Proceedings of the 7th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/28/20231309

Research on the Spatial Differences and Influencing Factors of Energy Development in Guangdong Province

DengGang[1,a,*] and Chen Hsing Hung[1]

[1]*Macau University of Science and Technology, Institute of Sustainability, Macao, China*
a. 164852092@qq.com
**corresponding author*

Abstract: Studying the spatial differences and influencing factors of regional energy development can promote regional sustainable development. This study uses the per capita electricity consumption of 21 cities in Guangdong Province in 2021 as an indicator to measure regional energy development and uses ArcGIS's natural discontinuity method, spatial trend surface analysis method, and spatial autocorrelation to study the spatial differences and spatial agglomeration of energy development in 21 cities in Guangdong Province, Finally, the geographically weighted regression model is applied to explore the various factors affecting the energy development of 21 cities in Guangdong Province. It is concluded that the energy development of 21 cities in Guangdong Province in 2021 has significant spatial differences and positive agglomeration, The energy development in the north-south and east-west wings is relatively weak, while the energy development in the north-south direction and the east-west transition zone is relatively strong. The coefficient of the level of industrial structure influencing factor is higher than that of the development of the digital economy, the level of scientific and technological development, the level of opening-up, the level of economic development, and other influencing factors.

Keywords: energy development, spatial differences, influencing factors

1. Introduction

One of the main sources of energy consumption is electricity consumption. The regional electricity consumption index reflects the development of the local economy to a certain extent. Studying regional energy development can promote regional sustainable development. At present, most of the works of literature on energy development are based on national and provincial data. Data research on prefecture-level cities is still relatively lacking. Most of them have conducted spatial analysis on power consumption, few have conducted spatial measurement research on per capita power consumption, and few have discussed the spatial agglomeration of per capita power consumption. In this study, the per capita electricity consumption index is divided by the electricity consumption (100 million kilowatt-hours) divided by the number of permanent residents at the end of the year (10000 people) as an indicator to measure energy development. The neoclassical economic theory puts forward that technological progress is one of the important sources of economic growth. This study takes scientific and technological innovation as one of the factors affecting energy development to explore the various factors affecting the spatial differences of energy development. The innovation lies in exploring the spatial difference of per capita power consumption in prefecture-level cities, not

DOI: 10.54254/2754-1169/28/20231309

limited to national and provincial data. In addition to exploring two-dimensional spatial differences, three-dimensional spatial differences such as spatial trend surface analysis are also added. On the basis of exploring spatial differences, research on spatial agglomeration is added, and the selection of influencing factors is more comprehensive and comprehensive.

2. Research Methods

2.1. Natural Discontinuity Method

The research method used in this study to classify the regional energy development level of 21 cities in Guangdong Province is the natural breakpoint grading method (Jenks) in ArcGIS, which more intuitively visualizes the spatial difference of regional energy development level and marks the spatial difference of regional energy development level on the map.

2.2. Trend Surface Analysis

If $Z_i(x_i, y_i)$is a certain development type of a prefecture-level city i, and (x_i, y_i) is the spatial plane coordinate. According to the definition of trend surface, we can know:

$$Z_i(x_i, y_i) = T_i(x_i, y_i) + \varepsilon_i \tag{1}$$

2.3. Spatial Autocorrelation

The statistical methods of spatial autocorrelation are diverse, and Moran's I is one of the most widely used methods.

$$I = \frac{n}{\Sigma_i \Sigma_j w_{ij}} \frac{\Sigma_i \Sigma_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\Sigma_i (x_i - \bar{x})^2} \tag{2}$$

The above is global Moran's I, and the following is local Moran's I.

$$I_i = \frac{n(x_i - \bar{x})\Sigma_{j \neq i} w_{ij}(\chi_i - \bar{x})}{\Sigma_i (\chi_i - \bar{x})^2} \tag{3}$$

Local Moran's I reflects the spatial autocorrelation of a space unit, that is, the direct correlation between a space unit and its adjacent units.

