Study on Evolution of Spatial Structure of Pan-Linxia Economic Zone

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Abstract

This paper applies spatial correlation method in spatial statistics and GIS technology to analyze special structural form and evolution process of regional economy of Pan-Linxia region. Morphological analysis of spatial structure shows the correlation between economic development level of Linxia City and regional economic development in the minority area of south Gansu has strong complementarities. The evolution of spatial structure shows spatial correlation between the economy in Linxia City and the economy in the adjacent area displays a declining trend. This means the pivotal role of Linxia economy in regional economy is weakening.

Keywords: spatial correlation, Linxia, regional economy, GIS

1. Introduction

The core of spatial statistical analysis is to cognize spatial dependence, spatial correlation or spatial autocorrelation among the data related to geographic position and to establish statistical relation of data through spatial position. Spatial autocorrelation is an important method in the research of spatial statistics. It establishes statistical relation of data through spatial positions carries out statistical analysis of characteristic values of some attribute of the space and describes the degree of correlation of specific characteristics or attribute values in the region or adjacent area quantitatively. During spatial data processing, spatial autocorrelation analysis can solve the problem of traditional quantity statistics model, i.e. it cannot consider the correlation of numerical values and the correlation of two-dimensional space. This method has been widely applied in many fields such as geology, environment, agriculture, economy and military. The applied research of spatial correlation in economic field started in China in 1980s. It was mainly used in study economic development difference, connection and interaction relations among regions. After 2005, with the introduction and application of GIS (Geographic Information System), spatial statistics method was applied more widely in economic field.

GIS is a specific and very important spatial information system. It is a technology system to collect, store, manage, operate, analyze, display and describe geographical distribution data in the whole or partial earth surface (including atmospheric layer) space under the support of computer hardware and software systems. GIS technology integrates unique visualization effects of the map, geographic analysis function and general database operation (such as inquiry and statistical analysis) to analyze and handle spatial information and provides a method to understand correlative dependence and mutual effect of regions in certain space. Spatial statistical analysis is a significant function of GIS. GIS software utilizes spatial characteristics of attribute data to implement numerical value correlation analysis on the basis of analysis of spatial position relations. The essence of spatial characteristics can be disclosed more accurately and visually through GIS.

Currently, international frequently-used GIS software includes ArcGIS launched by ESRI Company, MapInfo of MapInfo Company, Geoconcept of GEOCONCEPT Group and so on. Domestic software mainly includes SurperMap, MapInfo (development tool: MapX) and MapGIS of SurperMap Company. Among them, the function of ArcGIS software is most powerful and applied most widely.

In ancient times, Linxia was an important communication hub of the south section of the Silk Road, Tanfan ancient road and Gansu-Sichuan ancient road. It connects economic circle of Lanzhou (a central city) and the minority area in south Gansu, with profound commerce and trade culture traditions. It has been called “western dry wharf” and “tea-horse trade”. After the reform and opening-up, commerce circulation started to develop toward normalization and scale, and the operation mode gradually transformed to modern type from traditional type. Commerce circulation of Hui Autonomous Prefecture of Linxia has formed such circulation network that putting both ends of the production process on the world market, domestic and foreign connection and communicating urban and rural areas. National articles and Moslem food expand the new market. Modern logistics is rising. Pan-Linxia commerce and trade zone with Linxia City as the hub including south Gansu and the minority area in the east of Qinghai and connecting Qinghai-Tibet Plateau and Loess Plateau has formed. Besides, this zone is evolving continuously. For the convenience of study, based on China’s administrative division and combining natural geographic position, this paper defines Linxia City, Linxia County, Jishishan County, Xiahe County, Hezheng County, Lintan County, Dongxiang County and Luqu County of Gansu Province as well as Xunhua County of Qinghai Province as Pan-Linxia Economic Zone. Besides, this paper defines the areas in the west of Fengxian County of Gansu Province, including Jishishan County, Linxia County, Yongjing County, Dongxiang County, Dingxi County and Jingning County as well as 26 countries in the south of Fengxian County of Gansu Province (excluding Luqu County, relatively far away from Linxia City) plus Xunhua County of Qinghai Province as southern region of Gansu Province. Meanwhile, this paper defines three counties where the Tibetan nationality gathers (Xiahe, Luqu and Lintan) near Linxia City in Gannan Tibetan Autonomous Prefecture as Tibetan region in south Gansu. At the same time, in the study process, the region outside Pan-Linxia Economic Zone and other southern areas of Gansu Province serve as the comparison object for analysis. Spatial structural features of Pan-Linxia Economic Zone in economic development are explained through comparison.

