in industrial pollution control per unit (billion yuan/billion yuan), sulfur dioxide emission per unit GDP (tons/billion yuan), unit GDP wastewater emissions (tons / billion yuan), unit industrial solid waste generation (tons / billion yuan), unit total nitrogen oxide emissions (tons / billion yuan), unit total smoke (dust) emissions (tons / billion yuan).

4.2. Green New Dynamic Score Indicator Assignment

In order to ensure the objectivity and scientificity of the final measurement results of the Green New Dynamic Score Index, this paper adopts the entropy value method to determine the weights. The smaller the entropy value, the greater the degree of dispersion of the index, indicating the greater the influence of the index. The steps are:

1. the proportion of the jth option of the i-th factor$_{ij}$ is

$$y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}}$$

where m is the number of influencing factors considered.

$$e_j = -K \sum_{i=1}^{m} y_{ij} \ln y_{ij}$$

$$K = \frac{1}{\ln m}$$

where K=$^1/_{\ln m,}$, K is a constant.

2. Weighting each factor to obtain the score of the ith influencing factorS_i ,for

$$S_i = \sum_{j=1}^{n} y_{ij} w_j$$

3. According to the score of each influencing factor, the importance ranking of all factors can be obtained. The following table is obtained.

Table1. The weight of each indicator in the new green dynamic energy index system

	Information entropy value	Information utility value d	Weights
Centralized treatment in sewage treatment plants (%)	0.997	0.003	0.015
Park green space per capita (square meters)	0.984	0.016	0.071
Forest cover (%)	0.959	0.041	0.185
Unit industrial solid waste comprehensive utilization (tons / billion yuan)	0.907	0.093	0.420
Unit industrial pollution control completed investment (billion yuan / billion yuan)	0.950	0.050	0.226
Sulfur dioxide emissions per unit of GDP (tons/billion yuan)	0.997	0.003	0.016
Wastewater emissions per unit of GDP (million tons/billion yuan)	0.998	0.002	0.010
Unit industrial solid waste generation (tons / billion yuan)	0.997	0.003	0.014
Total unit NOx emissions (tons/billion yuan)	0.998	0.002	0.010
Total unit smoke (dust) emissions(milliontons/billion yuan)	0.993	0.007	0.032

4.3. The construction of new green dynamic energy score evaluation system

Functional model: $Y_j = S_1x_{1j} + S_2x_{2j} + \ldots + S_ix_{ij}$

4.4. Results and analysis of new green dynamic energy scores

4.4.1. Analysis of the new green dynamics score based on the time dimension

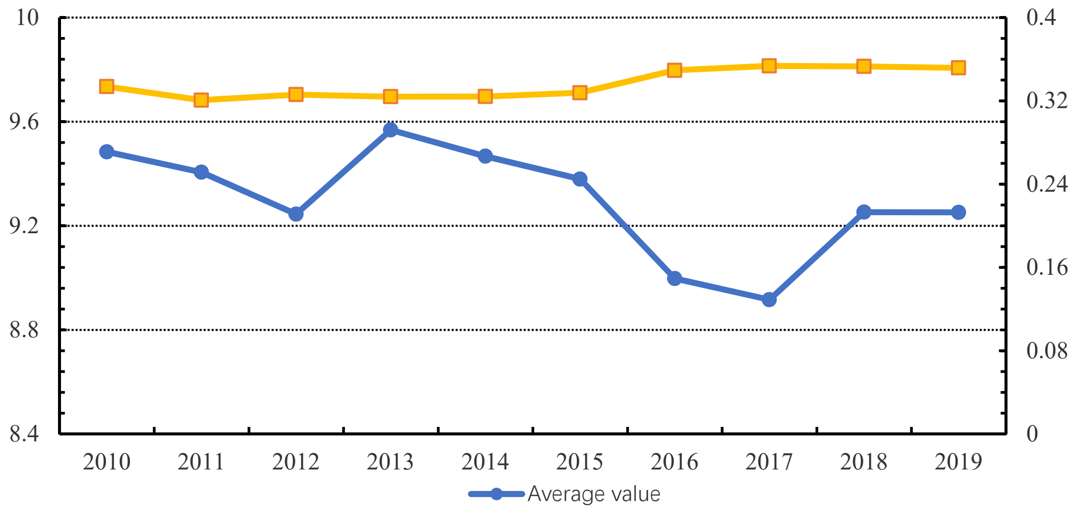

Figure1. Chronological evolution of China's new green dynamics score, 2010-2019

In terms of the mean value of the Green New Momentum Score, the mean value between 2010 and 2019 is 9.296698, with the highest mean value in 2013 at 9.56804; followed by 2010 with its mean Green New Momentum Score of 9.484244; the smallest mean value of the Green New Momentum Score in 2017 at 8.91602; followed by 2016, with 8.99755.

