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Spatial Disparity Analysis of County Agricultural Medicine Economics in Fujian Province

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ABSTRACT Taking per capital net income of rural residence as the measuring indicator, 67 counties, county-level cities and city districts in Fujian Province are studied. With the support of ArcGIS and Geoda, Exploratory Spatial Data Analysis (ESDA) is applied to study the spatial disparity of 2001-2010 county agricultural economic development in Fujian Province. The research results show the significant spatial autocorrelation on the county agricultural economic development in Fujian Province. Further, the research finds out zonal character on the county agricultural economic development in Fujian Province, including, certain agricultural economic development in northern Fujian areas since 2004, and in addition, the major factors of natural resource endowment and geographical location, social economic base, regional agricultural development policies, agricultural technology, and talents support in the agricultural economic development disparity in Fujian Province.

INTRODUCTION

With economic growth, increasing national income, and changing social structure and family structure, the eat-out population continuously increases (Wang 2014). Changes and developments occurring in the world in individual, social and economic areas are supposed to be reflected into educational systems and programs (Yadigar 2013). Regional economic disparity is an inevitable phenomenon in global economic development process (Wei 2006). Behind the rapid development of domestic overall economics, the unbalanced development is highlighted in regional economics that regional economic disparity is commonly concerned by economists and geographers (Tewari 2013). From the present literature, the research has become diverse and systematic, and the research area has covered from nation and three regions to provinces, cities, and counties (Kim and Knaap 2001; Wu 2001; Yu and Jiang 2007; Bai et al. 2009; Kuo and Tsai 2010), the selection of measuring indicators contains single indicator and multi-factor indicators (Wang and Wang 2011; Peng and Tang 2007; Li et al. 2011), and the application of research methods has changed from traditional coefficient of variation, standard deviation, Gini coefficient, and Theil coefficient to more comprehensive and in-depth spatial heterogeneity mining (Lu and Hsu 2005; Chen and Chu 2009; Sun and Wang 2011). ESDA (Exploratory Spatial Data Analysis) in GIS has also been applied to the research on the spatial disparity characteristics and the evolution of regional economics with better effects (Yu et al. 2012; Xia et al. 2012). ESDA is the combination of a series of spatial analyses and techniques to analyze the spatial property with statistics and to present the cluster or anomaly characteristics of spatial distribution with diagrams, showing the significant meaning on explaining the spatial mechanism between objects (Li et al. 2011; Hsu and Yueh 2009).

Agricultural economics plays a critical role in regional economic structure. Research on the spatial disparity of regional agricultural economics is increasing in the past years. In the spatial disparity analysis of county agricultural economics in Gansu Province, Wang et al. (2009) pointed out the "•N" shape distribution (Wang et al. 2009). Based on Exploratory Spatial Data Analysis, Hsieh (2010) studied the spatial disparity of agricultural economics around Poyang Lake. Yuan (2009) and Lien et al. (2010) also studied the agricultural economic disparity and the spatio-temporal pattern in Xiangfan County and Beijing City. As the body of Western Taiwan Straits Economic Zone, Fujian Province appears the important position on national regional development. It was proposed in 2011 *The Twelfth Five-Year Plan for National Economic and Social Development of Fujian* to constantly accelerate the construction of high-tech agriculture in southeastern Fujian, green agriculture in northwestern Fujian, and blue agriculture in

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coastal areas for improving the living condition of rural residence, completing rural development systems, and expanding income increasing channels for farmers, which have created favorable environments for the agricultural economic development in Fujian Province. By organizing the literature on the agricultural economic development in Fujian Province, most research focus on the evaluation of agricultural modernization development standard and agricultural development strategic thinking, but little base on space theory (Hsu et al. 2009; Tang 2010). For this reason, 67 counties, county-level cities, and city districts in Fujian Province are studied. Taking per capital net income of rural residence in 2001-2010 as the measuring indicator, ESDA is utilized for exposing the spatial disparity characteristics of regional agricultural economics in Fujian Province and the inner driving mechanism, expecting to provide the reference of scientific decision for the agricultural economic development in Fujian Province.

