Analysis of Regional Economic Spatial Agglomeration Characteristics in Jilin Province Based on Spatial Autocorrelation Theory

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Abstract-The theory of spatial autocorrelation analysis is applied to the study of clustering characteristics of the regional economy. Taking 60 county-level economic units in Jilin province as the research object, this paper made an empirical analysis on the spatial clustering characteristics of the regional economy, avoided the problem of non-uniform levels of statistical data units, analyzed the spatial autocorrelation of GDP, the primary industry, the secondary industry and the tertiary industry of GDP in Jilin province from 2010 to 2017, and made a quantitative analysis on the significance of clustering degree. On the whole, the regional economy of Jilin province has significant spatial clustering, showing the characteristics of positive spatial correlation. The significant spatial clustering units account for about one-third of the whole Jilin province. The overall agglomeration degree changed little from 2010 to 2017. The spatial clustering degree of the primary industry and the tertiary industry was consistent with GDP, while the clustering degree of the secondary industry was lower than that of the primary industry and the tertiary industry. To promote the coordinated development of the regional economy in Jilin province, it is necessary to keep close track of the changes of the clustering area and adjust regional economic policies in time.

Keywords-Regional economy; Spatial clustering; Spatial autocorrelation; GeoDa

1. Introduction

The regional economy is an important part of the national economic system. The national regional economic development strategy has been gradually adjusted in recent years, but it is still unable to avoid the increasing expansion of the regional economic differences in China. The coordinated development of the regional economy in Jilin province directly affects the social and economic development of Jilin province and even affects the coordinated economic development of Northeast China and even the whole country [1]. Therefore, it is of great significance to analyze the regional economic spatial differences in Jilin province.

The first law of geography shows that (Tobler, 1979), everything shows some connection with other things around, and is more closely related to the distance of similar things [2]. Goodchild

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proposed in 1992 that almost all spatial data have spatial dependence and spatial autocorrelation [3]. Moran's index and gear coefficient lay a foundation for the practical application of spatial autocorrelation theory. Tang Xiaoxu analyzed the spatial distribution of GDP of 44 county-level economic units in Liaoning Province and studied the spatial correlation of GDP of each county [4]. Hu Qingfeng studied the spatial correlation of the GDP growth rate of prefecture-level cities in Henan Province in the first quarter of 2006[5]. Liu Deying used ESDA spatial analysis method to study the global and local spatial distribution characteristics of 40 county-level economic units in Jilin province [6]. Gu Guofeng and Wu Yingzhe analyzed the temporal and spatial characteristics of the population age structure of 47 administrative units in Jilin province from 2005 to 2015 based on the ESDA analysis method [7].

There are relevant studies on the spatial correlation analysis of the regional economy in Jilin province. Most of the data used in the study are 47 economic units, and there are cases where multiple municipal districts are merged into the city for statistics. The high value of some units may be due to the merger of statistics in multiple municipal districts, which will affect the performance of spatial agglomeration, from two aspects of the time dimension and space dimension, this paper analyzes the spatial correlation of 60 county-level economic units in Jilin province from 2010 to 2017 based on the Geoda software and summarizes the spatial distribution characteristics of different economic indicators of county-level economic units in Jilin province.

2. Research methods

Collect and sort out the economic statistical data of 60 county-level units in Jilin province, mainly including GDP, primary industry, secondary industry, and tertiary industry data. After necessary data processing, make attribute connection with spatial data and use the typical software Geoda for exploratory spatial data analysis to carry out global autocorrelation and local autocorrelation analysis of economic indicators of 60 units in Jilin province. This paper analyzes the spatial agglomeration characteristics of the county-level regional economy in Jilin province.

3. Spatial autocorrelation analysis

Generally, the units with linear correlation have a small geographical distance, while the spatial autocorrelation analysis mainly studies whether the adjacent units are related to each other and summarizes the correlation strength. By comparing the observed results with their unknown similarity, we can deal with the variation law of these variables. Spatial autocorrelation can be divided into global spatial autocorrelation and local autocorrelation. The global autocorrelation index reflects the correlation mode of some attribute value of each spatial unit in the whole region, and the local autocorrelation reflects the correlation degree between the spatial unit and its adjacent units. To study the spatial distribution characteristics of county-level economic units in Jilin province, the Moran's index is used to analyze the global pattern and spatial distribution characteristics of county-level economic activities in Jilin province, and the Local Moran's index is used to identify the local aggregation characteristics, that is, the distribution characteristics of high-value clusters and low-value clusters.