In terms of the coefficient of variation of the green new dynamic score, the largest value of the coefficient of variation of the green new dynamic score was 0.35361 in 2017, followed by 0.353111 in 2018; the smallest value of the coefficient of variation was 0.32068 in 2011, followed by 0.324019 in 2013.

From the trends of the mean and coefficient of variation of the new green dynamics score, we can see that the coefficient of variation is relatively stable, all between 0.32-0.36, with basically no significant fluctuations, except for a significant increase in the coefficient of variation between 2015-2016, from 0.327814 to 0.349364; while the mean value has changed a lot in the last decade, generally showing a fluctuating decline followed by a fluctuating up, with a continuous decline between 2013-2017 and a fluctuating increase after 2017. From 2010 to 2012, the mean value of green new dynamics score decreases, and the coefficient of variation fluctuates down and then fluctuates up, indicating that the difference of green new dynamics score generally narrows and then widens from year to year; from 2013 to 2017, the mean value of green new dynamics score keeps decreasing and the coefficient of variation fluctuates up, indicating that the difference of green new dynamics score generally narrows and then widens from year to year. The coefficient of variation fluctuates and rises from 2013 to 2017, indicating that the difference between the scores of green new dynamics in each year is generally expanding.

4.4.2. Analysis of new green dynamics score based on spatial dimension

As can be seen from the figure, from 2010-2019, there is not much change in the new green dynamics scores of the provinces. Most of the lower scores are in the northwest region, containing provinces: Xinjiang, Tibet, Qinghai, Gansu, and Jiangsu; the next highest scores are in northern China, containing provinces: Inner Mongolia, Shanxi, Hebei, Shandong, Henan, and Anhui; the new green dynamics scores in the central region and the eastern provinces are in the middle gradient, containing provinces: Sichuan, Shaanxi, Hebei, Jilin, and Liaoning; most of the better scores are in the southern and eastern provinces, also contains a special case of Heilongjiang.

