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Analysis of Spatial Spillover Effect of Energy Intensity and its Influencing Factors in China

Qian Zhang *

College of Economics and Management, Chongqing Normal University, Chongqing 400000, China
*** Corresponding author Email:** 18784080835@163.com

Abstract: The time variation characteristics and spatial variation characteristics of China 's energy intensity are discussed. On this basis, the spatial Durbin model is used for empirical analysis to study the influencing factors of energy intensity. The results show that the spatial distribution of China 's energy intensity is characterized by low in the east and high in the west and low in the south and high in the north, and there are two agglomeration areas: one is low and one is high. The high intensity areas represented by Shanxi and Inner Mongolia and the low intensity areas represented by Shanghai and Jiangsu. The increase of industrial structure rationalization promotes the increase of energy intensity, but industrial rationalization has a spillover effect on the increase of energy intensity in surrounding areas. The industrial structure characterized by industrial upgrading reduces the intensity of energy consumption, but it has a spillover effect on the increase of energy intensity in the surrounding areas. The improvement of economic development level and the optimization of energy consumption structure have reduced the energy intensity. The increase of industrialization level can inhibit energy intensity and has spillover effect. However, the level of urbanization, social consumption level and informatization level have no obvious impact on energy intensity.

Keywords: Energy Intensity; Space-time Evolution; Influencing Factors; Spatial Dubin Model.

1. Introduction

China is the world 's largest energy consumer, energy saving potential is huge at the same time our country is in the country into the ' carbon peak, carbon neutral ' stage of rapid development, residents living, transportation and other fields of energy consumption continues to grow, energy consumption will maintain a rigid growth trend. In recent years, China has vigorously promoted the transformation of energy consumption patterns, accelerated the construction of a diversified and clean energy supply system, curbed unreasonable energy consumption, and improved energy efficiency, which is of great significance for achieving sustainable economic and social development.

1.1. Research Status at Home and Abroad

Zhuang Rulong et al. [1] found that household energy consumption showed an upward trend from 1995 to 2021. Energy intensity, population size, family size, education level, economic development, urbanization rate and car ownership are important influencing factors of household energy consumption, but there are differences in the degree of influence. Xu Feifei et al. [2] believed that the development of green finance helps to reduce energy intensity. Zhou Mengwen et al. [3] found that the impact of digital economy on energy intensity and carbon emission intensity showed an inverted ' N ' shape, with significant spatial spillover effect. Wang Fuzhong [4] believed that the efficiency of technological progress under low-carbon energy input factors is higher than that of high-carbon energy, and the improvement of R & D expenditure and invention patents helps to curb China 's energy intensity. Feng Yongsheng et al. [5], Wei Lili and Chen Xi [6] also believed that technological progress is conducive to reducing energy intensity or saving energy and reducing consumption, and the improvement of energy growth technology level has significantly inhibited China 's energy intensity. In terms of R & D investment, Liu Huihui and Xu Chao [7] believe that R & D investment is conducive to curbing China 's energy intensity, but there are also views that R & D expenditure does not show a significant positive impact on curbing energy intensity. Zhao Lijie [8] found that the change of industrial structure in the same region showed a steady trend, and showed the volatility of time and regional differences. The adjustment of industrial structure played a role in promoting the decline of energy intensity. Zhang Zhiqiang [9] proposed that the level of economic development has an inhibitory effect on energy intensity, the level of urbanization and energy consumption structure have a positive effect on energy intensity, and there is an inverted 'U 'type nonlinear relationship between industrial upgrading and energy intensity.

1.2. Research Review

Through the analysis and induction of domestic and foreign research, scholars have conducted a lot of useful research on energy intensity related issues, but there is still room for improvement. The existing research scope is mostly based on China as a whole, and does not distinguish the provinces, but the provinces do not exist independently, and they are interrelated, cooperative and common development. The existing research lacks the analysis of the spatial and temporal differentiation characteristics of energy intensity at the provincial level [10]. Few researchers have divided the industrial structure into two levels: the rationalization of industrial structure and the advancement of industrial structure to explore its relationship with energy intensity. This paper also analyzes the level of industrialization and social consumption level, information level and other factors.