This paper applies spatial statistics tools in Arcgis software system and spatial correlation statistics approach to study spatial correlation of regional economic development in the southern region of Gansu Province through taking county economy as a basic unit. This paper focuses on discussion of spatial structure and evolution law of county economic development in Pan-Linxia Economic Zone. The specific research methods are as follows: firstly, overall correlation of regional economy is estimated through calculation and analysis of overall correlation of regional economy in the southern area of Gansu; later, morphological characteristics of spatial structure and evolutionary trend of regional economic development in Pan-Linxia Economic Zone are gained through analysis of partial spatial correlation of regional economy in the southern area of Gansu; finally, based on analysis of structural evolution trend of regional economy in Pan-Linxia Economic Zone, suggestions on development direction of regional economic structure are put forward.

2. Data Source and General Situation of Study Area

2.1 Data Source

Spatial data in this study are vector format data of geographic space distribution in the county territory of Gansu and Qinghai. The attribute data mainly include GDP data of 26 countries in the southern area of Gansu Province and one county of Qinghai Province. The data come from statistical yearbooks in 2001, 2006 and 2011 in Gansu Province and Qinghai Province.

2.2 General Situation of Study Area

Pan-Linxia Economic Zone is located in the southern area of Gansu Province. Overall economic development of this area lags behind relatively and county economic development is unbalanced. Figure 1, Figure 2 and Figure 3 show the distribution diagrams of per capita GDP of southern area of Gansu Province and Xunhua County of Qinghai Province in 2001, 2006 and 2011. It can be seen from the figures that there are two regions with leading economic development in the southern area of Gansu Province: 1) geographic area including Chengxian County at the junction of Sichuan and Shaanxi, Huixian County and Liangdang County. This area is rich in natural resources with convenient traffic and developed economy; 2) Pan-Linxia Economic Zone at the junction of Gansu province and Qinghai Province. This area owns complementarity of regional economic development. Since Gannan Tibetan Autonomous Prefecture has rich natural resources and developed economy with national features, per capita GDP in 2001 reached 2302 Yuan. Though Hui Autonomous Prefecture of Linxia is relatively poor in natural resources, due to unique regional advantage and favorable trade culture tradition of Linxia City, this city becomes the hub connecting Gannan Tibetan Autonomous Prefecture and Lanzhou. So, the commodity economy is relatively developed and the starting point of economic development is high. In 2011, per capita GDP of Linxia City reached 3176. However, in recent years, the development speed has the slowdown trend compared with adjacent Gannan Tibetan Autonomous Prefecture. Due to the effects of endogenous factors such as economic development resources, population, science and technology, education and industrial structure, spatial structure of economic development in Pan-Linxia Economic Zone is evolving. (The place names in the maps below are all the names of the counties).