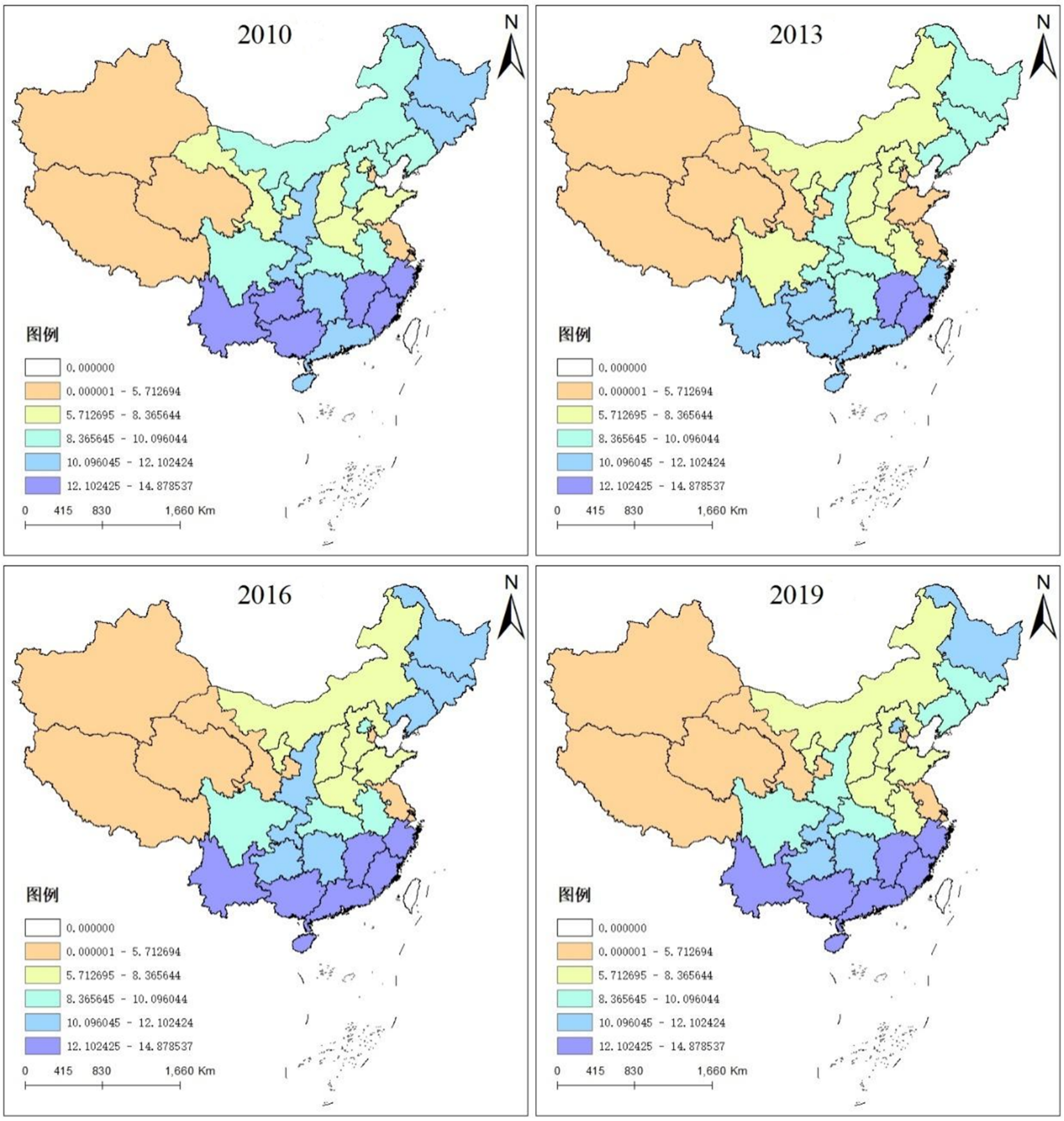

Figure2. Evolution of the spatial pattern of new green dynamics score in China, 2010-2019

The traditional measurement method requires its factors to be independent of each other, while it is known from the first law of geography of spatial economics that there is mutual influence between arbitrary attributes, but the attributes of things that are closer together are more relevant than those that are farther away. Based on this, in the following, spatial factors are incorporated into the analysis framework of the influencing factors of green new dynamics score, and the spatial econometric model is used to explore the reasons affecting the change of green new dynamics score in China.

5. Model Building and Parameter Estimation

5.1. Spatial autocorrelation test

First, this paper uses the spatial exploratory analysis approach (ESDA) to test whether there is a spatial effect from the perspective of global spatial autocorrelation and local spatial autocorrelation.

5.1.1. Global spatial autocorrelation

Before building the model, test whether the spatial correlation is significant. When the effect of spatial effects is obvious, it is necessary to take spatial effects into account. Here, Moran's I index is used to test the presence of spatial effects, defined as follows:

$$\text{Moran's I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(Y_i - \bar{Y})(Y_j - \bar{Y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}$$

$$S^2 = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y})$$

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i$$

where Y_i denotes the observation of the ith region, n is the total number of regions, and W_{ij} is the matrix of neighboring spatial weights, which indicates the relative distant relationship in space. The test statistic of Moran index is Z. When it is greater than the critical value, it indicates that the regional behavior has a significant positive correlation in spatial distribution, i.e., there is a cluster phenomenon in the neighboring regions.

Table 3 indicates the global Moran's I index of China's new green dynamics score from 2010-2019. The global Moran's I index reflects the degree of spatial autocorrelation, and the larger the absolute value of Moran's I indicates the stronger spatial correlation. From this table, we can see that its value is greater than zero and passes the significance test, which means that the green new dynamics scores among provinces are spatially positively correlated and there is a spatial clustering effect of green new dynamics scores among provinces.

Table 3. Global Moran's I Index for China's new green dynamics score,2010-2019

Year	Moran' I	mean	sd	p
2010	0.4704	-0.037	0.1155	0.001
2011	0.4436	-0.0335	0.1071	0.001
2012	0.4546	-0.0338	0.1148	0.001
2013	0.4565	-0.0328	0.1157	0.001
2014	0.4614	-0.0334	0.1126	0.001
2015	0.4678	-0.0392	0.1168	0.001
2016	0.4813	-0.0323	0.1186	0.001
2017	0.4836	-0.0362	0.1168	0.001
2018	0.4811	-0.0352	0.11125	0.001
2019	0.4804	-0.0346	0.1166	0.001

5.1.2. Local spatial autocorrelation

Local spatial autocorrelation describes the degree of similarity between a region and its neighboring regions, and the global Moran's I index based on the Queen's weight matrix for the provinces of the country in 2010, 2013, 2016, and 2019 are 0.4704, 0.4565, 0.4813, and 0.4804, respectively, thus suggesting that there may be a positive spatial correlation.