2.4. Geographically Weighted Regression Model

This study uses the spatial relationship modeling tool of AcrGIS10.8 software to conduct a spatial econometric analysis of energy development level. The construction model is as follows:

$$C_i = \alpha_0(x_i, y_i) + \sum_{j=1}^{k} \alpha_j (x_i, y_i) W_{ij} + \varepsilon_i \tag{4}$$

3. Results and Analysis

3.1. Analysis of Spatial Differences in Energy Development

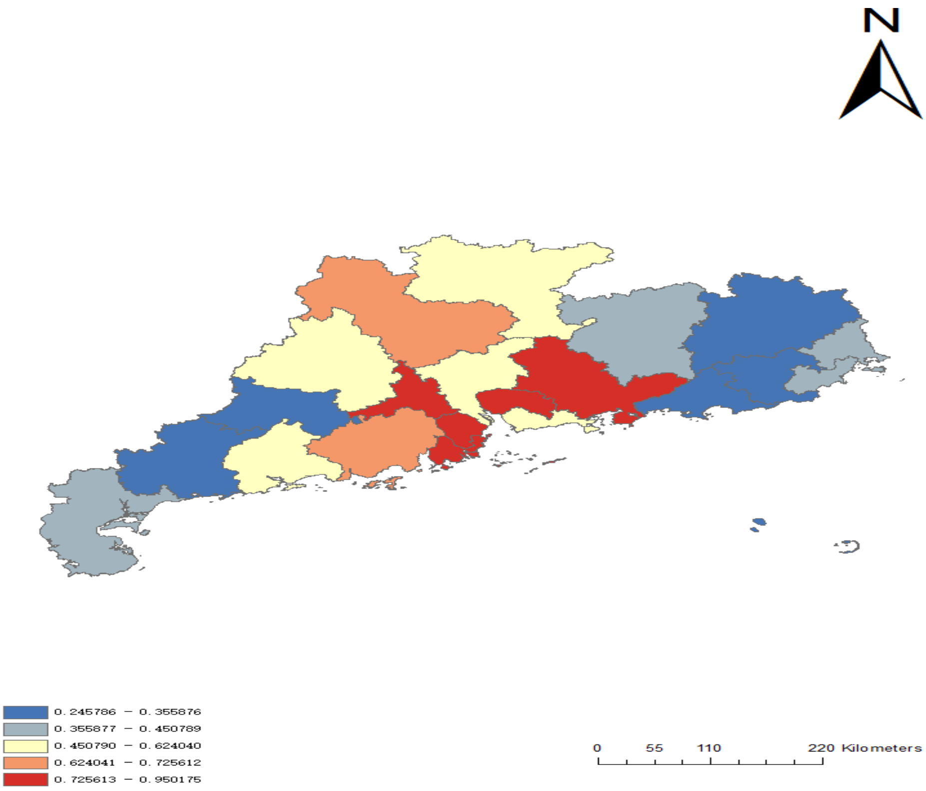

Figure 1: Spatial difference of energy development in 21 cities of Guangdong Province in 2021.

It can be seen from Figure 1 that Maoming city, Yunfu city, Meizhou city, Jieyang city, and Shanwei city are regions with low energy development levels; Zhanjiang city, Heyuan city, Chaozhou city, and Shantou city are regions with relatively low energy development level; Yangjiang city, Zhaoqing city, Guangzhou city, Shaoguan city, and Shenzhen city are regions with medium energy development level; Jiangmen city and Qingyuan city are regions with relatively high energy development level; Foshan city, Zhongshan city, Zhuhai city, Dongguan city, as well as Huizhou city, are regions with high energy development level. In 2021, the per capita power consumption of 21 cities in Guangdong Province will show significant spatial differences, gradually decreasing from the middle cities such as Foshan city, Zhongshan city, Zhuhai city, Dongguan city, and Huizhou city to the surrounding cities.

3.2. Trend Surface Analysis of Energy Development

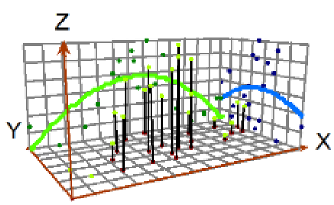

Figure 2: Trend surface analysis of energy development in 21 cities of Guangdong Province in 2021.