2. Model Building and Variable Selection

2.1. Spatial Weight Matrix

1) Geographical adjacency matrix W1, that is, the

geographical location between the two provinces is adjacent, then Wij = 1; otherwise Wij = 0. This paper uses a spatial weight matrix based on Rook proximity. Because Hainan Province is a separate island, it is not adjacent to any other province, but its economic activities may have frequent spatial interactions with neighboring Guangdong Province. Therefore, when constructing the geographical adjacency matrix, this paper assumes that Guangdong and Hainan are adjacent. The specific formula is as follows:

$$W1_{ij} = \begin{cases} 0, & i\ and\ j\ are\ not\ adjacent \\ 1, & \text{i and j are adjacent} \end{cases} \quad (1)$$

2) Geographical inverse distance matrix W 2. Let dij be the surface distance between the two provinces measured according to latitude and longitude, and its unit is converted to kilometers. The reciprocal of the distance between the two provinces is 1 / dij, and the specific formula is as follows:

$$d_{ij} = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} * pi/180 * 6378.2 \quad (2)$$

$$W2_{ij} = \begin{cases} 1/d_{ij}, & i \neq j \\ 0, & i = j \end{cases} \quad (3)$$

Where xi is the longitude of the ith province, and yi is the latitude of the jth province.

2.2. Spatial Autocorrelation Test

Because the sample of this study is at the national level, the global Moran index (Moran 's I) is used to study whether there is spatial autocorrelation in the whole. The calculation formula of the global Moran index is:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\,(x_i - \bar{x})(x_j - \bar{x})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \quad (4)$$

$$S^2 = \sum_{i=1}^{n}(x_i - \bar{x})^2 /n, \bar{x} = \sum_{i=1}^{n} x_i /n \quad (5)$$

Among them, I represents the global Moran index ; s2 represents the variance of variable x ; xi represents the observation value of i province ; xj represents the observed value of j province ; among them, I represents the global Moran index ; s2 represents the variance of variable x ; xi represents the observation value of i province ; xj represents the observed value of j province ; x represents the total average ; n represents the total number of provinces ; wij represents the data value of row i and column j of the spatial weight W matrix.

2.3. Spatial Econometric Model

This paper analyzes the spatial effect of different influencing factors on energy intensity in 30 provinces of China from 2000 to 2020 by means of spatial econometric model, regression model (SAR), spatial error model (SEM) and spatial Durbin model (SDM). According to the relevant test results, this paper adopts the spatial Dubin model (SDM) with spatial and temporal fixed effects [11]. The model is set as follows:

$$\begin{aligned} ei_{it} &= \alpha + \rho \sum_{j=1}^{n} \omega_{ij}\, ei_{ji} + \beta_1 hl_{ii} + \beta_2 gd_{ii} + \\ &\beta_3 ecs_{it} + \beta_4 indus_{it} + \beta_5 gdp_{it} + \beta_6 ur_{it} + \\ &\beta_7 rd_{it} + \beta_8 cons_{it} + \beta_9 inl_{it} + \theta_1 \sum_{j=1}^{n} \omega_{ij} \ln EI_{ijt} + \\ &\theta_2 \sum_{j=1}^{n} \omega_{ij}\, hl_{ijt} + \theta_3 \sum_{j=1}^{n} \omega_{ij}\, gd_{ijt} + \\ &\theta_4 \sum_{j=1}^{n} \omega_{ij}\, ecs_{ijt} + \theta_5 \sum_{j=1}^{n} \omega_{ij}\, indus_{ijt} + \\ &\theta_6 \sum_{j=1}^{n} \omega_{ij}\, gdp_{iji} + \theta_7 \sum_{j=1}^{n} \omega_{ij}\, ur_{iji} + \\ &\theta_8 \sum_{j=1}^{n} \omega_{ij}\, rd_{ijt} + \theta_9 \sum_{j=1}^{n} \omega_{ij}\, cons_{ijt} + \theta_9 \sum_{j=1}^{n} \omega_{ij}\, inl_{ijt} + \mu_i + \lambda_t + \varepsilon_{it} \end{aligned}$$

Where i represents the province, t represents the year, W is the corresponding spatial weight matrix, i represents the spatial fixed effect, t represents the time fixed effect, and it represents the error term.