5.2. Spatial modeling

5.2.1. Data index selection

Regarding the selection of variable indicators, mainly referring to the literature such as Tai De-jin (2020), Song De-yong and Xu Ao-lin (2022), as well as combining China's regions on the perception of new green dynamics, etc., it is considered that the possible factors affecting the new green dynamics score are: research and experimental development (R&D) personnel per unit GDP (persons/billion yuan), education expenditure ratio, number of high-tech enterprises per unit GDP (pcs/billion yuan), research and experimental development expenditure intensity rate, energy consumption reduction rate per unit GDP, and secondary industry increase rate.

5.2.2. Variable Check

Table 4. Multicollinearity test

	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	-0.3349	1					
X3	0.6456	-0.4148	1				
X4	0.8919	-0.2395	0.4577	1			
X5	0.1855	-0.168	0.2035	0.1038	1		
X6	-0.1131	-0.3995	0.1787	-0.3435	0.1833	1	

In order to avoid distortion of the model estimation due to high correlation between the explanatory variables, the explanatory variables were tested for multicollinearity. The results are shown in Table 4, where the correlation coefficient between research and experimental development (R&D) personnel per unit of GDP (person/billion yuan) and research and experimental development funding intensity rate is the largest at 0.8919. The final removal of the research and experimental development funding intensity rate as an influencing factor.

5.2.3. Variable relationship processing - spatial weight matrix

Among the three common geographical weights, this paper uses the contiguity index to represent the spatial weight matrix. If region i and region j are not adjacent to each other, then $W_{ij} = 0$; conversely, then $W_{ij} = 1$.

$$W_{ij} = \begin{cases} 0 \text{ If Region i and Region j are not adjacenti} \\ 1 \text{ If Region i and Region j are adjacent} \end{cases}$$

The adjacency can be divided into the following three types: car adjacency, elephant adjacency, and post-adjacency (Chen Qiang, 2017). In order to more reasonably reflect the spatial association patterns among provinces, the W_{ij} standardization process is carried out.

5.2.4. Spatial panel measures Model selection

Spatial panel econometric models can be classified accordingly: spatial panel autoregressive models, spatial panel error models, and spatial Durbin models.

Before conducting the impact factor analysis, a suitable model needs to be selected. The suitability test of the model is mainly divided into two parts: one is to judge whether to use a fixed-effects model or a random-effects model; the other is to judge whether to use a spatial panel autoregressive model or a spatial panel error model.

1. Choice of fixed-effects model and random-effects model

The results of Hausman's test showed a significant difference in coefficient estimates between fixed effects and random effects, so that fixed effects are better than random effects.

2. Selection of spatial panel autoregressive model and spatial panel error model

Regression was performed using traditional OLS to test the spatial correlation of residuals and analyze the significance of LMSAR and LMSEM. If neither was significant, the traditional least squares method was used.

Table 5. Tests of two econometric models based on fixed effects

Models	Test	Statistic	df	p-value
SAR	Moran's I	4.735	1	0.000
	L MSAR	18.806	1	0.000
	Robust LMSAR	22.005	1	0.000
SER	LMSEM	47.787	1	0.000
	Robust LSEM	50.985	1	0.000

The results are presented in Table 5, which lists the results of Moran'sI index, Lagrange multipliers of residuals and their robustness tests for the SAR model and SEM model of green new momentum score.SDM is compared with SAR or with SEM and found to be significantly significant, i.e., SDM model is more superior than SAR and SEM models. Therefore, this paper will use fixed-effects-based spatial Durbin model for the analysis of factors influencing the green new dynamics score.

5.2.5. Spatial panel model estimation results

The regression results in Table 6 show the estimation results of the green new momentum score based on the spatial adjacency weight matrix. Models 1, 2, 3, and 4 are based on no fixed effects, individual fixed effects, time fixed effects, and two-way fixed effects for the spatial panel, respectively.