DOI: 10.54254/2754-1169/28/20231309

It can be seen from Figure 2 that the X and Y axes represent the due east and due north directions respectively, and the Z axis represents the attribute value of energy development. The overall energy development of 21 cities in Guangdong Province presents a trend of "The north and south wings are low and the middle is high, and the east and west wings are low and the middle is high", and “U-shaped” differentiation in the north and west directions and the east and west directions", which indicates that the energy development of 21 cities in Guangdong Province is significantly different in the north and south directions and the east and west directions. The energy development in the north-south and east-west wings is relatively weak, while the energy development in the north-south direction and the east-west transition zone is relatively strong[1].

3.3. Analysis of the Characteristics of Spatial Agglomeration of Energy Development

Table 1: Global Autocorrelation of Energy Development in 21 Cities of Guangdong Province in 2021.

Type	Moran's I	Z-score	P-value
Value	0.552647	3.597404	0.000321

From Table 1, the Moran's I for 2021 is 0.552647, The p-value was less than 0.05 and passed the significance test, and the Moran's I is positive, indicating that the energy development level of the city will be positively affected by the energy development level of neighboring cities.

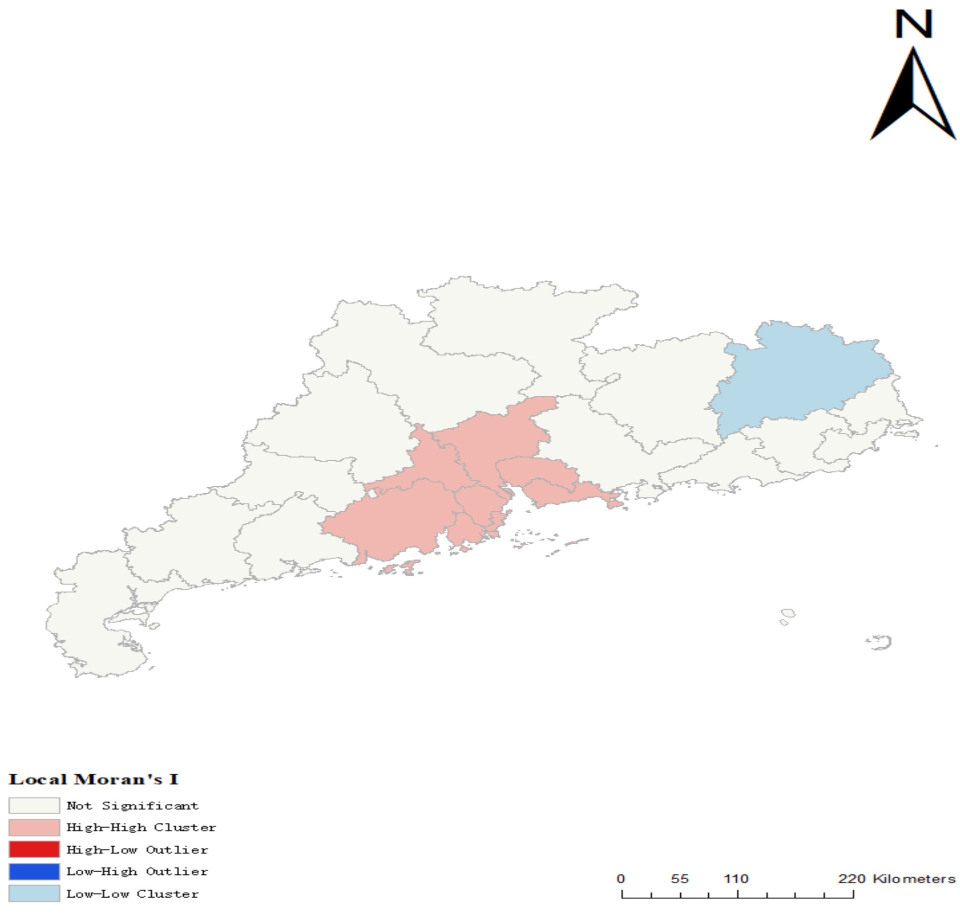

Figure 3: Local spatial autocorrelation analysis of energy development in 21 cities of Guangdong Province in 2021.