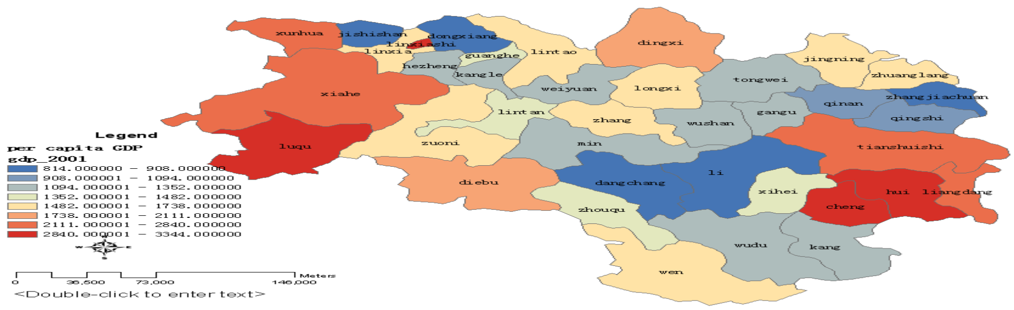

Figure 1. Average per person GDP distribution diagram of counties in south Gansu Province in 2001

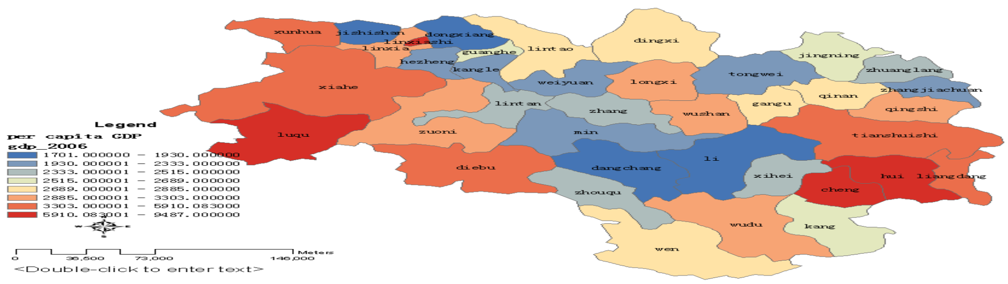

Figure 2. Average per person GDP distribution diagram of counties in south Gansu Province in 2006

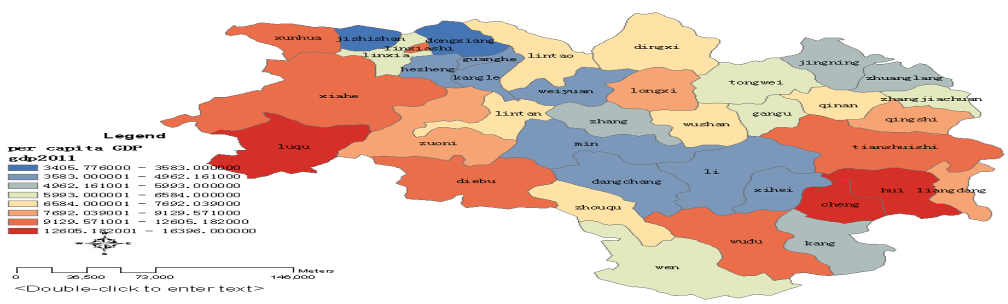

Figure 3. Average per person GDP distribution diagram of counties in south Gansu Province in 2011

3. Fundamentals and Methods

3.1 Overall Spatial Autocorrelation

Overall spatial autocorrelation index is used to describe the overall distribution of a geographical phenomenon or an attribute value in certain space and to judge whether such phenomenon or attribute value has aggregation feature in the space. There are many indexes and methods to express overall spatial autocorrelation, mainly including overall Moran's I, overall Geary's C and overall Getis-Ord G. All of them measure overall spatial autocorrelation through comparing the degree of similarity of observed values of adjacent positions of the space. Compared with these three overall spatial autocorrelation indexes, when judging whether a region has spatial aggregation and especially estimating the aggregation area is located at the edge of the area, the statistics result of Moran's I index is more reliable; when judging whether it is high-value aggregation or low-value aggregation, attribute values can be used.