RESEARCH DESIGN AND METHODS

General Situation in Research Region

Fujian Province, located next to East China Sea between 23°332 ~28°202 N and 115°502 ~120°402 E, faces Taiwan Province across Taiwan Strait. Total 9 cities, 14 county-level cities, and 44 counties (not including Kinmen County) are governed, with the total area about 121.5 thousand km^2. By the end of 2010, the total population by region was 3.693 million, and the gross regional product 1473.712 billion RMB. However, because of the differences in geographical location, institutional environment, and economic base, the regional economic development disparity in Fujian Province is enlarging, where the unbalanced economic development appears remarkably in east coast and west inland areas. Broadly, the economic development standard in Fujian Province revealed larger difference from other provinces in east coast.

Data Source

Selecting 2001-2010 per capital net income of rural residence in 67 counties, county-level cities, and city districts in Fujian Province as the research indicator, the data was acquired from 2001-2011 *Statistical Yearbook of Fujian*. Putien County was retracted by State Council and included in Putien City District in 2002. Based on the 2010 administrative division of Fujian Province, the per capital net income of rural residence data of Putien County and Putien City District in 2000 and 2001 are combined as the final data of Putien City District for the data continuity and unity in the spatial region. Meanwhile, present administrative division of Fujian Province is input to ArcGIS and the data indicator with the research unit of 10 years is regarded as the attribute of the digital base map to implement the screen digitalization of map.

Research Method

Based on ESDA, the county agricultural economic development in Fujian Province is proceeded spatial autocorrelation analysis. Spatial autocorrelation, an important indicator for reflecting the correlations with the phenomenon or attribute in a certain regional cell or the same phenomenon or attribute in the adjacent areas (Wei et al. 2007), contains global spatial autocorrelation and local spatial autocorrelation. The former often applies the statistics of Global Moran's *I*, while the latter utilizes Moran scatter plot and Local Moran's *I*. Anselin (1995) renamed Local Moran's *I* as LISA, local indicators of spatial association.

Establishment of Spatial Weighting Matrix

Exploratory Spatial Data Analysis is based on the introduction of spatial weighting matrix, which mainly contains two spatial weights based on adjacency and distance; a binary adjacency matrix is normally defined to express the spatial relationship between the research subjects.

$$W = [W_{ij}]_{nm} = \begin{pmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{pmatrix} \quad (1)$$

Base on adjacency, when two regions are adjacent, it shows 1; otherwise, it appears 0.

$$W_{ij} = \begin{cases} 1 & regini\ and\ regin\ j\ is\ adjacent \\ 0 & if\ not \end{cases} \quad (2)$$

Global Moran's I

Global Moran's *I* is used for describing the spatial distribution of a phenomenon or attribute

in the research region to judge the cluster characteristics. It is defined as

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(y_i - \bar{y})(y_j - \bar{y})}{s^2 \sum_{i}^{n}\sum_{j=1}^{n} w_{ij}} \quad (3)$$

where y_i is the attribute in region i,

$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \quad s^2 = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2$

Moran's *I* appears between -1 and 1. *I* being larger than 0 shows the regional spatial cluster with similar attributes; with the closer value to 1, the cluster appears more apparently; *I* being smaller than 0 reveals the regional spatial cluster with distinct attributes; the close value to -1, the difference appears more remarkably; and, *I* equal to 0 presents the independent regional attribute that no spatial autocorrelation exists, with random distribution.

The calculation of Moran's *I* is normally tested by standardized asymptotic normality of statistic *Z*, as

$$Z(I) = \frac{I\text{-}E(I)}{\sqrt{Var(I)}} \quad (4)$$

where *E(I)* is the mathematical expectation of Moran's *I*

$$E(I) = -\frac{1}{n-1} \quad (5)$$

$Var(I)$ is the variance of Moran's *I*.

$$Var(I) = \frac{n^2 w_0 - n w_2 + 2 w_0}{w_0 (n^2 - 1)} - \sum_{n}^{2}(I) \quad (6)$$

Generally speaking, when the value is larger than the critical value 1.96 under the significance of normal distribution function 0.05, the spatial distribution presents notably positive correlation.