3.1 Global spatial autocorrelation analysis

To test the spatial correlation of 60 county-level economic units in Jilin province in geospatial space, the most commonly used variable test method in Spatial Econometrics: global spatial autocorrelation statistics, which can reflect the spatial distribution characteristics of an element in the whole system, is usually expressed by Moran's index, and its calculation formula is as follows (1):

$$I = \frac{\sum_{i=1}^{n}\sum_{j\neq i}^{n} W_{ij}(X_i - \overline{X})(X_j - \overline{X})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{1}$$

Where: S^2 is the variance of the sample; X_i and X_j respectively represent the GDP and other economic indicators of county-level unit i and county-level unit j. $\overline{X}$ is the average value of county-level GDP and other economic indicators. n is the total number of county-level administrative units in Jilin province, where it is equal to 60. W_{ij} is the spatial weight matrix adjacent to the queen, which defines the adjacency relationship between regions. If region i and region j are adjacent, $W_{ij} = 1$, otherwise $W_{ij} = 0$. The value range of Moran's index value is [-1, 1]. When it is between (0, 1), it indicates that there is a spatial positive correlation between variables, and the closer the value is to 1, the stronger the spatial positive correlation; when it is between [-1, 0), it indicates that there is a spatial negative correlation between variables, and the closer the value is to -1, the stronger the spatial negative correlation; if Moran's index value is equal to 0, it indicates that regional variables are random in spatial distribution.

3.2 Local spatial autocorrelation analysis

Local spatial autocorrelation is used to reflect the local spatial correlation and spatial difference degree of spatial units with certain attribute characteristics. The spatial visualization of local differences can be realized through software, and then the regional spatial distribution law can be found. Local Moran's index formula is as follows (2):

$$I_i = \frac{X_i - \overline{X}}{S^2} \sum_{j\neq i} W_{ij}(X_j - \overline{X}) \tag{2}$$

$I_i > 0$ indicates that there is a positive correlation between regions with certain attributes and adjacent regions, otherwise, there is a negative correlation. Moran scatters plot is generally used to depict local spatial correlation. The four quadrants of the Moran scatter diagram represent four different spatial correlation patterns: spatial positive correlation includes HH (high-high) region in the first quadrant; The third quadrant is LL (low-low) area; The spatial negative correlation includes that the second quadrant is the LH (low-high) region; The fourth quadrant is the HL (high-low) area.

4. Empirical analysis of spatial agglomeration characteristics of the regional economy in Jilin Province Based on spatial autocorrelation theory

4.1 Data acquisition

The attribute data of 60 county-level economic units used in the study are from the data publicly released in the statistical yearbook of Jilin province, the statistical yearbook of various regions, and the government work report. The spatial data of 60 county-level economic units are from the relevant data of the Ministry of Civil Affairs and the Internet. The format is SHP and the spatial reference system is CGCS_2000, geographic coordinate system, accurate domain information, which can meet the macro requirements of research.

4.2 Data preprocessing

Extract the GDP, primary industry, secondary industry, and tertiary industry data of 60 county-level economic units in Jilin province into excel tables for necessary standardized processing, to meet the requirements of numerical units and attribute connection. The attribute connection between vector data and excel table is realized by ArcGIS, and the SHP format data for analysis is exported.

4.3 Global spatial autocorrelation analysis of the regional economy in Jilin province

With the support of Geoda 1.12.1.139, the spatial weight matrix is created based on the first-order queen adjacency standard, and the global spatial autocorrelation analysis of GDP, primary industry, secondary industry, and tertiary industry in the economic indicators of 60 county-level economic units in Jilin province from 2010 to 2017 is carried out. The analysis results are shown in Table 1.

Table 1 Statistics of global moran's index and its significance test of economic indicators of county-level economic units in Jilin Province from 2010 to 2017

Year	GDP			Primary industry			Secondary industry			Tertiary industry		
	Moran's index	Z score	P-value	Moran's index	Z score	P-value	Moran's index	Z score	P-value	Moran's index	Z score	P-value
2010	0. 4190	5. 1979	0. 00004	0. 4190	5. 1979	0. 00004	0. 1976	2. 5855	0. 01132	0. 5009	6. 1490	0. 00001
2011	0. 4429	5. 4906	0. 00002	0. 4429	5. 4906	0. 00002	0. 1906	2. 5534	0. 01214	0. 4166	5. 1644	0. 00003
2012	0. 4664	5. 7549	0. 00001	0. 4664	5. 7549	0. 00001	0. 2620	3. 3160	0. 00177	0. 4024	4. 9714	0. 00003
2013	0. 4211	5. 2110	0. 00003	0. 4211	5. 2110	0. 00003	0. 1904	2. 4892	0. 01121	0. 3909	4. 8428	0. 00005
2014	0. 4847	5. 9610	0. 00001	0. 4847	5. 9610	0. 00001	0. 1428	1. 9546	0. 03426	0. 4022	4. 9931	0. 00005
2015	0. 4585	5. 6509	0. 00002	0. 4585	5. 6509	0. 00002	0. 1655	2. 1493	0. 02298	0. 4151	5. 1468	0. 00002