Specific algorithm of Moran's I is as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{1}$$

Where, $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$

$W = \begin{bmatrix} w_{11} & \dots & w_{1n} \\ \dots & \dots & \dots \\ w_{n1} & \dots & w_{nn} \end{bmatrix}$ is spatial weight matrix. The values of spatial weights have two types: 1) Distance-Based Spatial Weights; 2) Contiguity-Based Spatial Weights Distance-Based Spatial Weights include:

K-Nearest Neighbor

Sort in an ascending order according to regional distance and top k values nearest the region are the solution.

$$w_{ij} = 1/d_{ij}^{m}$$

Where, m is power; d_{ij}^{m} is regional distance (generally the distance of gravity center between two regions)

Threshold Distance Weight

$$w_{ij} = \begin{cases} 1 & \text{Distance from Region i and Region j is less than d} \\ 0 & \text{Distance from Region i and Region j is greater than or equal to d} \end{cases}$$

d is the minimum distance set.

Contiguity-Based Spatial Weights include:

Rook Weight

$$w_{ij} = \begin{cases} 1 & \text{Region i and Region j have a common boundary} \\ 0 & \text{i=j or Region i and Region j have no common boundary} \end{cases}$$

Queen Weight

$$w_{ij} = \begin{cases} 1 & \text{Region i and Region j have a common boundary or common peak} \\ 0 & \text{i=j or Region i and Region j have no common boundary or common peak} \end{cases}$$

For Moran's I index, standardized statistics Z can be used to test whether n regions have spatial autocorrelation. The computational formula of Z is as follows:

$$Z = \frac{I - E(I)}{\sqrt{VAR(I)}} \tag{2}$$

Where, the expected value is $E(I) = -\frac{1}{n-1}$

When the value of Z is positive and significant, this indicates there is positive spatial autocorrelation; when the value of Z is negative and significant, this indicates there is negative spatial autocorrelation; when the value of Z is zero, the observed values present completely independent random distribution.

3.2 Partial Spatial Autocorrelation

Overall spatial autocorrelation index describes the correlation of specific attributes of all individuals in the space. Such description cannot display instability of partial state in the space. Thus, partial index is needed to explore autocorrelation of partial space. Partial spatial autocorrelation analysis is used to identify spatial correlation modes (or spatial agglomeration modes) which may exist in different spatial positions so as to discover partial instability in different space and spatial heterogeneity of data and provide basis for classification of space regions. Statistical indexes to describe partial spatial correlation mainly contain partial Moran's I, partial Geary's C and partial Getis-Ord G. In accordance with the conclusion of Literature, partial Moran's I index and partial Getis-Ord G index have significant difference in the ability to detect spatial aggregation. The ability of partial Moran's I, index to detect side and corner aggregation regions is stronger than that to detect other positions. Generally, Moran's I index can roughly detect the center of the aggregation regions, but has large deviation in the aspect of identifying aggregation scope. Thus, the scope detected is smaller than the actual scope. Partial Getis-Ord G index is partial spatial autocorrelation index based on spatial weight matrix. It can detect high-value aggregation and low-value aggregation. Besides, it can accurately detect the aggregation region. After overall consideration, this paper adopts partial Getis-Ord G index to carry out partial spatial autocorrelation analysis of spatial correlation of regional economic development in the southern area of Gansu Province and Pan-Linxia Economic Zone. The specific algorithm of partial Getis-Ord G index is as follows:

$$G_i = \frac{\sum_{j}^{n} w_{ij} x_j}{\sum_{j}^{n} x_j} \tag{3}$$

Where, w_{ij} is distance weight between Unit I and Unit j. Significant positive G_i means the observed value adjacent to Unit i is high. This indicates spatial attribute in this neighborhood is positive correlation. Significant negative G_i means the observed value adjacent to Unit i is low. This indicates spatial attribute in this neighborhood is negative correlation. When G_i is zero, the observed values present completely independent random distribution.