Local Moran's I

Local Moran's *I* refers to dividing global Moran's *I* into small regional cells locally for the spatial correlation in the measured area to specifically describe the locations of cluster points and scatter points in the regional space. It is defined as

$$I_i = z_i \sum_{j \neq i}^{n} w_{ij} z_j \quad (7)$$

where z_i and z_j are the standard form of regional attributes. When I_i appears significantly positive, a high-value regional cell is surrounded by high-value regional cells, or a low-value regional cell is surrounded by low-value regional cells, that is the difference between regional *i* and the peripheral areas is small, showing high-high and low-low correlation. When I_i shows remarkably negative, a high-value regional cell is surrounded by low-value regional cells, or a low-value regional cell is surrounded by high-value regional cells, that is the difference between region *i* and the peripheral areas is large, presenting high-low and low-high correlation.

The value of *LISA* also requires *Z* test, and the explanation is the same as above. The equation reveals

$$Z(I_i) = \frac{I - E(I_i)}{\sqrt{Var(I_i)}} \quad (8)$$

RESULTS

Disparity Analysis of County Agricultural Economic Development in Fujian Province

Global Spatial Autocorrelation Analysis

With Geoda to calculate 2001-2010 per capital net income of rural residence spatial correlation index Moran's *I* and the examination of 67 counties in Fujian Province, the results are shown in Table 1.

Table 1: Moran's *I* and its examination of per capital net income of rural residence in Fujian from 2001 to 2010

Year	*Moran's I*	*E(I)*	*Mean*	*Standard deviation*	*Z*
2001	0.5208	-0.0152	-0.0145	0.0763	7.02
2002	0.5939	-0.0152	-0.0177	0.075	8.12
2003	0.5962	-0.0152	-0.0158	0.0748	8.17
2004	0.5639	-0.0152	-0.0212	0.0728	7.95
2005	0.5639	-0.0152	-0.0145	0.0766	7.56
2006	0.5451	-0.0152	-0.0149	0.078	7.18
2007	0.5133	-0.0152	-0.0195	0.0754	7.01
2008	0.4862	-0.0152	-0.0187	0.0761	6.59
2009	0.4856	-0.0152	-0.0151	0.0775	6.46
2010	0.4775	-0.0152	-0.0158	0.0776	6.35

From Table 1, the examination Z of Moran's *I* based on normal distribution is a lot larger than the critical value 1.96 under the 95% confidence level, revealing the significantly positive correlation in the agricultural economic growth in Fujian Province, with per capital net income of rural residence as the measuring indicator, and cluster characteristics on the spatial distribu-

tion. That is, the peripheral countries with higher per capital net income of rural residence would have higher income; and vice versa. To more clearly demonstrate the changes of per capital net income of rural residence in Fujian Province, the line chart of Moran's *I* is drawn (Table 2). With analyses, the development is divided into two stages, including the growing stage in 2001-2003 and the declining stage in 2003-2010. In the first stage, Moran's *I* continuously increases that the county agricultural economic development is faster and the cluster effect is obvious. Joining in WTO in 2001 has brought new opportunities for the agricultural development in Fujian Province. Being the starting year of Ten Five-Year Plan, the nation, Fujian Province Committee, and Provincial Government have enlarged the support for the agricultural development; and, Minnan Delta has rapidly increased the difference from the peripheral areas because of the location, geography, and policy. Since 2004, counties in Fujian Province have devoted to practicing the spirit of No.1 Central Document that the farmers are largely enhanced the income and the disparity of regional agricultural economic development is gradually reduced.

Table 2: Moran's I of per capital net in CPME of rural residence in Fujian

Year	*2000*	*2002*	*2004*	*2006*	*2008*	*2010*
Moran's I	0.52	0.58	0.56	0.54	0.48	0.47

Local Spatial Autocorrelation Analysis

The per capital net income of rural residence data in 2001, 2004, and 2010 are selected for the temporal-spatial variation analysis of agricultural economic development disparity in Fujian Province with Moran scatter plot and LISA cluster map.