2016	0. 4587	5. 6361	0. 00001	0. 4587	5. 6361	0. 00001	0. 1694	2. 2139	0. 0206	0. 4108	5. 0839	0. 00002
2017	0. 4525	5. 6500	0. 00002	0. 4525	5. 6500	0. 00002	0. 2001	2. 5656	0. 01079	0. 4126	5. 1282	0. 00003

Where P-value represents probability. It reflects the possibility of an event. In the analysis of spatial correlation, P-value represents the probability that the observed spatial pattern is created by a random process. The Z score represents a multiple of the standard deviation. Table 2 shows the uncorrected critical P values and critical z scores at different confidence levels:

Table 2 Z score and P score

Z score	**P value**	**Confidence**
<-1. 65 or >1. 65	<0. 10	90%
<-1. 96 or >1. 96	<0. 05	95%
<-2. 58 or >2. 58	<0. 01	99%

From the global Moran's index and significance test statistics of GDP and the output value of three industries in Jilin province, except that the Z score of secondary industry in Jilin province in 2014 was 1. 9546, which was only less than the threshold of 1.96, P-value was much less than 0.01 except that the secondary industry was greater than 0. 01 and less than 0. 05 from 2013 to 2017. On the whole, the county-level economic units in Jilin province have significant spatial positive correlation agglomeration in GDP, primary industry, secondary industry, and tertiary industry. In the spatial agglomeration model with similar attribute values, the spatial units with higher (low) GDP values tend to the spatial units with higher (low) GDP levels.

Comparing the GDP Moran's index with the Moran's index of primary industry, secondary industry, and tertiary industry (Figure 1), shows the changes of Moran's index of the county-level economy in Jilin province from 2010 to 2017. On the whole, GDP, primary industry, and tertiary industry fluctuate little, ranging from [0.3909-0.5009], and are stable each year, It reflects that the county-level economic units in Jilin province have obvious agglomeration characteristics as a whole, and have always maintained this agglomeration characteristics. The overall Moran's index of the secondary industry is lower than GDP, the primary industry, and the tertiary industry, between [0.1428-0.2620], which also reflects certain agglomeration characteristics. The degree of agglomeration is lower than the former and has always been in a stable agglomeration state.

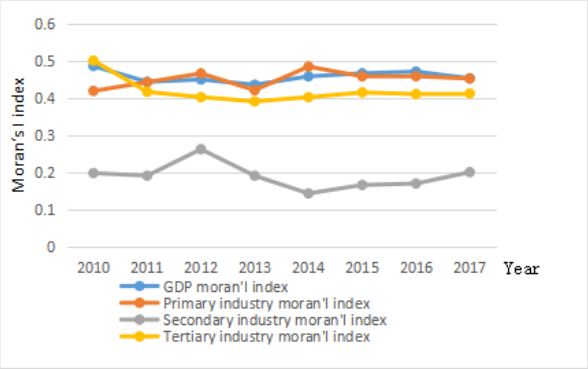

Figure 1. Global Moran's index changes of county-level economic units in Jilin province over the years

4.4 Local spatial autocorrelation analysis of regional economy in Jilin province

The same as the global spatial autocorrelation method, the spatial weight matrix is also created based on the first-order queen adjacency standard. The local spatial autocorrelation analysis of GDP, primary industry, secondary industry, and tertiary industry in the economic indicators of 60 county-level economic units in Jilin province from 2010 to 2017 is carried out, and the Lisa significance map and Lisa cluster map are generated.

1) The local autocorrelation analysis of GDP indicators of county-level economic units in Jilin province (Fig. 2) shows that from 2010 to 2017, an average of 20 county-level economic units have significant spatial correlation, and the annual change of agglomeration scope is small. High-level agglomeration occurs in 11 county-level units in most years, including Changyi District, Chaoyang District, Dehui City, Fuyu County, Jiutai District, Kuancheng District, Lvyuan District, and Ningjiang district, Nong'an County, Yushu city and Changling County have repeatedly adjusted the agglomeration scope of Gaogao, with a maximum of 13 county-level units in 2012 and a minimum of 8 in 2017. From 2015 to 2017, the agglomeration scope tends to gradually narrow. In most years, low-level agglomeration occurred in five county-level units in Dongchang District, Fusong County, Helong City, Hunchun city, and Tonghua County. In 2010, there were up to nine county-level units. The agglomeration scope showed a narrowing trend and narrowed to four county-level units in 2017. The spatial negative correlation is relatively concentrated. The low and high agglomeration is mainly concentrated in two county-level units of Shulan city and Shuangliao City, and the high and low agglomeration is mainly concentrated in two county-level units of Hunjiang district and Yanji city.