Standardization of partial G_i index:

$$Z(G_i) = \frac{G_i - E(G_i)}{\sqrt{VAR(G_i)}} \tag{4}$$

Where, $E(G_i)$ is the expected value; $VAR(G_i)$ is the variance.

4. Applied Analysis

4.1 Analysis of Evolution Features of Overall Spatial Economic Development

Spatial Autocorrelation Morans I of Arcgis software system is applied to conduct overall Moran's I statistical analysis of per capita GDP of the counties in the southern area of Gansu province in 2001, 2006 and 2011 according to Formula (2). Overall evolution trend chart of regional economic development pattern in this region can be gained, as shown in Figure 4.

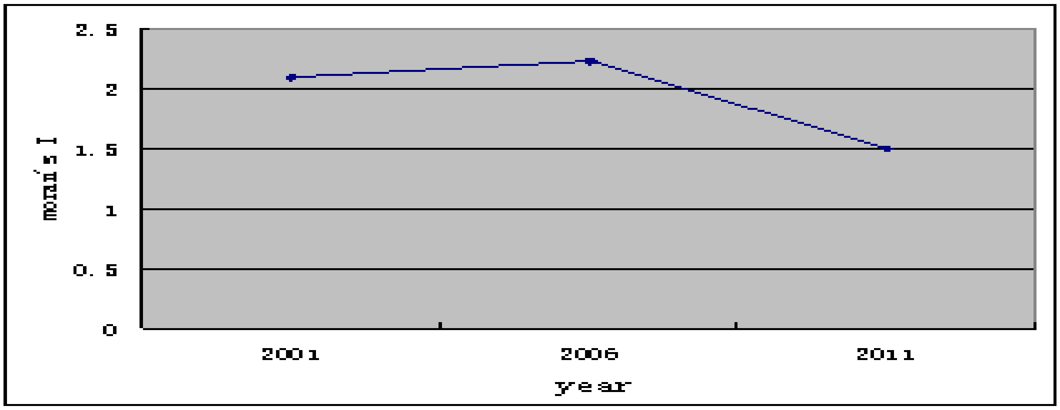

Figure 4. Overall evolution trend chart of regional economic development pattern in the southern area of Gansu Province

It can be seen from Figure 4 that Z value of per capital GDP o f the counties in the southern area of Gansu Province exceeded 2.1 in 2001 and 2006. This shows spatial features have significant positive correlation. In other words, high value and high-value region, low value and low-value region are adjacent. Spatial correlation of overall distribution is strong, and the economic development is relatively balanced. In 2011, overall Moran's I statistics Z of each county territory in this region was 1.5, down significantly. This indicates the economy of this region is in the stage of polarized economic development and that the overall situation presents non-balanced development characteristic. Such polarization effect has significant increasing trend.

4.2 Analysis of Evolution Features of Partial Spatial Economic Development

Through overall Moran's I analysis, overall structure trend of economic development in the southern area of Gansu Province since 2001 can be seen. To further analyze the effects of Pan-Linxia Economic Zone on economic development of the whole southern area of Gansu Province, this paper adopts partial spatial autocorrelation index to analyze spatial structure of economic development of the southern area of Gansu Province and get structural characteristics of economic development of Pan-Linxia Economic Zone. The specific practice is as follows: partial Getis-Ord G index and Hot Spot Analysis (Getis-Ord Gi*) of Arcgis are applied to analyze per capital GDP of the counties in the southern area of Gansu Province in 2001, 2006 and 2011 according to Formula (4). Threshold Distance Weight and ROOK Weight are adopted to take the values of spatial weight matrix. Threshold Distance Weight is mainly used to analyze spatial correlation of trans- territory. ROOK Weight is mainly used to analyze spatial correlation of adjacent regions. Figure 5a, Figure 6a and Figure 7a show partial GIZScore distribution diagrams of the southern area of Gansu Province in 2001, 2006 and 2011 gained through analysis of minimum weight value. Figure 5b, Figure 6b and Figure 7b show partial GIZScore distribution diagrams of the southern area of Gansu Province in 2001, 2006 and 2011 gained through analysis of ROOK weight value.