It can be obtained from Figure 3, Jiangmen city, Foshan city, Guangzhou city, Zhongshan city, Zhuhai city, Dongguan city, and Shenzhen city are high-high cluster areas, Indicates that these areas are high-value areas, and other surrounding areas are also high-value areas. Meizhou city is a low-low cluster area, Which means that Meizhou city is a low-value city and the surrounding cities are low value.

3.4. Analysis of Driving Factors of Energy Development

3.4.1. Selection of Influencing Factors

Table 2: Selection of energy development indicators.

Explained variable	Hypotheses	Explanatory variables	Treatment of explanatory variables
per capita electricity consumption	The improvement of the degree of external development can promote the introduction and improvement of advanced new energy technologies. It is assumed that the improvement of the degree of opening up can improve the level of energy development	IE represents the level of opening-up	the proportion of total imports and export in GDP
	Now the digital economy can drive the industrial structure up a level, effectively promoting the ecological economics of the economy, Assume that the digital economy can promote energy development	DE represents the development of the digital economy	the proportion of total post and telecommunications business in GDP
	Scientific and technological progress can promote the improvement of green production technology for enterprises. It is assumed that improving scientific and technological levels can promote energy development	TI represents the level of scientific and technological development	The proportion of R&D internal expenditure in GDP
	The tertiary industry is characterized by low energy consumption, high added value, and low emission pollution. It is assumed that optimizing the industrial structure can promote energy development	IS represents the level of industrial structure	Value added of the secondary sector divided by the value added of the three sectors combined
	Economic development can Provide a financial base for the utilization and development of new energy, assuming that economic development can promote energy development	ED represents reflecting economic levels	per capita GDP

DOI: 10.54254/2754-1169/28/20231309

3.4.2. Results

Table 3: GWR model test results.

Residual Squares	Effective Number	Sigma	AICc	R^2	R^2 Adjusted
0.22358	6.008086	0.12212	-13.161776	0.755837	0.674274

This study uses ArcGIS10.8 software to calculate the geographically weighted regression results, the value of R2 is 0.755837, and the value of AICc is -13.161776, It can be concluded that the model fits well.

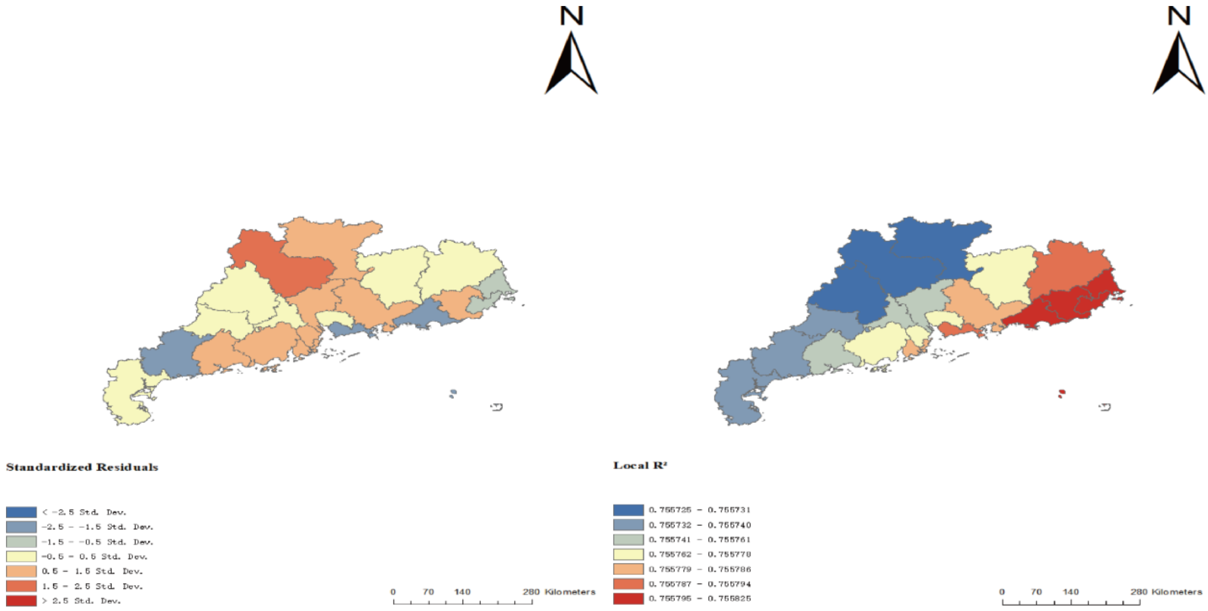

Figure 4: Standardized residuals and local R2 of geographically weighted regression of energy development in 21 cities of Guangdong Province in 2021.