Local Moran's I Scatter Plot

The observed value is regarded as the horizontal axis in the Moran's *I* scatter plot and the spatial lagged variable as the vertical axis for four quadrants to express four types of spatial relationship in a region and the peripheral areas. The first quadrant, "high-high" correlation, shows the higher per capital net income of rural residence in the area and the peripheral areas, with smaller difference. The second quadrant, "low-high" correlation, presents lower per capital net income of rural residence in the area, but higher in the peripheral areas, with larger difference. The third quadrant, "low-low" correlation, reveals low per capital net income of rural residence in the area and the peripheral areas, with smaller difference. The fourth quadrant, "high-low" correlation, presents higher per capital net income of rural residence in the area, but lower in the peripheral areas, with larger difference. Geoda is utilized for calculating the Moran scatter plots in Fujian Province at three time intervals.

With comparisons, 1.) most points locate in the first and the third quadrants, showing the stronger spatial cluster of regional agricultural economics in Fujian Province, 2.) the number of points in the third quadrant is larger than it in the first quadrant, revealing the high weight of counties with backward agricultural economic development and more remarkable cluster, 3.) the points in the first and the third quadrants decrease from 2001 to 2010, while the ones in the second and the fourth quadrants increase that the cluster between counties is reduced, 4.) the points in the first quadrant scatter the widest area in 2010, presenting the rapid agricultural economic development in such counties and notable polarization, and 5.) points in the quadrants appear greater dispersion in 2001-2010, revealing the increasing disparity of agricultural economic development among counties (see Fig. 1).

DISCUSSION

The positions and distribution density of points in the Moran scatter plot effectively display the spatial correlation of cells in the research area and reflect on the LISA statistic.

Figure 2 shows the zonal character of agricultural economic development in Fujian Province, with notable cluster effects. 1.) Areas with higher agricultural economic development still locate in Fuzhou, Xiamen, and Quanzhou, which are in southeastern Fujian high-tech industrial belt. The rural urbanization standard is higher in such areas, with strong leading role of enterprises. Private economy is advanced in Jienjiang and Shihshih that the farmers receive more non-agricultural income. Putien City appears comparatively less increasing income and withdraws