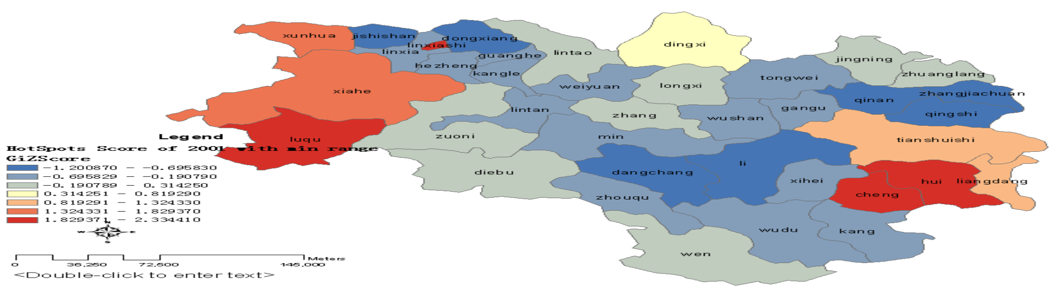

Figure 5a. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2001 (min. distance weighted)

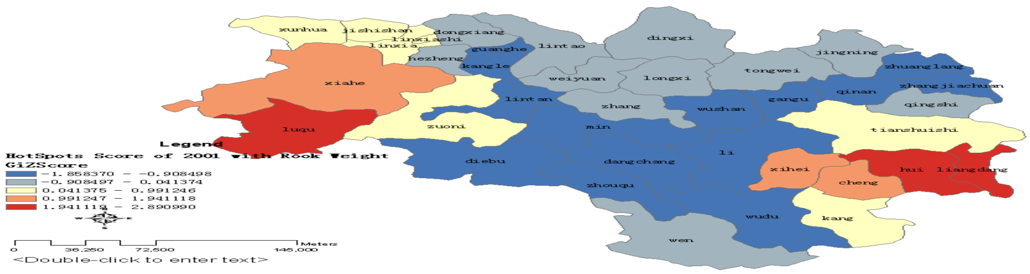

Figure 5b. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2001 (ROOK weighted)

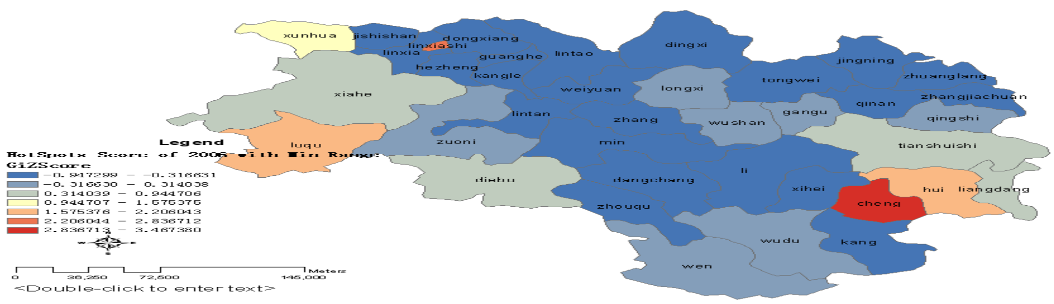

Figure 6a. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2006 (min. distance weighted)