2.4. Variable Selection

2.4.1. Explained Variable

Energy intensity ei. The energy intensity in this paper refers to the energy consumption per unit of GDP, which is an important index to reflect the economic development of a country (region). The most commonly used unit is ' tons of standard coal / ten thousand yuan '.

2.4.2. Explanatory Variables

See Table 1.

3. Authentic Proof Analysis

3.1. Data Source and Processing

Taking 30 provinces in China from 2000 to 2020 as the research object, this paper explores the influencing factors of energy intensity. The original data of energy intensity measurement index are mainly from China Statistical Yearbook, China Energy Statistics Bureau and China Energy Statistics Yearbook, and a small amount of missing data are supplemented by interpolation method. The original data collection of industrial rationalization and industrial advancement mainly comes from China Statistical Yearbook, provincial statistical yearbooks, population and employment statistical yearbooks. The macro-level control variable data are mainly from the China Statistical Yearbook.

Table 1. Variables and indicators description

Variable name	meaning	symbol
rationalization of industrial structure	theil index	hl
advancement of industrial structure	The proportion of added value of primary industry * 1 + the proportion of added value of secondary industry * 2 + the proportion of added value of tertiary industry * 3	gd
energy of formation	The proportion of regional coal consumption in the total coal consumption in China	ecs
industrialization level	Industrial value added /regional GDP	indus
economic development level	per capita gdp	gdp
urbanization level	Urban population / total population	ur
technical level	r & d expenditure internal expenditure / regional GDP	rd
social consumption level	Total retail sales of social consumer goods / regional GDP	cons
informatization level	Total post and telecommunication business / regional GDP	inl

3.2. Spatial Autocorrelation Test

3.2.1. Descriptive Statistic

Table 2. Variable descriptive statistics

Variables	n	mean	sd	min	max
ei	630	1.231	0.786	0.188	4.553
hl	630	0.213	0.126	0.00816	0.772
gd	630	2.336	0.134	2.069	2.834
ecs	630	0.0333	0.0233	0.00280	0.110
indus	630	0.344	0.0850	0.101	0.559
gdp	630	11,287	7,592	2,662	47,118
ur	630	0.510	0.158	0.139	0.896
rd	630	0.0137	0.0109	0.00151	0.0644
cons	630	0.361	0.0626	0.218	0.582
inl	630	0.0691	0.106	0.0147	2.513

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3.2.2. Dlobal Moran's Index

Before determining the spatial econometric model, based on the Rook proximity matrix, the spatial correlation of energy intensity in different provinces is measured according to the formula. The results of the global spatial correlation test are shown in Table 3. The results show that the global Moran 's index of energy intensity in different provinces is positive, that is, the energy intensity shows a spatial positive correlation, and the Moran 's index is significant at the level of 5%, which fully confirms that the energy intensity has spatial correlation between different provinces. The spatial econometric model can be used to further characterize the relationship between different factors and energy intensity [12].

Table 3. Significance test of global Moran 's index

year	I	z	P-value	year	I	z	P-value
2000	0.284	2.619	0.009	2011	0.452	3.997	0.000
2001	0.310	2.847	0.004	2012	0.460	4.065	0.000
2002	0.312	2.871	0.004	2013	0.443	3.961	0.000
2003	0.284	2.685	0.007	2014	0.445	3.980	0.000
2004	0.315	2.932	0.003	2015	0.443	3.967	0.000
2005	0.370	3.404	0.001	2016	0.449	3.992	0.000
2006	0.362	3.331	0.001	2017	0.453	4.061	0.000
2007	0.384	3.479	0.001	2018	0.456	4.110	0.000
2008	0.438	3.883	0.000	2019	0.449	4.086	0.000
2009	0.458	4.019	0.000	2020	0.437	4.025	0.000
2010	0.471	4.107	0.000				

3.2.3. Local Moran'i Index

Global spatiality reflects the overall spatial correlation of spatial variables, but may ignore the local spatial correlation.