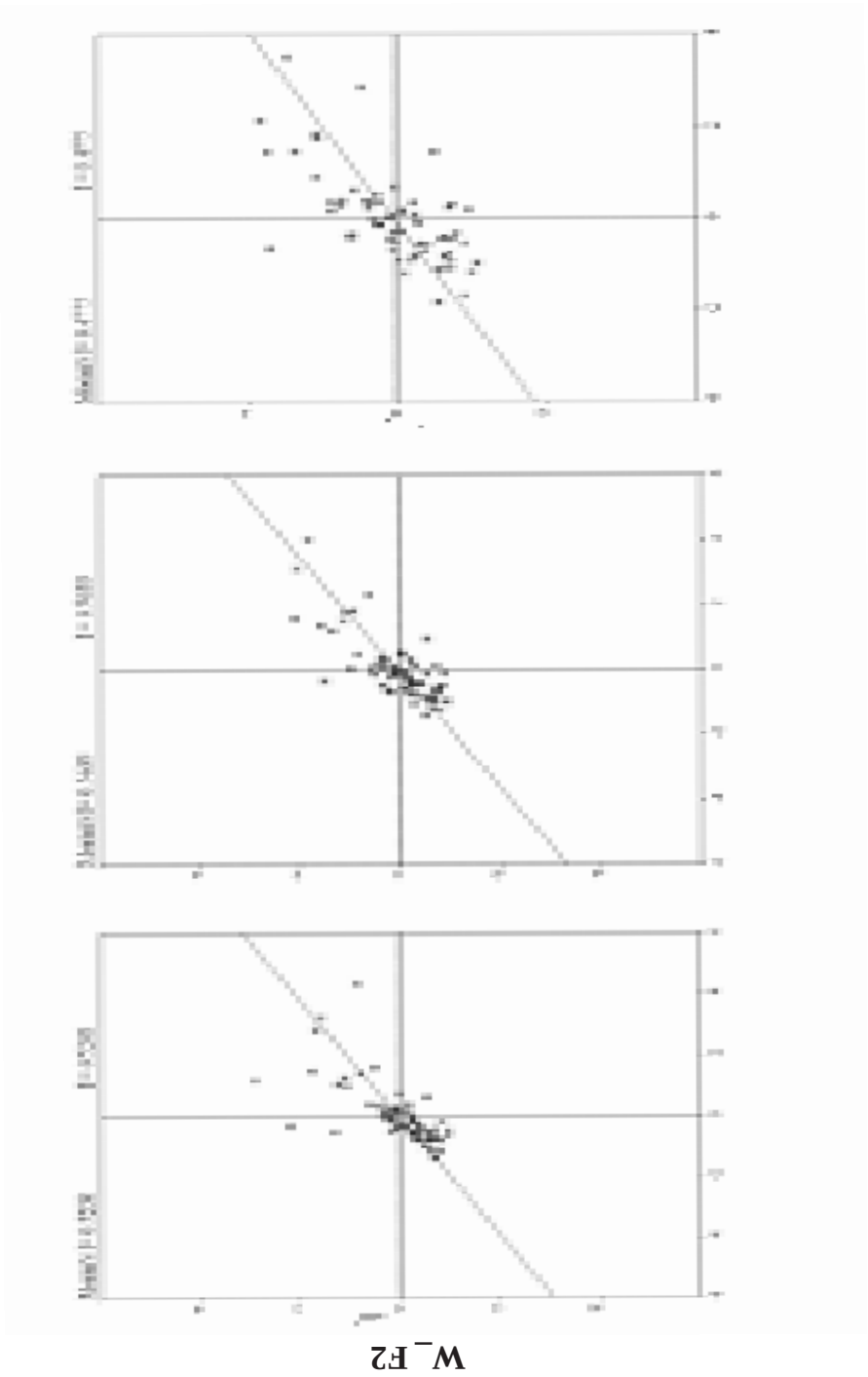

Fig. 1. Mora scatter plot of per capital net income of rural residence in Fujian (2001, 2004, 2010)

from "high-high" correlation formed with the peripheral areas in 2004. The rural development in Siyan County and Pingtan Island is still low and presents "low-high" correlation with the peripheral areas because of the economic base and geographical location. 2.) The agricultural economic development in northern Fujian and southwestern Fujian areas are comparatively lower. The agricultural economic development in northern Fujian areas has progressed since 2001. Songsi County and Syapu County are developed adoptable potato, as they are listed in the southern potato advantage area. Jianou City has developed local waterfowl species and formed scaled dry-feeding cultivation. Wuyi Rock Tea is expanded in Wuyishan City so that the difference from the peripheral areas is increasing to form "high-low" correlation. The agricultural development in Southwestern Fujian areas is still backward because of weak economic base. During Ten Five-Year Plan, Wuping County is established rabbit raising bases with favorable results, while the development in Ninghua County is declining and thus, becomes "low-low" correlation with Chengting.

CONCLUSION

Natural Resource and Geographical Location

Natural factors of landform and soil present primary effects on regional agricultural economic development. With plenty hills and abundant forest resources, most counties in Fujian Province locate in Wuyi Mountains and Daiyun Mountains, with dispersive distribution and weak ecological environments. Landform also appears certain effects on traffic. Railways and highways in Chenghe County and Songsi County in northern Fujian and Ninghua and Jianning counties in northwestern Fujian are few and scattered that the delivery of produce is inconvenient. Minnan Delta, located in eastern coastal plain, presents the advantages of convenient traffic and excellent climate for the growing of rice and sweet potato, the cultivation of longan, loguat, and litchi, and the production and export of winter vegetable. Geographically, Fujian Province and Taiwan are separated by water that it could enhance the agricultural economic development and cooperation between Fujian and Taiwan to increase the export quota of the produce and create high foreign exchange. It lays the foundation for the rapidly agricultural economic development in southeastern Fujian areas. The coastal advantage also creates favorable environments for the aquaculture in southeastern Fujian areas.

Social Economic Development Base

Eastern coastal areas in Fujian Province show excellent locations. With the support of national policies, the rapid development of regional economics and the high rural urbanization lay the powerful foundation for regional agricultural economics. Further, the agricultural infrastructure in southeastern coastal areas in Fujian is complete, with higher agricultural mechanization and advanced industrialization, and emerges several leading agricultural enterprises. Being the core of economic development, Fuzhou and Xiamen appear the stronger leading role in the peripheral agricultural development. Private economy in Quanzhou, Jienjiang, and Shihshih is active that the farmers receive higher non-agricultural income. The central cities of Sanmin, Longyen, and Nanping in northern Fujian and western Fujian areas are smaller and scattered that the leading role of agricultural development in the peripheral counties is weaker. The industrial structure focuses on the first industry in such areas, but most of them appear extensive development, with backward agricultural infrastructure, low urbanization and modernization, and insufficient talents, capital, and technological support for the agricultural economic development.

