

MEASUREMENT OF AGGLOMERATION ECONOMIES AT COUNTY LEVEL IN JIANGSU PROVINCE

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ABSTRACT: Agglomeration economies are the important factors for the regional development. However, the common indicators to measure them, such as Gini Coefficients neglect the spatial ingredient of data, leading to a-spatial estimates. In order to assess spatial neighbor effects of agglomeration economies, this study makes the new attempts by applying a series of techniques of spatial autocorrelation analysis, specifically, measuring the economies of urbanization and localization at the county level in the secondary and tertiary industries of Jiangsu Province in 1999 and 2002. The conclusions in this study reveal that on the whole, the localization effects on the economies of the secondary industry might be stronger than urbanization effects for that period, and highly agglomerative economies were limited within the southern Jiangsu and parts of middle along the Changjiang (Yangtze) River. Moreover, the tertiary industry has been strong urbanization rather than localization economies in the whole Jiangsu. Unlike the secondary industry, the tertiary industry held the high levels of agglomeration economies can be also found in the poor northern Jiangsu, and then the spatial clusters of trade and services might be basically seen in each of urban districts in 13 cities. All in all, spatial autocorrelation analysis is a better method to test agglomeration economies.

KEY WORDS: agglomeration economies; urbanization economies; localization economies; spatial autocorrelation; Jiangsu Province

CLC number: F299.27

Document code: A

Article ID: 1002-0063(2005)01-0052-08

1 INTRODUCTION

Agglomeration economies have played important roles in the growth of regional economies in developed countries, which has been a hot topic of empirical studies for a couple of decades (GLAESER *et al.*, 1992). However, the researches on the relationship between economic agglomeration and regional economies attracted limited interest in China due to the centrally planned economies for a long term. As China's economic system has been transformed gradually since 1979, the spatial agglomerative phenomenon reappears to be a major research issue in China's economic geography in recent years (LI and LI, 1999). So far the literature on economies of agglomeration in China has been paid much attention to the introduction of theory, rather than empirical investigation.

The statistical indices such as Gini Coefficient can be employed to measure the degree of agglomeration economies. KRUGMAN(1991) calculated Gini Coeffi-

cients of 106 industries across the USA, and found that many industries were indeed highly concentrated at the state level. Additionally, HAN *et al.* (2003) adopted a set of indices of Gini Coefficient, Variation Coefficient and Power Variation Coefficient to analyze the trends of spatial centralizations of marine industry in China in the 1990s. One of their conclusions was that the speed of regional centralizations of multiple marine industries has slowed considerably down in some areas of China for that period.

However, the above measurement of agglomeration economies is a-spatial (ARBIA, 2001). This is mainly because that the factors of geographical proximity have not been explicitly incorporated into such type of indices. In fact, it is the neighborhood effects of knowledge spillovers and transportation production that might generate the agglomeration forces (HANSON, 2001). If so, the spatial autocorrelation analysis is considered as an alternative to the appropriate measures of geographical agglomeration in this study.

Received date: 2004-06-23

Foundation item: Under the auspices of the National Natural Science Foundation of China (No.40271040)

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Spatial autocorrelation can occur in many contexts. In a general sense, it is described as "the degree to which objects or activities at some places on the earth's surface are similar to other objects or activities located nearby" (GOODCHILD, 1986). That is considerably consistent with the concept of regional agglomeration economies defined by MILLS and MCDONALD (1992), "the so-called agglomeration economies mean regional economic growth is also influenced by the economies generated by spatial proximity". Hence it goes without saying that the agglomeration of economic activities appears to be one kind of spatial autocorrelation.

Up to date, a few researches have employed the analysis of spatial autocorrelation to address the issues about the social and economic phenomenon with relation to the geography in China. For instance, ZHU *et al.* (2001) found three clusters and five zones of Chinese floating population since the 1990s by means of spatial correlation analysis. CHEN and DU (2002) incorporated spatial statistical analysis methods into GIS environment to analyze the economic growth in Xinjiang Uyger Autonomous Region between 1978 and 1999. As a method for the social and economic researches, spatial autocorrelation analysis has been accepted in the field of China's geography.