Therefore, this paper further uses the local Moran 's index to examine the local agglomeration characteristics of energy intensity in different provinces. The results are shown in Figures 1,2,3,4: provinces with significant local Moran 's index at the 5 % level do not express the agglomeration characteristics of non-significant provinces. The results of 2000 show that the high-high energy intensity areas are concentrated in Xinjiang, Inner Mongolia, Gansu, Liaoning, Hubei, Heilongjiang, Qinghai, Ningxia and Shanxi, and the low-low energy intensity areas are concentrated in Shandong, Hubei, Hunan, Jiangsu and other coastal provinces. Compared to 2000. In 2007, Jilin joined the high-high energy intensity region, and other provinces remained unchanged. In 2015, Jilin Province withdrew from the high-high region and joined the low-high energy intensity region; yunnan Province withdrew from the low-high energy intensity region in 2007 and joined the low-low energy intensity region; in 2020, Guizhou Province will withdraw from the high-low energy intensity region and join the low-high energy intensity region; other provinces remain basically unchanged. In general, the high-high type area is basically stable, and the remaining types of areas are constantly changing.

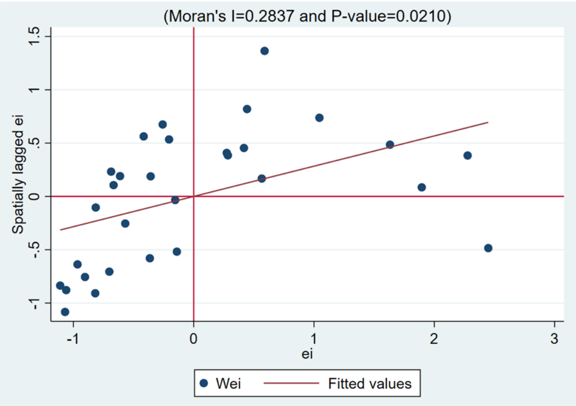

Fig 1. Scatter plot 2000

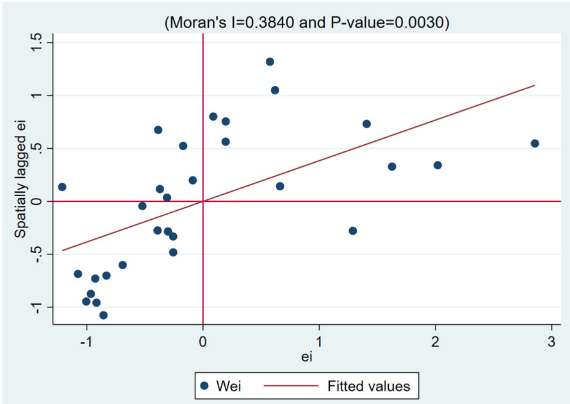

Fig 2. Scatter plot 2007

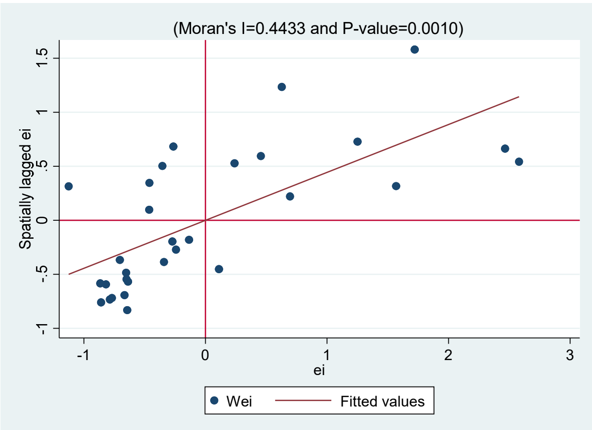

Fig 3. Scatter plot 2015

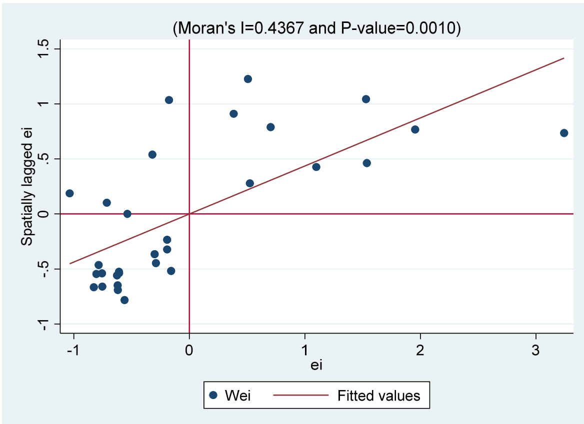

Fig 4. scatter plot 2020

3.3. Spatial Spillover Effect Analysis

3.3.1. LM Test

Using stata17.0 to test the LM value of the constructed spatial model, see table 4. The results show that the LM lag value of energy consumption intensity passes the 1 % significance test, and the robust LM lag is significant, and the LM error passes the 1 % significance test, so the spatial Durbin fixed effect model is selected [10].

Table 4. LM test

	adjacency matrix W1		Geographical matrix (inverse distance power W2)	
type	statistic	P-value	statistic	P-value
Moran's I	2.016	0.044	377.941	0.000
Spatial Error Model LM	63.962	0.000	120.366	0.000
Spatial Error Model LM Robust	16.917	0.000	24.939	0.000
Spatial Lag Model LM	59.460	0.000	148.839	0.000
Spatial Lag Model LM Robust	12.415	0.000	53.412	0.000

3.3.2. Model Selection

According to the characteristics of the sample data selected in this paper, Wald test and LR test are basically rejected at a significant level of 1 % under the setting of three spatial weight matrices. SDM can be simplified to SAR or SEM, indicating that the setting of SDM is very reasonable [1].