Table 6. Spatial econometric estimation results of green new dynamics score based on SDM model

Variables	Model 1 No fixed effects		Model 2 Individual fixed effects		Model 3 Time fixed effects		Model 4 Two-way fixed effect	
	Regression coefficient	T-value	Regression coefficient	T-value	Regression coefficient	T-value	Regression coefficient	T-value
x1	-0.113***	-2.82	-0.113***	-2.82	-0.101	-1.31	-0.110***	-2.83
x2	-2.234	-0.44	-2.234	-0.44	-15.56	-1.59	-0.0593	-0.01
x3	-2.385***	-5.92	-2.385***	-5.92	-2.211	-0.22	-2.462***	-6.36
x5	-0.958*	-1.9	-0.958*	-1.9	1.45	0.57	-0.673	-1.37
x6	2.158**	2.55	2.158**	2.55	0.817	0.35	1.720*	1.93
Rho	0.341***		0.341***		0.323***		0.0409	
R-squared	0. 1580		0. 1580		0.1530		0.1410	
AIC	348.1454		348.1454		1433.39		317.2589	
BIC	392.9843		392.9843		1478.229		362.0978	

Note: ***, **, * indicate passing significance test at 1%, 5%, 10% level.

In terms of regression coefficients, most of the regression coefficients of the explanatory variables in model 2 pass the significance test, and in general, model 2 is better than models 3 and 4. model 1 assumes the same level of green new dynamics score among provinces, ignoring the regional differences in green new dynamics score; model 3 takes into account the effect of time, but ignores the effect of regional differences, making the results show different degrees of bias; model 4 takes into account the effect of time and regional differences in green new dynamics score. From the above analysis, it is clear that the spatial Durbin model with individual fixed effects is more appropriate.

5.2.6. Robustness test

Since the specific interactions of green new dynamics scores among provinces are not known, robustness tests are needed. In this paper, the robustness is determined by varying the selection of indicators to examine the sign and significance of the regression coefficients of the influencing factors. The research and experimental development (R&D) personnel per unit of GDP (person/billion) is analyzed by replacing the research and experimental development (R&D) personnel per unit of GDP with the research and experimental development (R & D) investment intensity rate.

Table 7. Robustness test results of the green new dynamics score based on spatial fixed effects

Variables	Model 1 Individual fixed effects		Model 2 Robustness tests	
	Regression coefficient	T-value	Regression coefficient	T-value
x1	-0.113***	-2.82	-	-
x2	-2.234	-0.44	-6.641	-1.27
x3	-2.385***	-5.92	-2.690***	-6.5
x5	-0.958*	-1.90	-0.824	1.03
x6	2.158**	2.55	2.752***	-1.61
x4	-	-	1.969	3.19
rho	0.341***		0.337***	
R-squared	0.1580		0.053	
AIC	348.1454		369.3807	
BIC	392.9843		414.2196	

Note: ***, **, * indicate passing significance test at 1%, 5%, 10% level.

As shown in Table 7, the direction of the sign of the regression coefficients of each influence factor for the robustness test remained relatively stable with the magnitude of the regression coefficients of the results of the individual fixed effects regression, and the significance level was also largely unchanged. Therefore, the estimation results of this study are robust.

5.2.7. Analysis of estimation results

1. Analysis of the measurement results of spatial autoregressive coefficients

In recent years, some scholars have begun to focus on the spatial effect of the green new dynamics score. According to the spatial Durbin model with individual fixed effects, the estimated value of the coefficient ρ of the national green new dynamics score is 0.341, and it passes the significance test at the 1% level. The rationality of choosing the spatial econometric model instead of the traditional panel data model is verified. Spatial dependence of the green new dynamics scores for the provinces at the national level:

The green new dynamic score of a province is not only related to its own research and experimental development (R&D) personnel per unit GDP (persons/billion yuan), education expenditure ratio, number of high-tech enterprises per unit GDP (units/billion yuan), energy consumption reduction rate per unit GDP, and secondary industry increase ratio, but also has positive mutual influence among neighboring provinces with similar spatial characteristics. As the degree deepens, the greater the spatial mobility of green new dynamic score, and the phenomenon of interdependence of green new dynamic score between neighboring provinces becomes more obvious.

2. Analysis of the measurement results of the influencing factors

I) Research and experimental development (R&D) personnel per unit of GDP (persons/billion yuan)

The coefficient of for research and experimental development (R&D) personnel per unit of GDP is -0.113, indicating that the effect of R&D personnel per unit of GDP on the green new dynamics score of each province is negative. Other things being equal, an increase of 1 percentage point in research and experimental development (R&D) personnel per unit of GDP would decrease the green new dynamics score by 0.113 percentage points. This may be due to the fact that R&D personnel focus on the development of the Internet, pharmaceuticals, and other areas, with less green development firms associated.