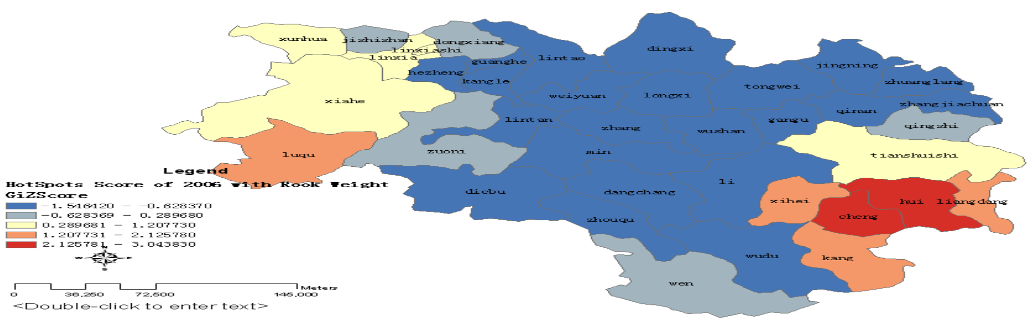

Figure 6b. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2006 (ROOK weighted)

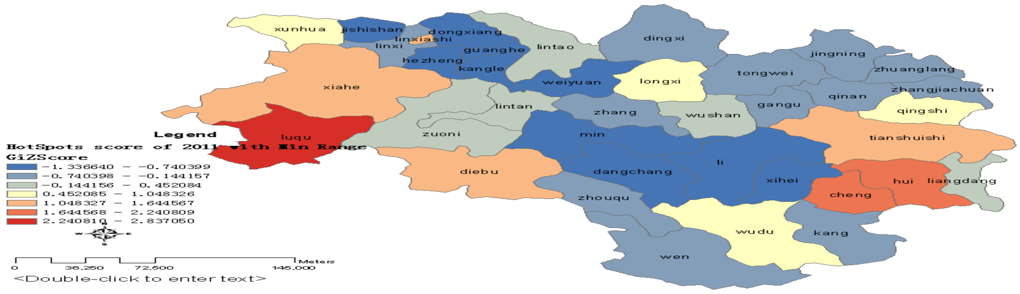

Figure 7a. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2011 (min. distance weighted)

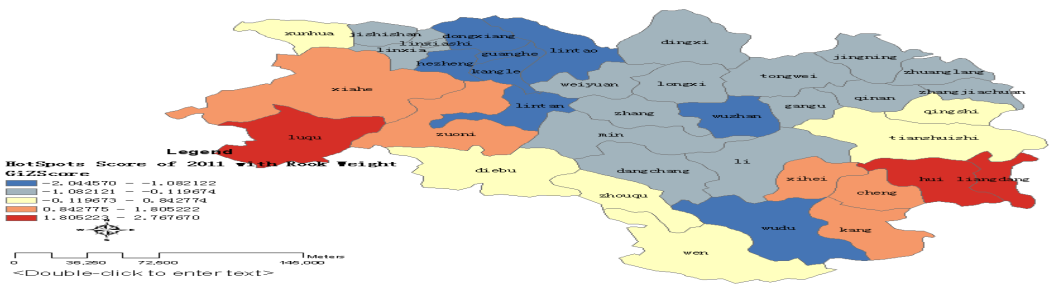

Figure 7b. Average per capita GDP gizscore distribution diagram of counties in south Gansu Province in 2011 (ROOK weighted)

The following conclusions can be drawn according to the distribution of partial Getis-Ord G index in the study area and time evolution shown in Figure 5a, Figure 6a and Figure 7a and Figure 5b, Figure 6b and Figure 7b.

Firstly, seeing from geographical distribution, two major high value and highly correlated aggregation regions exist in county economy in the southern area of Gansu Province. The first region is the boundary region near Sichuan and Shaanxi in southeast Gansu with the center of Huixian County and Chengxian County including Kangxian County, Xihe County and Liangdang County. This region is rich in natural resources with convenient traffic. Highly correlated aggregation group has formed. The other high-value correlation region is the economy and trade zone in the southwest region of Gansu province, including of Linxia City, Xiahe, Hezuo, Luqu and Lintan. Linxia City is the major commodity distributing center of this economy and trade zone. Although Hui Autonomous Prefecture of Linxia ia poor in natural resources and the industrial and agricultural production lags behind, owning to specific commercial culture tradition and unique geographical advantage, integrated economic cluster which takes Linxia City as the hub and connects Gannan Tibetan Autonomous Prefecture and economic circle of Lanzhou. Thus, Pan-Linxia Economic Zone forms.