At the same time, Hausman was performed separately. Under the two spatial matrices, both passed the Hausman test, showing a significant correlation. Under the adjacency matrix w1, p = 0.0026, passed the significance test at the 1 % level. Under the geographical matrix W2, p = 0.0000, passed the significance test at the 1 % level.

3.4. Analysis of Spatial Dubin Model Results

Based on the test results, this paper uses the formula to analyze the spatial Durbin model with time and space fixed under the adjacency matrix (W1) and the geographical inverse distance matrix (W2, two spatial weight matrices). The results are shown in Table 5. At the same time, according to the comprehensive results, under different spatial matrices, the direction and significance of the core explanatory variables on energy intensity are consistent, and the effect and significance of some variables are significantly different [12].

Table 5. Spatial Durbin Model (SDM) estimation results under double fixed

Main	adjacency matrix (w1)			Geographical matrix (W2)		
	ind	time	both	ind	time	both
hl	1.116*** (4.30)	0.312 (1.08)	1.039*** (4.36)	1.437*** (6.46)	0.644* (2.45)	0.544* (2.31)
gd	-2.237*** (-6.08)	2.970*** (7.76)	-1.160** (-3.05)	-1.760*** (-6.47)	3.134*** (9.39)	0.274 (0.81)
ecs	10.26*** (4.37)	0.00877 (0.01)	8.064*** (3.79)	14.18*** (6.00)	-1.793 (-1.80)	9.986*** (4.45)
indus	-2.067*** (-6.30)	0.576* (1.97)	-1.494*** (-4.87)	-1.625*** (-5.96)	0.155 (0.55)	-0.785** (-2.68)
gdp	-0.0000393*** (-5.76)	-0.0000189** (-3.14)	-0.0000173** (-2.61)	-0.0000325*** (-5.07)	-0.0000254*** (-4.43)	0.00000276 (0.39)
ur	-0.0742 (-0.48)	0.478* (2.15)	0.0580 (0.41)	-0.613*** (-4.10)	0.151 (0.67)	-0.117 (-0.76)
rd	19.25*** (4.15)	-26.00*** (-7.26)	18.36*** (4.25)	17.92*** (4.46)	-29.14*** (-7.74)	33.97*** (8.22)
cons	0.132 (0.45)	-2.186*** (-5.50)	-0.0595 (-0.22)	0.0154 (0.06)	-2.086*** (-5.54)	-0.211 (-0.75)
inl	-0.00299 (-0.03)	0.0106 (0.06)	-0.000722 (-0.01)	0.00463 (0.05)	-0.0551 (-0.30)	0.0153 (0.16)

3.5. Spatial Effect Decomposition

3.5.1. Direct Effect Analysis.

Table 6. shows the direct effect, indirect effect and significance of different explanatory variables on energy intensity. The direction of action of the core explanatory variables on energy intensity is basically consistent with the parameter estimation results, indicating that the direct effect results of each variable are relatively robust.

