ESDA-GIS Analysis of Spatial-temporal Disparity in Rural Economic Development of Guangxi

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Abstract On the basis of spatial-temporal perspective, by using the data of farmers' net income per capita from 1996 to 2007 in counties of Guangxi coupled with the global and local spatial auto-correlation analysis of ESDA and GIS technology, we conduct the empirical research on the rural economic developmental disparity of counties in Guangxi and the evolving characteristics of local spatial heterogeneity. The results show that the rural economic developmental disparity of counties in Guangxi from 1996 to 2007 varies infinitesimally on the whole, and the regions with similar rural economic developmental level have spatial concentrated distribution. Based on these, the local MORAN'S I scatter diagram and LISA concentration diagram are drawn. In comparison with the traditional analytical method, the spatial analytical method of ESDA-GIS can explain the problem of spatial heterogeneity of rural economic development clearly, and have direct visual effect.

Key words Rural economy, ESDA-GIS, Spatial auto-correlation, Guangxi, China

Regional economic difference has been the hot topic during the socio-economic development of China since the opening up and reform. In the light of the experience of all countries across the world, due to the different resources endowment in different regions, the regional developmental difference is the result of economic developmental process, and it is necessary[1-2]. In the perspective of space, economic development is the dialectic process of spatial concentration and dispersion. The appropriate regional economic difference can offer momentum for the economic development in backward areas so as to give play to advantage. But if the regional economic gap becomes big or even excessively large in the long run, it will generate severe negative impact. Since the decade, Guangxi's rural regional economy develops by leaps and bounds, but the problems of imbalance during rural regional economic development are still outstanding. Guangxi is a region with many ethnic minorities, so coping with the problems of rural regional economic development well is significant to the stability and development of Guangxi. There are multifarious methods to measure rural regional economic spatial difference, like variance, standard deviation and so on[3-4]. But these methods have certain limit, namely we assume that the regions are independent of each other, and there are no interacted spaces. While in fact, the spatial impact, especially the spatial auto-correlation and spatial heterogeneity should be taken into consideration when researching different problems of regional difference[5-6]. Consequently, when researching regional economic difference, I consider the problems of rural regional economy by using spatial perspective and spatial dimension, so as to find the spatial mechanism of the extension or shrinkage of rural regional economic differentiation.

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1 Research methods and data sources

1.1 Research methods

1.1.1 The analysis of spatial auto-correlation. The spatial auto-correlation, an important form of spatial dependence, refers to the existing correlation between research object and its spatial location. The spatial auto-correlation is an important index to test whether the attribute value of one factor is associated with the attribute value of its adjacent spatial points conspicuously. The positive correlation demonstrates that the attribute value variation of certain unit has the same tendency of variation with its adjacent spatial unit, and the negative correlation demonstrates that the attribute value variation of certain unit has the different tendency of variation with its adjacent spatial unit.

1.1.2 Global spatial auto-correlation. The global spatial auto-correlation is description of the whole regional spatial characteristics of attribute value. It is mainly by using estimation of global spatial auto-correlation statistical amount, like Global Moran's I and Global Geary'S C to analyze regional spatial correlation and spatial difference degree on the whole. Moran's I is used most frequently, and its calculation formula is[7]:

$$I = \frac{n}{s_0} \times \frac{\sum_{i}^{n}\sum_{j=1}^{n}\omega_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i}^{n}(x_i-\bar{x})^2} \quad (1)$$

In the formula, x_i is the observed value of the ith region, $\bar{x}$ is the average of x_i, s_0 is the total of all factors of spatial weight phalanx(W). ω_{ij} is the phalanx of spatial connection between i and j, which can be denoted as the nth-order phalanx $W(n \times n)$. Generally it can be constructed by the attribute of topology of spatial data, such as the attribute of connection or the spatial distance. If the distance between i and j is smaller than the given distance, then $\omega_{ij}=1$; in other cases, it is equal to 0. The thesis defines the spatial relationship among counties according to the principle of common boundary. After we figure out

Moran'S I, we conduct the statistical test on the results by using z test[7]:

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

Generally we explain Moran's I as a relevant coefficient, and the interval of its value is $[-1, 1]$. Under the given level of significance, when Moran's I is significant and positive, it indicates that there is significant positive correlation among the observation values; the high observation values tend to cluster with the high observation values; the low observation values tend to cluster with the low observation values; it takes on high-high cluster or low-low cluster. When Moran's I is significant and negative, it indicates that there is significant negative correlation among the observation values; the high observation values tend to cluster with the low observation values, taking on the scattered spatial pattern; when Moran's I is close to 0, it indicates that there is no spatial auto-correlation and the observation values are arranged randomly in space.