So far, few have referred to the field that the spatial autocorrelation analysis would be applied to the empirical analysis of agglomeration economies in China. In this study, a series of techniques of spatial autocorrelation analysis are used to detect the neighbor effects in the agglomeration economies at the county scale in the secondary and tertiary industries of Jiangsu in 1999 and 2002, respectively. And then the comparison is made between the observed geographical patterns of various industries across agglomeration economies over time.

2 SPATIAL AUTOCORRELATION ANALYSIS

The concept of spatial autocorrelation originates from time series autocorrelation. Though both have common points, spatial autocorrelation is conceptually more complicated to be represented because time series autocorrelation is one-dimensional, while spatial autocorrelation is multi-dimensional. In the framework of what ANSELIN proposed, spatial weights matrix can be used to represent spatial multi-dimension, or the spatial proximity (ANSELIN, 2001). Specifically, weights are nonzero when two locations share a common boundary, or are within a given distance. The binary spatial weight matrix is as follows:

$$W_{ij} = \begin{cases} 1 & \text{if region } j \text{ is adjacent to } i \\ 0 & \text{if region } j \text{ is not adjacent to } i \end{cases} \quad (1)$$

At first, the global spatial autocorrelation is necessary to be tested using the following global Moran's I statistic:

$$I = y'Wy/y'y \quad (2)$$

where y denotes a vector of the observed values of some economic activities in deviations from the mean, y' is a transpose of y , W denotes a row-standardized spatial weights matrix that the elements in each row sum to 1, and Wy is the product of matrix W and y , also denoting associated spatial lag vector.

If spatial autocorrelation exists at some scale of analysis, then the spatial pattern shows two different spatial phenomena: clustering of similar (positive spatial autocorrelation) or dissimilar values (negative spatial autocorrelation) (GRIFFITH, 1992). The Moran's I statistic is significant and positive when some observed value at region i tends to be very similar, negative when it tends to be dissimilar, and approximately zero when the observed values are arranged randomly and independently across the entire region under study.

The global Moran's I statistic reveals the overall pattern of a geographical phenomenon in reality. In the case of agglomeration economies, it is similar to the indicators such as Gini Coefficient, thus does not convey any information about whether there are local spatial clusters of high or low values, explicitly whether the economies in some regions are influenced by its neighbors' economic growth. To deepen our understanding of local spatial concentration of one type of economic activities, Moran scatterplot, Local Moran and Local Geary statistics can all be served as this purpose (ANSELIN, 1996).

Moran scatterplot can visualize the local spatial autocorrelation between observations and their associated spatial lags in a graph that contains four quadrants to indicate individually four different spatial relationships. More specifically, the upper right (HH) and the lower left (LL) quadrants represent positive spatial clusters of high values (above the mean) and low values (below the mean) respectively. The upper left quadrant (LH) expresses low values with surrounding high values, whereas the lower right quadrant (HL) high values with surrounding low values.

The measures for Local Moran (I) and Local Geary (C) statistics or Local Indicators of Spatial Association (LISA) are the extreme magnitude of the influence of some regions on their surrounding regions (ANSELIN, 1995). The statistics are defined as:

$$I = Z \sum_{i \neq j} W_{ij} Z_j \quad (3)$$

$$C_i = \sum_{j \neq i}^n W_{ij} (Z_i - Z_j)^2 \quad (4)$$

where Z_i, Z_j are in deviations from the mean; W_{ij} may be in row-standardized form, n is the total number of counties (cities).

Given a pseudo-significant level p -value of 5%, Local Moran statistic is combined with Local Geary statistic to identify four different significant spatial associations between region i and nearby areas as follows (BAO *et al.*, 1995):

- (1) low p -value of I_i and high p -value of C_i —positive spatial autocorrelation (HH);
- (2) high p -value of I_i and high p -value of C_i —positive spatial autocorrelation (LL);
- (3) high p -value of I_i and low p -value of C_i —negative spatial autocorrelation (HL);
- (4) low p -value of I_i and low p -value of C_i —negative spatial autocorrelation (LH).