The standardized residual value is more than 2.5 times, which indicates that the regression fitting effect of this region is not ideal. The standardized residual value of each city in 21 cities in Guangdong Province does not exceed 2.5 times, which indicates that the regression fitting effect of each city is ideal, and the regression result has a certain reference value. The local R2 of each city is visualized through the local R2 map, and it is found that 21 cities in Guangdong Province are gradually increasing from southwest to northeast, showing an obvious clustering trend [2].

The coefficient of the impact factors of each city is calculated by the geographically weighted regression model (GWR), and then it is divided into seven grades by the Natural interruption point method and summarized into a visual map, to reveal the local characteristics of each impact factor and analyze the spatial heterogeneity and explain the factors affecting the energy development of 21 cities in Guangdong Province and their distribution from a spatial perspective.

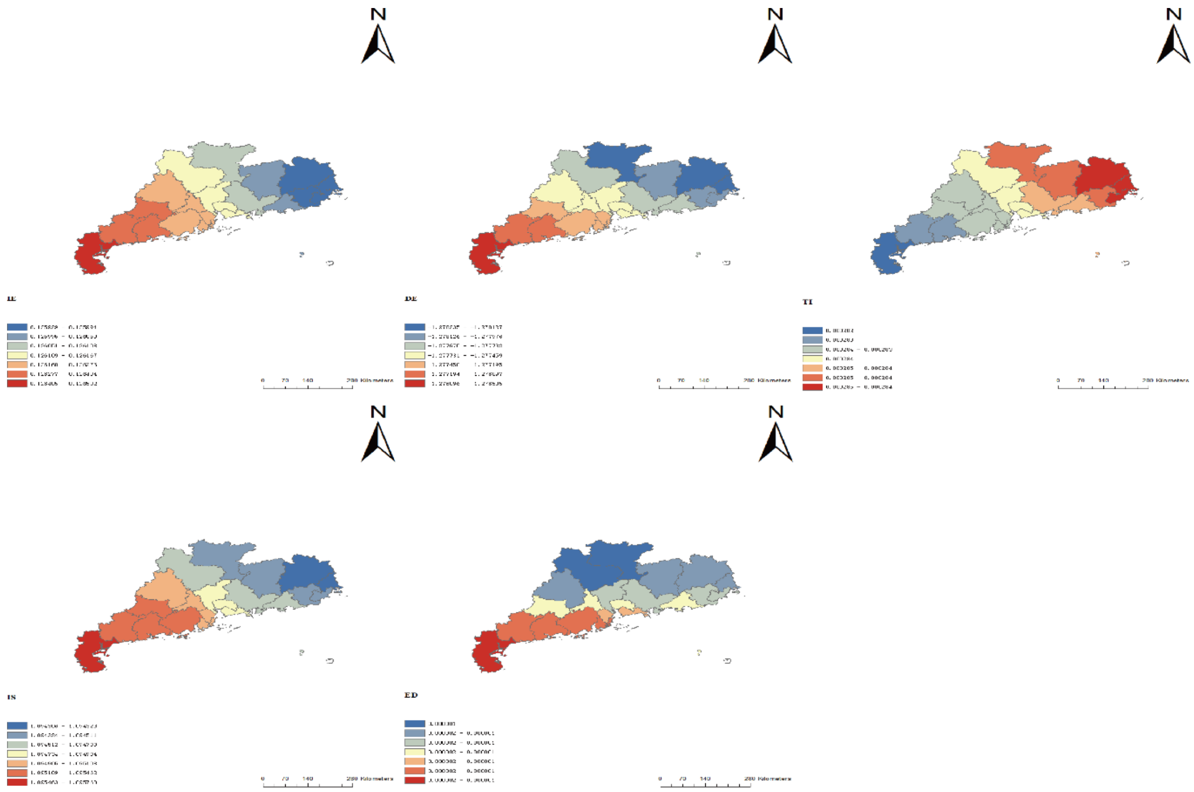

Figure 5: Various influencing factors of geographically weighted regression of energy development in 21 cities of Guangdong Province in 2021.