1.1.3 The auto-correlation analysis of local space. The statistical amount of global Moran's I is an overall statistical index, and it can just indicate the average degree of spatial difference between all regions and the surrounding regions. Under the circumstance of the dwindled overall spatial difference in the region, the local spatial difference may distend. In order to reflect the tendency of change of regional economic spatial difference comprehensively, it needs the local analytical method of ESDA. In 1994, Anselin propounded LISA (Local Indicators of Spatial Association) of spatial association, which can disclose the spatial auto-correlation characteristic of local and even each spatial unit. LISA, in nature, breaks down Moran's I into each regional unit. As for each spatial unit I, it can be denoted as follows[7]:

$$I_i = \sum \omega_{ij} Z_i Z_j \quad (3)$$

In the formula, Z_i and Z_j are the average value standardization of observation value; ω_{ij} is the weight phalanx of spatial connection. Thus under the level of certain significance, if I_i is significant, positive, and bigger than 0, it indicates that the observation value of location i and the surrounding neighbors are both high, belonging to high-degree cluster; if I_i is significant and positive, and Z_i is smaller than 0, it indicates that the observation value of location i and the surrounding neighbors are both low, belonging to low-degree cluster; if I_i is significant and negative, and Z_i is bigger than 0, it indicates that the observation value of location i is higher than that of the surrounding neighbors, belonging to high-low cluster; if I_i is significant and negative, and Z_i is smaller than 0, it indicates that the observation value of location i is lower than that of the surrounding neighbors, belonging to low-high cluster.

I_i is the product of weighted average of observation value of location i and the observation value of surrounding neighbors. Thus, the statistical amount relationship between global Moran's I and local Moran's I_i is as follows:

$$I = \frac{1}{n} \sum_{i}^{n} (Z_i \sum \omega_{ij} Z_j) \quad (4)$$

In the formula, Z_i and Z_j are the average value standardization of observation value; ω_{ij} is the weight phalanx of spatial connection. The condition form of statistical amount of local Moran's I_i and LISA is as follows:

$$I_i^* (d) = Z_i \sum_{j, j \neq i}^{n} d_{ij} Z_j \quad (5)$$

In the formula, Z_j is the observation value after standardization; d_{ij} is spatial weight phalanx after standardization.

The scatter diagram of Moran can be used to distinguish the local spatial correlation model, spatial abnormality value or the local instability. So the scatter diagram of Moran can be used to describe local spatial correlation. The abscissa denotes all observation values of corresponding variable x, while ordinate denotes all values of corresponding spatial lag vector (W_x). The spatial lag of observation value of every region is the weighted average of the observation value of the surrounding neighbors in the region, which can be defined by standardized spatial weight phalanx. The scatter diagram of Moran is divided into 4 quadrants which denote 4 different types of regional economic spatial difference: the right above quadrant (HH) shows that the economic level of the region itself and the surrounding regions is high, and the spatial difference degree of both is low; the left above quadrant (HL) shows that the region itself is low, but the economic level of the surrounding regions is high, and the spatial difference degree of both is high; the left below quadrant (LL) shows that the economic level of the region itself and the surrounding regions is low, and the spatial difference degree of both is low; the right below quadrant (LH) shows that the region itself is high, but the economic level of the surrounding regions is low, and the spatial difference degree of both is high.

1.2 The study area and data sources This research takes the spatial difference of rural economy in Guangxi as research objective, selects the farmers' net income per capita as research index. The farmers' net income per capita is an important statistical index which can reflect farmers' practical income status. In the process of constructing new socialist harmonious village comprehensively, the farmers' net income per capita is the core index of appraising the rural economic development of a region and measuring farmers' life standard. The statistical data of this research are selected from the *Statistical Yearbook of Guangxi* from 1997 to 2008[8]. The spatial analytical scale is 89 counties and cities of Guangxi, and the data of administrative boundary are selected from 1∶4 million database of the state basic geographical center.

2 Results and analysis

2.1 The global auto-correlation analysis By using Geoda software, we calculate the Moran's I index regarding the farmers' net income per capita of county in Guangxi from 1996 to 2007 (Table 1). The calculation values of Global Moran's in the period of research are all positive, indicating that the regions with similar rural economic developmental level of county in Guangxi, concentrate in terms of space, namely in the counties with high per capita net income of farmers, the per capita net income in the surrounding regions is also high, and vice versa. The outstanding characteristic of spatial positive correla-

tion demonstrates the existence of spatial difference. On the whole, as time goes by, this tendency is increasingly strengthened. The Moran'S I index, on the whole, tends to decrease and then increase.