3 EMPIRICAL RESULTS

Generally speaking, agglomeration economies are composed of urbanization economies and localization economies (MOOMAW, 1988). The former occurs due to more opportunities that people are engaged in various economic activities in densely populated regions; whereas the latter results from the industries of specialization, such as increasing returns to scale. Obviously, the type of agglomerative economies may be fairly connected with the strategy of development in a region, which implies that it is important to measure and identify the geographically concentrated industry activities in a region under the existing agglomeration economies.

Within the framework of spatial autocorrelation, there are four different regional structures of spatial clustering of economic activities: 1) both regions and their neighbors with highly agglomerative activities (HH); 2) both regions and their neighbors with lowly agglomerative activities (LL); 3) regions with highly agglomerative activities but their neighbors with lowly agglomerative activities (HL); 4) regions with lowly agglomerative activities but their neighbors with highly agglomerative activities (LH).

Probably, each structure mentioned above might be explained by the Growth Pole theory. In general, once a region becomes the growth pole, it might exert two distinctly different kinds of influence on its neighbors: one is the polarization effect and the other is the beneficial effect (CUI *et al.*, 1999). In the early stages of its establishment, the polarization effects make this region absorb its adjacent regions' resources and factors of pro-

duction as well. As it is developed, the beneficial effects on its periphery tend to dominate over the polarization effects. Therefore, the observations appearing in HL or LH quadrants imply that the economic growth in the regions is negatively influenced by the economies generated by its neighbors, which may result from the polarization effects. On the contrary, the observed values in HH and LL quadrants are supposed to represent that the economies in the regions grow at the same rate as that in their neighbors. It is explicit to the core role of beneficial effects on the regional growth.

This study makes attempts to classify the urbanization and localization economies of the secondary and tertiary industries into four groups as described above at the county scale in Jiangsu Province in 1999 and 2002, and then to analyze empirical results obtained. In order to achieve this aim, a total of four variables are considered as the measures of urbanization as well as localization effects on economies. The first two variables are the employment of secondary or tertiary industries by the population per county, respectively. Another two variables are the proportions of the employment in two respective industries to total employment per county.

3.1 Global Moran's I Statistic

We have estimated the values of global Moran's I statistic of the economies of urbanization and localization in the secondary and tertiary industries of Jiangsu in 1999 and 2002 (Table 1). At the 5% significant level, all the hypotheses with no spatial autocorrelation about geographically concentrated economies would be rejected. In other words, on the average there were significant tendencies towards spatial clusters of both industries in the whole Jiangsu for that period.

Table 1 Estimates for urbanization and localization economies at the county level in Jiangsu

Year	Secondary industry		Tertiary industry			
	Urb*	Loc**	Urb-loc ratio	Urb*	Loc**	Urb-loc ratio
1999	0.795	0.807	0.985	0.535	0.368	1.454
2002	0.814	0.849	0.959	0.340	0.286	1.189

Notes: 1. all the estimates of global Moran's I statistic are significant at 5%; 2.* urbanization economies; **localization economies

There are several evidences to be suggested in Table 1. First of all, in terms of the secondary industry, its ratio of urbanization to localization (urb-loc ratio) indicates that the localization economies were more important than the urbanization economies across Jiangsu whether in 1999 or in 2002, but the importance would

gradually get weaker over time. That means the average increases of industrial outcomes in Jiangsu might be largely dependent on the higher production specialization of industries and increasing returns to scale in the production processes.

Second, its urb-loc ratios of tertiary industry are consistent with the fact that the tertiary industry in the entire Jiangsu had strong urbanization effects on economies rather than localization effects, but such effects have fallen down over year from 1999 to 2002. That implies the regional development of the tertiary industry in Jiangsu arose from a densely populated market and improved services for residents.

Third, comparing the estimates of urbanization and localization economies in the secondary and tertiary industries by year show that the secondary industry has contained increasingly strong agglomeration effects in the whole Jiangsu during the four years. On the contrary, the levels of urbanization and localization in the tertiary industry have gone down over time for that period in spite of the significantly high levels of spatial clusters in both industries.

In terms of Jiangsu Province, the average development of the secondary industry in that time was dependent in a large part on scale economies in the handicraft industrial production, while the transfer of population and a densely populated market might contribute to the tertiary industry's fortunes.