II) Number of high-tech enterprises per unit of GDP (pcs/billion yuan)

The coefficient of the number of high-tech enterprises per unit of GDP is -2.385, indicating that the number of high-tech enterprises per unit of GDP has a negative impact on the green new dynamics score of each province. All other things being equal, for every 1 percentage point increase in the number of high-tech enterprises per unit of GDP, the green new dynamics score will decrease by 2.385 percentage points. This may be due to the fact that high-tech enterprises focus on the development of the Internet, chips, etc., with fewer green development enterprises associated.

III) Energy consumption reduction rate per unit of GDP

The coefficient of the reduction rate of energy consumption per unit of GDP is -0.958, indicating that the reduction rate of energy consumption per unit of GDP has a negative impact on the green new dynamics score of each province. All else being equal, for every 1 percentage point increase in the rate of reduction in energy consumption per unit of GDP, the green new dynamics score will decrease by 0.958 percentage points. This may be due to the fact that the implementation of energy efficiency and emission reduction in the three industries and other aspects of life is still problematic.

IV) Secondary industry increase ratio

The coefficient of the secondary industry increase ratio is 2.158, which indicates that the effect of the secondary industry increase ratio on the green new dynamic score of each province is negative. For every 1 percentage point increase in the increase ratio of the secondary industry, the green new dynamics score will decrease by 2.158 percentage points. This may be due to the fact that in recent years, the country has gradually paid attention to the treatment of industrial pollution, closed heavy-level polluting enterprises, and improved medium-level polluting enterprises to achieve the carbon peak in 2030. This eventually led to an increase in the increase ratio of the secondary industry and an increase in the score of new green dynamics.

6. Conclusions and Recommendations

6.1. Conclusion

1. In this paper, we give the weight to each index by entropy weighting method, and add up each index according to the corresponding weight to get the green new dynamics score of each province, and divide different green new dynamics scores into five levels, and use Arcgis to make a graph to obviously see that different regions have different green new dynamics score levels, thus there are regional differences. Most of the provinces with lower scores are in the northwest, and most of the provinces with higher scores are in the south.

2. The amount of comprehensive utilization of industrial solid waste per unit and the amount of completed investment in industrial pollution control per unit dominate the score of green new dynamic energy, and their weights in the green new dynamic energy score are 0.42 and 0.226 respectively, and the sum of their influences has exceeded the sum of other factors, indicating that the amount of comprehensive utilization of industrial solid waste per unit and the amount of completed investment in industrial pollution control per unit play an important role in the development of new dynamic energy. play an important role in the development of new dynamic energy.

3. The research and experimental development (R&D) personnel per unit GDP, the number of high-tech enterprises per unit GDP, and the energy consumption reduction rate per unit GDP have a negative impact on the green new dynamic score, while the increase ratio of secondary industry has a positive impact on the green new dynamic score, indicating that there are still many problems in energy conservation and emission reduction in China.

6.2. Recommendations

1. Strengthen green exchanges among provinces (cities) to promote the development of new green dynamics, and mutual assistance among provinces, so that provinces and cities with high scores of new green dynamics can drive the development of low scores. Promoting cross-regional exchanges and cooperation among provinces can effectively drive the improvement of green new dynamics scores in neighboring areas. The spatial geography factor has a significant positive

influence on the green new dynamics score among provinces. It indicates that the development of new green dynamics in different provinces has significant spatial dependence, and the new green dynamics in different provinces are influenced by each other. Therefore, provincial governments should coordinate planning and set up cross-provincial environmental cooperation mechanisms.

2. Actively advocate cross-provincial technology exchange and cooperation, guide the flow of advanced technology and advanced talents to provinces with low scores of new green dynamic energy, promote the development of new green dynamic energy in backward provinces to improve, and narrow the differences between different provinces, so as to coordinate the development of new green dynamic energy in different provinces.

3. Increase the investment in green science and technology, help green technology enterprises, and help the development of green economy. Help green science and technology enterprises. For example, the treatment of industrial solid waste, not only to handle properly, clean, but also to ensure that it does not damage the environment; and then the development of new energy, not only to develop available energy fuels, but also to "green" energy.

4. Actively promote the green culture system, so that the concept of green culture system is deeply rooted in people's hearts, using a variety of ways, a variety of forms of publicity to schools, enterprises, communities, etc. actively promote the green culture system, so that the concept of green culture system is deeply rooted in people's hearts.

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