Table 1 Global Moran's I for rural per capita net income in Guangxi autonomous region during 1996 – 2007

Year	Moran'S I index	Year	Moran'S I index	Year	Moran'S I index	Year	Moran'S I index
1996	0.596 0	1999	0.467 6	2002	0.493 2	2005	0.569 9
1997	0.512 5	2000	0.467 1	2003	0.536 8	2006	0.546 2
1998	0.450 8	2001	0.465 7	2004	0.544 4	2007	0.509 9

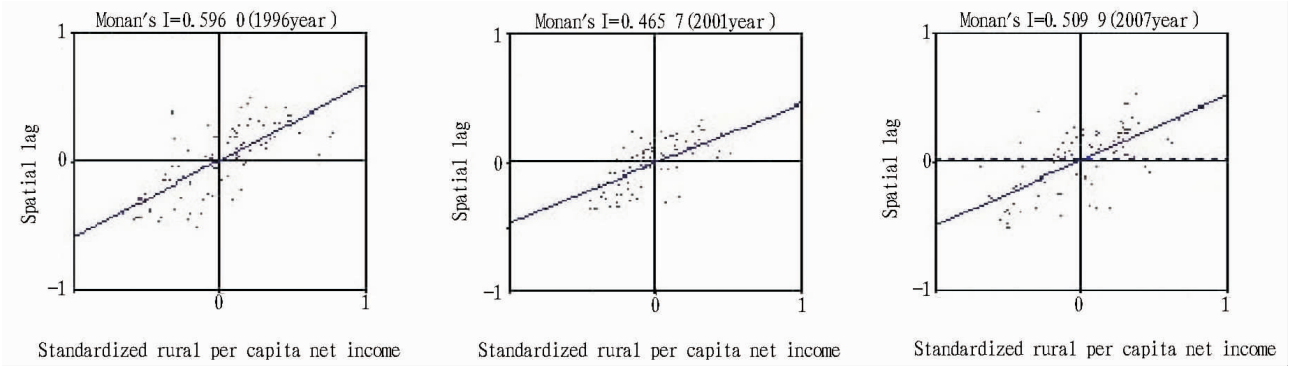

Fig.1 Moran scatter-plot for rural per capita net income of Guangxi autonomous region in some years

2.2 The measuring of local spatial auto-correlation By using Geoda software, we calculate the local Moran's I value of farmers' per capita net income from 1996 to 2007 in each statistical unit (county unit). We count the annual Moran's I, according to 5 intervals of <0,[0,0.2),[0.2,0.4),[0.4,0.6], >0.6. The statistical results can be seen in Table 2. From Table 2, we know that the statistical unit quantity of Moran's I value in every interval distribution of Guangxi from 1996 to 2007 changed little, especially in the 2 intervals of " <0" and " >0.6". if it is in the interval of " <0", there were about 22 in each year, apart from 15 in 1996 and 18 in 2007. Most of these regions concentrate in the eastern Guangxi, like Teng County and Zhaoping. In the interval of " >0.6", the number in most of years is more than 30. These regions concentrate in the northwestern Guangxi, the southeastern Guangxi and central Guangxi. The rural economic development of these regions is identical, belonging to high-high or low-low cluster basically.

Table 2 Local Moran's I interval statistic table of rural per capita net income during 1996 – 2007

Year	<0	[0,0.2)	[0.2,0.4)	[0.4,0.6]	>0.6	Year	<0	[0,0.2)	[0.2,0.4)	[0.4,0.6]	>0.6
1996	15	16	16	7	35	2002	23	21	8	6	31
1997	24	12	12	3	38	2003	23	23	3	9	31
1998	28	6	15	7	33	2004	20	24	7	6	22
1999	24	11	11	11	32	2005	20	22	7	9	31
2000	23	28	7	4	27	2006	18	22	9	8	32
2001	25	16	11	11	26	2007	23	18	12	4	32