Regional Agricultural Development Policy

Actually solving three rural issues is the primary focus in domestic social economic development. The three rural issues have been emphasized in No.1 Central Document for eight times since 2004. Several policies for benefiting the agriculture and farmers have been practiced, and the practice efficiency and quality of relevant policies in core regional economic areas are far higher than those in distant areas, particularly the counties and villages with lower economic development. When learning national policies, formulating correspondent development strategies and the specific practice process being delayed, the rapidly agricultural economic development in northern Fujian and west-

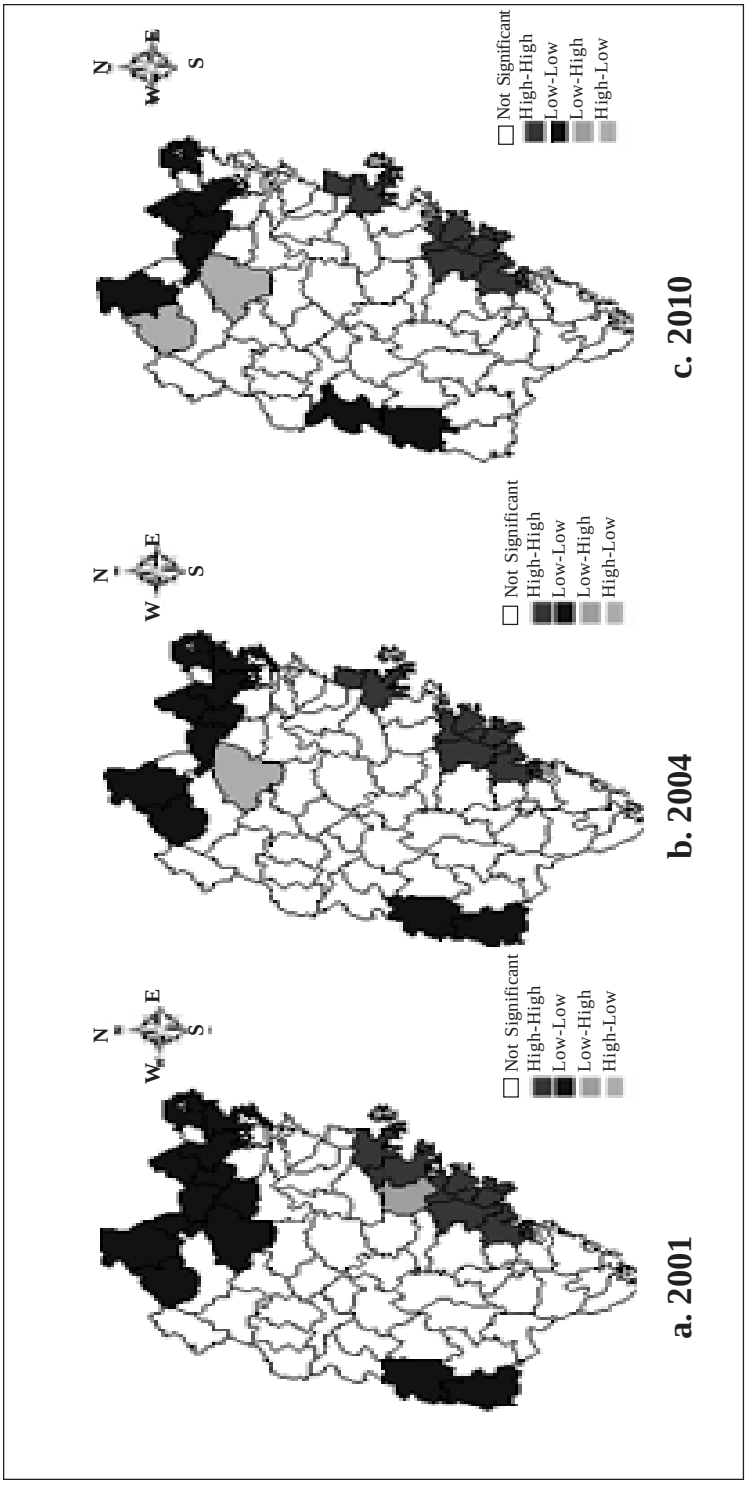

Fig. 2. LISA cluster map of per capital net income of rural residence in Fujian (2001, 2004, 2010)