From Figure 5 we know that IE impact factors reflect the level of opening up of the region. The value range of IE impact factors is ［0.125929,0.126502］, that is, IE impact factors have a positive influence on the energy development of 21 cities in Guangdong Province, and the degree of impact shows a trend of increasing from northeast to southwest. The high-value area is in Zhanjiang city, and the low-value areas are in Meizhou city, Chaozhou city, Jieyang city, and Shantou city. Secondly, the DE impact factor reflects the development level of the regional digital economy. The range of the DE impact factor is［ -1.278235， -1.276505］, that is, the DE impact factor has a negative influence on the energy development of 21 cities in Guangdong Province, and the degree of impact shows a trend of increasing from the northeast to the southwest. The high-value area is in Zhanjiang city, and the low-value areas are in Shaoguan city, Meizhou city, Chaozhou city. Thirdly, the TI impact factor reflects the level of regional scientific and technological development. The value range of the TI impact factor is ［0.000282, 0.000285］. The TI impact factor positively impacts the energy development of 21 cities in Guangdong Province, and the degree of impact shows an increasing trend from the southwest to the northeast. The high-value areas are in Meizhou city, Chaozhou city, and Shantou city; the low-value area is in Zhanjiang city. In recent years, eastern Guangdong has actively achieved industrial transformation and increased the proportion of GDP in the province. Shantou city has 209 technological innovation platforms above the provincial level, leading other cities. Fourthly, the IS impact factor reflects the level of regional industrial structure. The value range of the IS impact factor is［1.094306,1.095760］. The IS factor positively impacts energy development, and the impact degree shows an increasing trend from northeast to southwest. The high-value area is in Zhanjiang city, and the low-value areas are in Meizhou city and Chaozhou city. Fifthly, the ED impact factor reflects the level of regional economic development. The value range of the ED impact factor is ［

DOI: 10.54254/2754-1169/28/20231309

0.000001,0.000002］. The ED factor positively impacts the energy development of 21 cities in Guangdong Province, and the degree of impact shows an increasing trend from north to south. The high-value area is in Zhanjiang city, and the low-value areas are in Qingyuan city and Shaoguan city. Finally, By comparing the size of the regression coefficient, the coefficient of IS influencing factor is higher than that of DE, TI, IE, ED, and other influencing factors, the influencing factor coefficient of the IE influencing factor is relatively high, and the influencing factor coefficient of DE and TI, as well as ED, are relatively low, DE influencing factors have a negative influence on the energy development of all cities in Guangdong Province, indicating that it is not necessary to over-develop the digital economy[3].

4. Conclusions and Suggestions

In 2021, the energy development of 21 cities in Guangdong Province shows significant spatial differences. About Spatial Trend Surface Analysis, the north and south wings are low and the middle is high, and the east and west wings are low and the middle is high. In 2021, the energy development of 21 cities in Guangdong Province presents positive spatial agglomeration, The coefficient of the influence factor of the level of industrial structure is higher than the influence factors of the level of development of the digital economy, the level of technological development, the level of opening up to the outside world and the level of economic development. Investment in clean and low-carbon energy, nuclear power generation, and solar power generation should be continuously increased, The construction of relevant energy engineering projects should be strengthened[4]. And focus on developing green high-tech industries with low carbon emissions[5].

References

[1] *Ren, S., et al., Digitalization and energy: How does internet development affect China's energy consumption? 2021.*

[2] *Li, Z., et al., Development of renewable energy multi-energy complementary hydrogen energy system (A Case Study in China): A review. 2020. 38(529): p. 014459872095351.*

[3] *Adom, P.K., et al., Energy poverty, development outcomes, and transition to green energy. 2021. 178.*

[4] *Jh, A., et al., Energy-saving research and development activities and energy intensity in China: A regional comparison perspective. 2020. 213.*

[5] *Guney, T.J.T.I.J.o.S.D. and W. Ecology, Biomass energy consumption and sustainable development. 2020. 27(7a8).*