For the better comparison of local variation framework of spatial difference of the rural economic development from 1996 to 2007, we use GIS technology to draw LISA Clustering Figure. We can find that from 1996 to 2007, the basic framework of rural economy in Guangxi varies little. The developed regions concentrate in the southern and northeastern Guangxi; the underdeveloped regions concentrate in the western Guangxi. In comparison with the surrounding regions, the whole region can be divided into 4 types: first, the counties and cities (HH) with small spatial difference and high level of the region and the surrounding regions, concentrate in the southern and northwestern Guangxi. The more the quadrants in HH, the smaller the overall spatial difference of agricultural economy; second, the regions (LL) with little spatial difference, and low level of itself and the surrounding regions, concentrate in the western Guangxi. In these regions, the location advantage is not so prominent, lacking the leading of other industries, so they need the correct governmental guidance; third, the counties (HL) with big spatial difference, high level of itself and low level of other surrounding regions, concentrate in the southeastern and central Guangxi. The rural economy develops well and farmers' income is high in these counties and cities, which play the role of radiation in propelling the rural economic development of surrounding areas; fourth, the counties (LH) with big spatial difference, low level of itself and high level of other surrounding regions, scatter in the periphery of some counties and cities with better agricultural basis. After we distinguish the distinctive regions from the surrounding regions, we can find the spatial heterogeneity of rural economy. 2 LISA clustering figures in 1996 and 2007 are selected to elucidate the result (Fig.2 and 3).

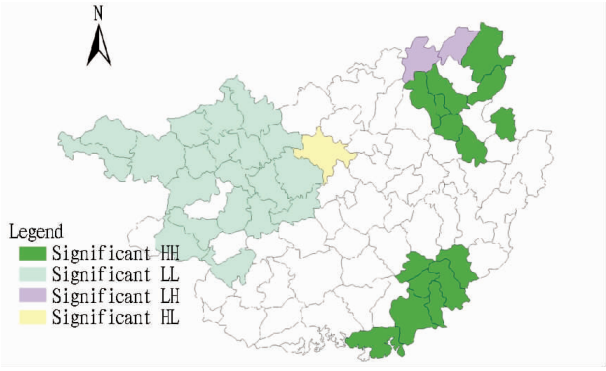

Fig.2 LISA clustering of rural per capita net income in Guangxi (1996)

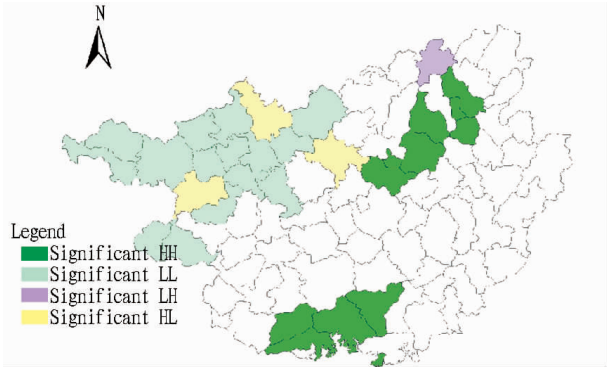

Fig.3 LISA clustering of rural per capita net income in Guangxi (2007)

3 Conclusion and suggestions

By using ESDA technology which takes the spatial correlation measure technology as core and GIS technology, we can discern directly the spatial distribution characteristics of regionalized difference. In addition, due to the consideration of spatial effect, it is beneficial to unveil the spatial heterogeneity and spatial correlation of rural economic difference, so it is suitable for researching the problems of rural regional economic difference. On the whole, the spatial difference of rural economy of Guangxi tends to dwindle, the spatial interaction among counties is increasingly strengthened, and the county economy and the surrounding areas tend to develop in tandem. But the basic framework of imbalanced development of rural regional economic development has not been changed radically. The developed regions concentrate in the southeastern and central Guangxi, while the northern Guangxi is still the underdeveloped agricultural region. In order to change the status quo of underdeveloped regions which arises from the factors of location and history, as far as I'm concerned, we should endeavor to do as follows:

Firstly, Taking advantage of the establishment of China-ASEAN Free Trade Area, and the historical opportunity of the development of Beibu Gulf Economic Zone, Guangxi should adjust the irrational factors in the process of economic development; develop the stagnant regional economy vigorously; promote the rural economic development of these regions.

Secondly, we should adjust the agricultural industrial structure actively, and develop modern agriculture. The local government should develop the local economy actively, and pay attention to the development of modern agriculture and characteristic agriculture, for example one village with one characteristic product and one region with one characteristic product. We should also take advantage of the local characteristics, and develop the agriculture of region by using the concept of agricultural industrial cluster so as to elongate the agricultural industrial chain. In the meanwhile, the agricultural management department of autonomous region should coordinate the development of Guangxi's agriculture and lay out rationally the agricultural industry in whole region so as to offer good developmental environment and policy guidance for agricultural development.

Thirdly, we should reinforce the construction of agricultural infrastructure, quicken the pace of land circulation, exert the advantage of the concentrated management of land, and introduce powerful agricultural enterprises to propel the development of local agricultural industry.

Fourthly, we should coordinate the development of agricultural industrial service, for example, perfecting the agricultural logistics system in order to formal modern agricultural industrial system. We should also support the agricultural technology vigorously and strengthen farmers' vocational training.

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