1) Industrial structure [13]. The industrial structure characterized by rationalization has a significant positive effect on energy intensity, while the industrial structure characterized by elevation has a parameter estimation value of-1.338 * * *, and has passed the 1 % significance test. From the perspective of industrial structure, optimizing the industrial structure, increasing the proportion of the tertiary industry, and reducing the energy consumption of the secondary industry can reduce the energy consumption intensity [10].

2) Energy consumption structure. ecs has a significant positive correlation with energy consumption intensity, which passes the significance of 1 % under the three matrices. This shows that the higher the proportion of coal consumption in energy consumption, the higher the consumption intensity will be. The adjustment of energy consumption structure is to change the consumption mode dominated by fossil energy into low-carbon renewable energy, but the existing consumption mode will continue to increase carbon intensity, which is not conducive to the realization of carbon emission reduction targets.

3) Industrialization level. The parameter coefficient of industrialization level is negative, and it has passed the 1 % significance test under the three matrices, indicating that the increase of industrialization level inhibits the energy consumption intensity. Because a considerable part of the industry is high energy consumption industry, improving the level of industrial technology, energy efficiency will increase, which is conducive to reducing energy consumption intensity.

4) Economic development level. The impact of economic development level on energy intensity only passes the 0 % test under the proximity matrix test, and the parameter estimate is − 0.0000190 *, that is, the increase of per capita GDP can reduce energy intensity. This is because with the increase of per capita GDP, people 's living standards have been improved, and the requirements for the environment have gradually increased.

5) Technical level. The coefficient of the r & d parameter is positive, and it has passed the significance test under the three matrices. It shows that the increase of R & D promotes the energy consumption intensity. This result shows that the development of new technologies has invested a lot of energy, resulting in an increase in energy consumption intensity, while the economic output brought by the application of new technologies is not high, and the overall energy consumption intensity has increased.

The urbanization level, social consumption level and informatization level have not passed the significance test, and the direct effect is not obvious, indicating that their impact on energy intensity is not obvious.

In summary, controlling economic growth and optimizing energy structure can effectively reduce energy consumption intensity. Technological progress has increased energy consumption intensity, but different industrial structure measurement methods have different effects on energy intensity. The growth of urbanization level, social consumption level and informatization level has no obvious effect on the reduction of energy consumption intensity [14].

3.5.2. Indirect Effect

The indirect effect is the spatial spillover effect of different variables on adjacent areas [15].

1) Industrial structure. The rationalization of the industrial structure to measure the industrial structure only passed the 10 % significance test under the W3 matrix. The industrial structure measured by sophistication has passed the significance test of at least 5 % under the three matrices. It shows that the adjustment of industrial structure in neighboring provinces will also lead to the change of energy consumption intensity in the region.

2) Energy structure. The impact of the proportion of coal in total energy consumption on energy consumption intensity only passed the 10 % test at the significant level in the adjacency matrix, and its indirect effect was-23.84 * * *.

3) Industrialization level. The level of industrialization has passed the 1 % significance test under the three matrices, indicating that the increase in the level of industrialization in the surrounding provinces will also lead to an increase in the intensity of energy consumption in the region.

4) Technical level. The r & d has passed the significance test of at least 5 % under the three matrices, indicating that the increase of the technical level of the surrounding provinces will also lead to the increase of the energy consumption intensity in the region.

The spatial spillover effect of urbanization level, economic development level, social consumption level and informatization level on energy consumption intensity is not obvious. This is due to the vast territory of China 's provinces, the administrative boundaries are obvious, the economically developed southeast coastal areas are difficult to radiate to the economically backward western and northern regions, subject to regional policy restrictions, often take local conditions, independent operation between provinces, lack of cooperation between regions, spillover effect is difficult to play a role.