Secondly, economic development of Pan-Linxia Economic Zone has particularity. When Hot Spot Analysis is adopted in this paper, two types of weight matrixes are adopted including Threshold Distance Weight and ROOK Weight. The two types of analytical methods correspond to a series and b series of Figures, 5, 6 and 7 respectively. Spatial correlation of economic development in Linxia City and Gannan Tibetan Autonomous Prefecture can be seen from a series of analysis charts. This is matched with the reality that Linxia City serves as national commodity distributing center of Gannan Tibetan Autonomous Prefecture. It can be seen from b series of analysis charts that spatial correlation between economic development of Linxia City and economic development of the adjacent counties is not strong. Economic development of this city has no strong radiation for surrounding counties and cities and does not play the role in driving economic development of surrounding areas. This is mainly because weak industrial foundation of Hui Autonomous Prefecture of Linxia, irrational planning layout, insufficient talent cultivation and lagged technological development cause single industrial structure of Linxia City. Thus, no overflow effect is caused for economic development of surrounding counties.

Thirdly, seeing from time evolution in Figure 5, 6 and 7, spatial correlation of county economic development in Pan-Linxia Economic Zone was being weakening in 2001, 2006 and 2011. The gap in county economic development was expanding, showing polarized development trend. There are major two reasons. On the one hand, due to the influences of administrative factor on development pattern of economic space, under the background of rapid development of government-led regionalization and urbanization and under the effects of market power and administrative force, each region pays attention to maintaining economic growth rate. Economic elements always gather toward the most beneficial unit. Thus, polarized economic effect (unbalanced economic development) will inevitably appear among regions. As relative difference in regional economic development increases, the cumulative result is that absolute difference is expanding increasingly. Thus, spatial distribution of economic growth level in the counties does nit present aggregation trend. Such polarization effect will further expand in a period. On the other hand, since modern mode of commerce and trade logistics appears, the development of new logistics industry characterized by modern e-commerce imposes impacts on traditional commerce and trade logistics mode. This also affects traditional hub position of Linxia City in regional economy.

Aiming at spatial structure features and overall development trend of economic development in Pan-Linxia Economic Zone, the government should take practical coping strategies and optimize spatial structure of economic development to achieve harmonious development of regional economy. In microcosmic view, it is required to give priority to developing education, enhance technical accomplishment of all the people, optimize industrial structure and strive to develop modern logistics industry so as to keep the hub function of Pan-Linxia Economic Zone and drive economic development surrounding areas. In macroscopic view, in the early and middle stages of regional economic development, it is necessary to conduct macroscopic readjustment and control of the market through administrative intervention, break regional spatial pattern with continuous polarization development and realize balanced and harmonious development of regional economy.

5. Conclusion

Space exploration analysis method provides new viewing angle for understanding space-time law of regional economic development and contributes to exploration of regional spatial structure and development trend. This paper applies overall spatial correlation analysis and partial spatial correlation analysis and utilizes different properties of Threshold Distance Weight and ROOK Weight in spatial weight matrix to analyze spatial characteristics and evolution law of economic development in the counties of Pan-Linxia Economic Zone and obtain special spatial structure features of economic development in Pan-Linxia Economic Zone and the overall trend with the time. This provides research support for objectively estimating economic development situations of this zone and making scientific decisions by the government.

The following aspects in this paper deserve further discussing: 1) in spatial statistical analysis, spatial weight standard directly influences the changes of statistics; how to allocate spatial weights according to practical spatial correlation; 2) how to utilize macroscopic readjustment and control of regions to solve complementation of regional economy and achieve balanced and harmonious development of regional economy.

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