ern Fujian areas is to some extent conditioned. In face of the major opportunity to enhance "western coast", Fujian Province has facilitated the establishment of agricultural cooperation experimental zones across the strait. In consideration of traffic location, agricultural industrialization, and agricultural modernization, the experimental zones concentrate mainly on Minnan Delta that a lot of favorable policies are provided in such areas and the agricultural economic development is accelerated. Meanwhile, the open-up of eastern Fujian coastal areas is high that the foreign investment focuses more on Fuzhou, Xiamen, Quanzhou, and Zhangzhou, where more capitals are supported to largely enhance the agricultural modernization and industrialization and enlarge the disparity of agricultural economic development in Fujian Province.

Agricultural Technology and Talents Support

Overall enhancing the schedule of agricultural modernization is a critical basis to accelerate the change of agricultural development and implement agricultural economic development. The power of agricultural technology plays a significant role in enhancing the abilities of agricultural production, anti-risks, and market competition. It is proposed in *Ten Five-Year Plan of Fujian* to develop remote training of practical skills, promote agricultural "five new", and accelerate agricultural technology transformation. Southeastern Fujian areas show advanced economy and high informatization that Xiamen University, Fuzhou University, Huaqiao University, and Fujian Agriculture and Forestry University are established in such areas. The good agricultural scientific research attracts a lot of agricultural technology talents. Northern Fujian and western Fujian areas appear comparatively backward economics, incomplete agricultural infrastructure, large rural population, backward ideas and concepts, and low educational standard that the agricultural mechanization, informatization, modernization, and industrialization reveal great differences among areas.

RECOMMENDATIONS

With the support of ArcGIS and Geoda, 67 counties (cities) in Fujian Province are studied, in which per capital net income of rural residence is regarded as the measuring indicator to analyze the spatial disparity of county agricultural economic development in Fujian Province in 2001-2010 and the factors. The research findings and suggestions are organized as below.

(1) With the analysis of Moran's *I*, the county agricultural economic development in Fujian Province presents significant spatial autocorrelation, that is counties with similar agricultural economic development appear spatial cluster, and the economic development standard outperforms backward areas. The agricultural economics in Beijing City in 2005 also shows strong spatial cluster characteristics. Both reveal great correlation with the agricultural patterns and natural conditions.

(2) The county agricultural economic development in Fujian Province presents zonal character. The agricultural economic development in southeastern Fujian areas is high, showing "high-high" correlation; the shift difference among counties (cities) in northern Fujian enlarges with time, when Wuyishan City and Jianou County appear faster development and change from "low-low" correlation to "high-low" correlation with the peripheral areas.

(3) Differences in economic base among research areas are the key in agricultural economic development disparity. Core cities, Fuzhou, Xiamen, and Quanzhou, locate in Minnan Delta, where the regional economic progress benefits the rapid development of agricultural economics that the agricultural modernization and industrialization are high. Northern Fujian and western Fujian areas present worse natural conditions, inconvenient traffic, backward economics, low rural urbanization standard, and extensive rural development. As a result, the governmental financial expenditure in the areas should be increased to reinforce the agricultural infrastructure and establish the agricultural cooperation system between eastern and western areas so as to reduce the difference.

(4) The applied Spatial Analysis has to some extent compensated traditional measurement of economic disparity. However, the analysis is still at the preliminary stage. Using per capital net income of rural residence as the indicator to evaluate the re-

gional agricultural economic development has the analysis not deep enough that the conclusion might not be comprehensive. Various indicators and distinct weighting matrices could be utilized for studying smaller scales, like towns and villages, so as to complete more scientific and comprehensive analyses of spatial disparity of agricultural economic development in Fujian Province.

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