Table 6. Spatial effect decomposition

explanatory variables	Proximal space matrix (w1)		Geographical matrix (inverse distance power W2)		Geographical matrix (inverse distance square W3)	
	direct effect	indirect effect	direct effect	indirect effect	direct effect	indirect effect
hl	1.024*** (4.15)	0.211 (0.57)	1.111*** (4.46)	1.523 (1.63)	1.168*** (4.70)	1.352* (2.19)
gd	-1.338*** (-4.16)	1.820** (2.78)	0.284 (0.89)	9.421*** (5.88)	0.477 (1.56)	6.104*** (5.97)
ecs	9.996*** (4.30)	-23.84*** (-5.90)	10.80*** (4.55)	-14.56 (-1.14)	10.48*** (4.39)	-13.25 (-1.60)
indus	-1.681*** (-5.12)	2.516*** (6.10)	-1.179*** (-3.48)	4.109*** (4.50)	-1.048** (-3.05)	3.667*** (5.85)
gdp	-0.0000190* (-2.51)	0.00000460 (0.45)	-0.0000101 (-1.24)	0.00000414 (0.25)	-0.00000520 (-0.66)	0.00000674 (0.63)
ur	0.00898 (0.07)	0.691** (2.77)	0.101 (0.66)	1.246 (1.84)	0.171 (1.14)	0.794 (1.81)
rd	15.52*** (3.32)	39.92*** (6.94)	13.31** (2.79)	38.89** (2.85)	13.38** (2.85)	24.81** (2.65)
cons	-0.0665 (-0.25)	-0.407 (-1.04)	-0.341 (-1.24)	0.385 (0.49)	-0.260 (-0.95)	0.330 (0.57)
inl	-0.0153 (-0.19)	0.146 (1.03)	0.00226 (0.03)	0.304 (0.95)	0.00316 (0.04)	0.214 (1.09)

4. Conclusion and Recommendations

4.1. Conclusion

This paper takes energy intensity as the breakthrough point, and takes industrial structure, energy structure, economic development, industrialization level, urbanization level and innovation level as explanatory variables to study the influencing factors of energy intensity. The main conclusions are as follows:

First, the actual value of China 's energy intensity is on the rise, indicating that energy efficiency is not high. There are many factors that restrain energy consumption demand in the short term. The energy saving and emission reduction advocated by the state and the low cost of low-carbon energy may be more important factors. In the long run, it is imperative to take the road of low-carbonization and practice the strategic goal of ' carbon peak and carbon neutralization '.

Second, the energy consumption intensity of each province in China changes frequently, but the change range is not large. The provinces with ' low ' energy consumption intensity are mostly distributed in the southeast coastal areas, represented by Jiangsu, Zhejiang, Guangdong and other provinces. The provinces with high energy consumption intensity are mainly concentrated in the western and northern regions represented by Inner Mongolia, Shanxi, Ningxia, Gansu, Qinghai and

Xinjiang.

Thirdly, through spatial data analysis, the spatial and temporal evolution of energy consumption intensity in various provinces of China is analyzed. The research shows that in the 21 years of research, there is a certain correlation between the energy consumption intensity of each province, and the energy consumption intensity of each province will have an impact on the energy consumption intensity of the surrounding areas. Through the Moran scatter plot and the spatial clustering table of energy consumption intensity, it is found that the spatial distribution of energy consumption intensity in China presents the characteristics of ' low in the east and high in the west ' and ' low in the south and high in the north ', and there are two agglomeration areas : one is low and one is high, the high consumption intensity area represented by Shanxi and Inner Mongolia, and the low consumption intensity area represented by Shanghai and Jiangsu. China 's provincial energy consumption intensity has obvious spatial agglomeration characteristics, showing the differences and agglomeration of energy consumption intensity among provinces in geographical location.

Fourth, the empirical analysis of the influencing factors of energy consumption intensity, the study found that in addition to the two factors of social consumption level and information level did not pass the significance test, the remaining variables have played a role in inhibiting or promoting the reduction of energy consumption intensity.