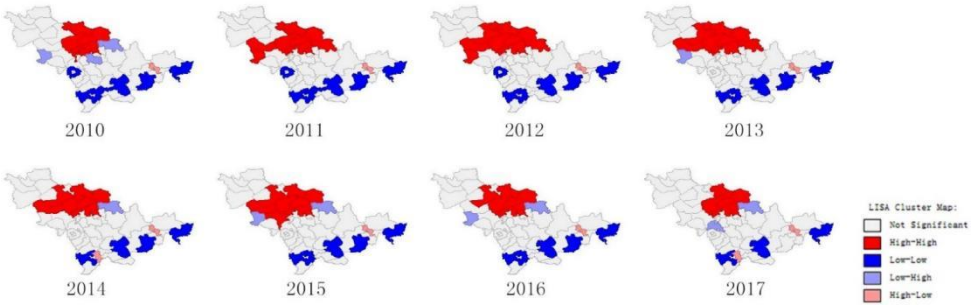

Figure 2. Lisa cluster diagram of county-level unit GDP in Jilin province from 2010 to 2017

2) The local autocorrelation analysis of the primary industry indicators of county-level economic units in Jilin province (Fig. 3) shows that from 2010 to 2017, an average of 14 county-level economic units had significant spatial correlation, and the agglomeration range was relatively stable. The high-level agglomeration occurred in 9 county-level units in most years, including Dehui City, Fuyu County, Gongzhuling City, Jiutai District, Nong'an County, Shulan city and Shuangliao City, In Yushu city and Changling County, low-low agglomeration occurs in four county-level units in Hunjiang District, Longjing City, Tonghua County and Tumen City in most years. The spatial negative correlation is relatively concentrated, low-high agglomeration does not exist, and high-low agglomeration is mainly concentrated in one county-level unit in Tiedong District.

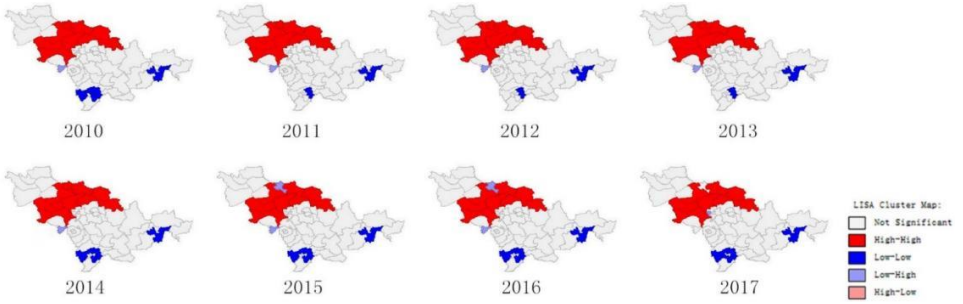

Figure 3. Lisa cluster diagram of the primary industry of county-level units in Jilin province from 2010 to 2017

3) The local autocorrelation analysis of secondary industry indicators of county-level economic units in Jilin province (Fig. 4) shows that from 2010 to 2017, an average of 10 county-level economic units has a significant spatial correlation. High concentration occurs in four county-level units in Fuyu County, Jiaohe City, Ningjiang district, and Nong'an County in most years. Ningjiang district did not enter the range of high concentration from 2015 to 2017. In most years, low-low agglomeration occurs in Helong city and Tonghua County. Longjing City was added from 2016 to 2017, with a relatively concentrated spatial negative correlation. Low high agglomeration is mainly concentrated in Changyi district and Shulan City, and high-low agglomeration is mainly concentrated in Hunchun city and Yanji city.