3.2 Moran Scatterplot Map

The Moran scatterplot map is immensely helpful for the show of the local spatial distribution under study because it can visualize clearly local spatial autocorrelations of geographically agglomerative economies between counties (cities) and their neighbors. In addition, assuming some significant level (for example, with an overall α level of 0.05, the individual significance levels for each observation at the county scale in Jiangsu should be taken as 0.05/67 or 0.00075), LISA can provide the significantly local estimates of the variables under consideration, named "hot spots". To demonstrate regional arrangements of agglomeration economies in both the industries of Jiangsu in 1999 and 2002, this paper proposes a new visual technique, named Moran scatterplot map by combining Moran Scatterplot with LISA statistics. The illustrations of the results are organized by secondary and tertiary industries.

3.2.1 Secondary industry

Now we first examine the Moran scatterplot maps of spatial concentration of economic activities in the secondary industry in 1999 (Fig. 1, Fig. 2). The general

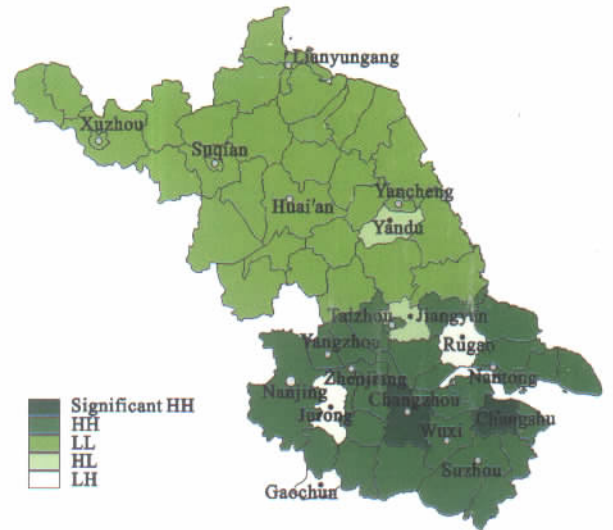


Fig. 1 Urbanization economies of secondary industry in Jiangsu in 1999

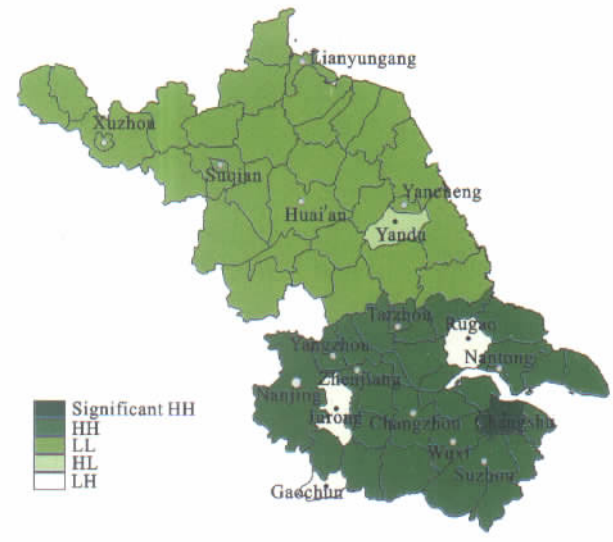


Fig. 2 Localization economies of secondary industry in Jiangsu in 1999

conclusion is that the significantly spatial patterns of agglomeration economies can be showed in both maps. Specifically, the counties (cities) with high levels of agglomeration economies are located in the southern and the parts of middle Jiangsu along the Changjiang River (HH); whereas all of the counties (cities) with lower urbanized and localized effects are located in the northern Jiangsu (LL). By the speed of economic development, Jiangsu Province can roughly be divided into two areas: one is the developed southern Jiangsu and the parts of middle Jiangsu along the Changjiang River, and the other is the less developed northern Jiangsu.

Historically, the southern Jiangsu has ever been one of the most developed parts of the province. Since China's economy began to reform in 1979, the remarkable

economic growth in the southern Jiangsu was booming by means of increasing foreign investment. While, for some reasons the north counties (cities) have developed their economies at a slower speed for a long term. Based on the statistical figures of Jiangsu in 1999, per capita GDP and income in the southern Jiangsu were over two times those in the northern.