4.2. Recommendations

In view of the above research conclusions, the following countermeasures and suggestions are proposed: First, strengthen the development of low-carbon industry and low-carbon logistics industry. In view of the largest energy consumption of industry, improving the energy consumption efficiency of industry and inhibiting the energy intensity of industry are the top priorities. Therefore, we should strengthen the low-carbon development of industry and take the road of scientific and technological innovation to realize the industrial power.

Second, actively promote the transformation of industry and energy structure, and improve energy efficiency with the development of high value-added manufacturing industry. Promote the rapid development of energy-saving industry with industrial structure optimization and technological progress.

Third, China should further optimize the energy consumption structure, reduce the proportion of coal energy in energy consumption, and optimize the energy consumption structure. At the same time, China should encourage the development and utilization of new energy, which will further improve the energy consumption structure and energy efficiency.

Fourth, technological progress can promote the development of energy application technology, thus promoting the progress of energy efficiency. The enlightenment to us is that first, relevant institutions or departments can further increase investment in R & D of energy technology, and the country can ensure the smooth progress of R & D in the system.

Fifth, per capita GDP can reduce energy intensity and improve energy efficiency. This means that at the current stage, with the increase of residents ' income in China, residents ' consumption can effectively guide the transformation of energy utilization mode, to improve energy efficiency and reduce energy intensity. Therefore, China should pay more attention to the guidance of macro economy and ensure the improvement of residents ' income.

References

[1] Zhuang Rulong, Yang Jie, Mi Cona, Zhang Chaoyang, Zhi Menglu. Spatio-temporal characteristics, influencing factors and trend prediction of household energy consumption in China [J]. Geographic Science and Progress, 2024,5.18.

[2] Xu Feifei, Peng Geng. Research on the influence mechanism of green financial development on energy intensity [J]. Zhejiang Finance.2024.01.05.

[3] Zhou Mengwen, Liu Chuanming. The energy saving and emission reduction effect and mechanism of the digital economy-based on the spatial correlation network spillover model [J]. Industrial technology economy.2024.01.01.

[4] Wang Fuzhong. Research on China 's energy intensity from the perspective of technological progress [J].Technological economy and management research.

[5] Feng Yongsheng, Zhang Ya, Liu Zimin. Energy Price, Technological Progress and Energy Intensity - Dynamic Spatial-Temporal Evolution Based on Urban Data in China [J]. City and Environment Research.2020.09.20.

[6] Wei Lili, Chen Xi. Digital Finance, Technological Progress and Energy Intensity [J]. Lanzhou Academic Journal.2022.05.05.

[7] Liu Huihui, Xu Chao. Research on China 's energy intensity change under biased technological progress [J]. Research on science and technology management.2020.04.20.

[8] Zhao Lijie. Research on the impact of industrial structure upgrading on regional energy consumption-based on Moore structure index [J]. Modern marketing.2021.10.15.

[9] Zhang Zhiqiang. Analysis of the inverted ' U ' relationship between industrial structure upgrading and energy intensity [J]. Coal engineering. 2021.01.20.

[10] Sun Yongbo, Gao Shuai. Research on the measurement and effect of influencing factors of energy consumption intensity in China [J]. Research on coal economy.2021.12.28.

[11] Zhang Chenqi, Jiang Juan. Analysis of the influencing factors of regional energy intensity from the perspective of spatial econometrics-Taking the two major regions of North China and East China as an example [J]. Economic Research Guide 2022. 04. 15.

[12] Liu Ronghua, Lu Huizhi. Research on the spatial spillover effect of energy efficiency and its influencing factors-Empirical analysis based on spatial econometric method [J]. Industrial technology economy.2024.02.

[13] Xu Jiexiang, Wang Enhui. Human capital, industrial structure and regional energy efficiency improvement-Empirical research based on spatial Durbin model [J]. Journal of Hefei University of Technology (Social Science Edition). 2019.12. 15.

[14] Zhao Changjin. Analysis of the influencing factors of energy intensity in China 's provinces [J]. Guangxi economy 2023. 08. 10.

[15] Wang Li. Identification of key influencing factors of energy transformation and its spatial spillover effect on regional carbon intensity [D] Nanjing: Nanjing University of Finance and Economics, 2023.04.21.