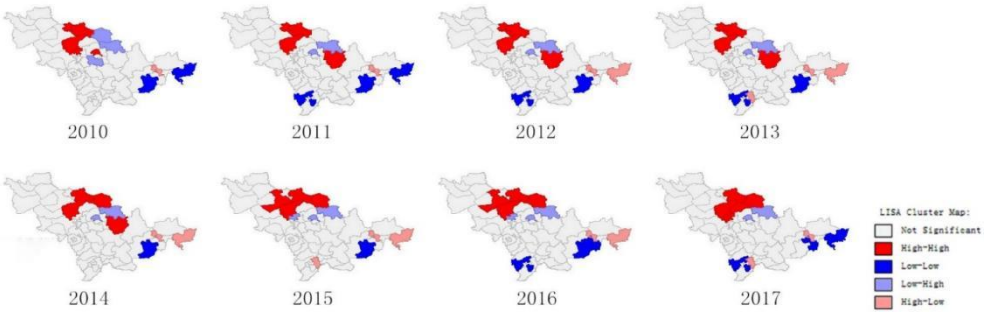

Figure 4. Lisa cluster diagram of secondary industry of county-level units in Jilin province from 2010 to 2017

4) The local autocorrelation analysis of tertiary industry indicators of county-level economic units in Jilin province (Fig. 5) shows that from 2010 to 2017, an average of 19 county-level economic units has a significant spatial correlation. High concentration occurs in 9 county-level units in Changyi District, Chaoyang District, Dehui City, Erdao District, Fuyu County, Kuancheng District, Longtan District, Nanguan District, and Nong'an County in most years, from 2010 to 2017, there was a trend of narrowing the scope of agglomeration. Low-level agglomeration occurred in 6 county-level units in Dongliao County, Fusong County, Helong City, Hunchun City, Hunjiang district, and Longshan District in most years. From 2010 to 2017, there was a trend of narrowing the scope of agglomeration. The spatial negative correlation is relatively concentrated. The low and high concentration is mainly concentrated in three county-level units of Lvyuan District, Shulan city, and Yitong Manchu Autonomous County, and the high and low concentration is mainly concentrated in one county-level unit of Yanji city.

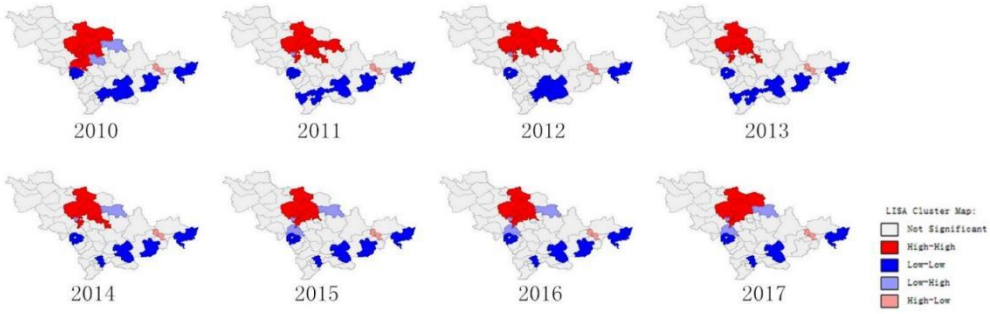

Figure 5. Lisa cluster diagram of tertiary industry of county-level units in Jilin province from 2010 to 2017

5. Conclusions

The theory of spatial autocorrelation analysis is applied to the agglomeration characteristics of the county-level regional economy in Jilin province. Using the exploratory analysis software Geoda, this paper selects 60 county-level economic units in Jilin province as the research object,

avoids the problem of inconsistent level of statistical data units, analyzes the spatial autocorrelation of GDP, primary industry, secondary industry, and tertiary industry from 2010 to 2017, and makes a quantitative analysis on the degree and significance of agglomeration. The following conclusions are obtained.

1) On the whole, the regional economy of Jilin province has significant spatial agglomeration, showing the characteristics of spatial positive correlation. The significant spatial agglomeration unit accounts for about 1 / 3 of the whole Jilin province. The spatial aggregation characteristics of primary industry, tertiary industry, and GDP are relatively consistent, and the aggregation degree of the secondary industry is lower than that of primary industry and tertiary industry.

2) There are great differences in regional economic development among counties and cities in Jilin province. The county-level units in Changchun, Jilin, and Songyuan in the middle of Jilin province have formed high-rise agglomeration areas, and the economic development presents a benign trend. Yanbian, Tonghua, and Baishan areas in the southeast of Jilin province are low concentration areas. There are relatively few spatial negative correlation areas.

3) From 2010 to 2017, the spatial agglomeration change of county-level economic units in Jilin province was relatively stable. To realize the coordinated development of the regional economy in Jilin province, the follow-up economic policies can tend to strengthen the high agglomeration area, so that this area can quickly form a cluster scale response; The low-level agglomeration area develops one unit intensively, and then drives the surrounding areas to gradually form the agglomeration effect; Strengthen policy guidance in low and high concentration areas to integrate them into the surrounding high concentration areas; High and low concentration areas increase the radiation effect on surrounding units and form industrial complementarity with high-value areas.

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