Changshu City (in Suzhou)^① and Changzhou proper in Fig. 1 as well as Changshu City (in Suzhou) in Fig. 2 are the counties (cities) with the significantly clustered activities of secondary industry (Significant HH). As mentioned above, they are supposed to be considered as the growth roles, benefiting to the adjacent regional economies around themselves.

As for atypical regions (HL and LH), the counties (cities) showed in Fig. 1 are almost the same as the ones in Fig. 2, such as Gaochun County (in Nanjing), Jurong City (in Zhenjiang), Rugao City (in Nantong), and Yandu County (in Yancheng). Owing to polarization effects, the population and skilled employment in these counties (cities) have been transferred from their neighbors (HL) or to their neighbors (LH), leading to the higher or lower level of agglomeration economies of themselves.

The geographically agglomerative economies of secondary industry in Jiangsu in 2002 are showed in Fig. 3 and Fig. 4. Between 1999 and 2002, there are several changes found in the overall spatial patterns of agglomeration economies. Specifically, the growing numbers of the counties (cities) with significant agglomeration economies (Significant HH) are illustrated whether in urbanization or localization economies. That implies that the economic disparities between the southern and northern have been increasingly enlarged during the four years.

Furthermore, it may be of interest to notice through Fig. 3 and Fig. 4 that the counties (cities) with significant agglomeration economies of some type in 2002 (Significant HH) are centered within the economic circle of Shanghai, also called the Shanghai Metropolitan Area. Generally speaking, the agglomeration of economic activity generates externalities that raise the productivity of regional industries and the economic growth. Thus, it is possible that the "hot" counties (cities) concentrated around Shanghai had the opportunities of sharing learning and the exchange of ideas with it.

Comparing both maps illustrates that the group with the presence of localization and the absence of urbanization consists of Rugao City and Lishui County (in Nanjing), which suggests that the economic growth in

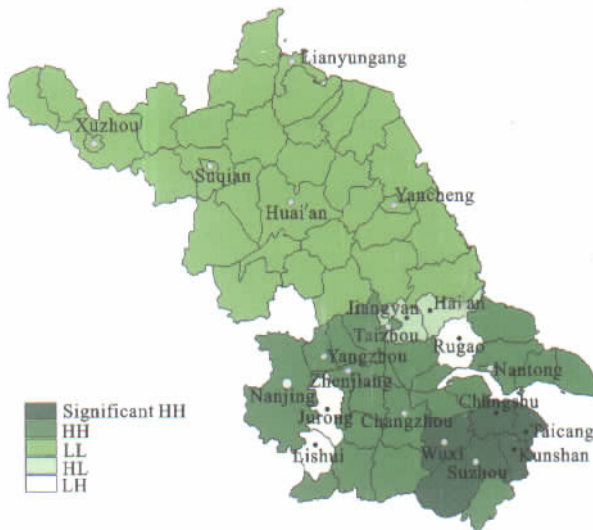


Fig. 3 Urbanization economies of secondary industry in Jiangsu in 2002

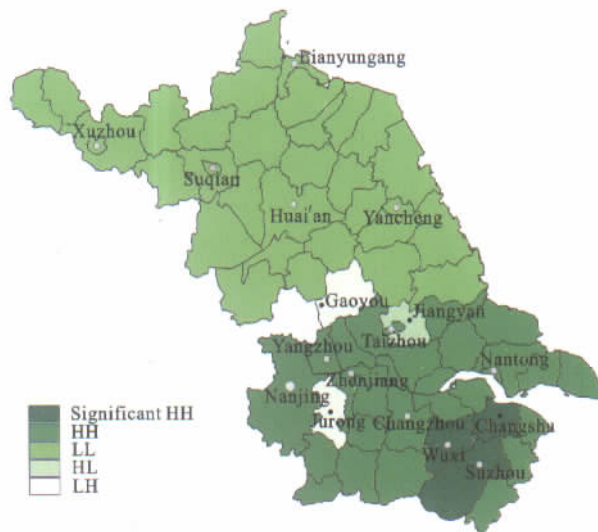


Fig. 4 Localization economies of secondary industry in Jiangsu in 2002

such counties (cities) relies mainly on increasing returns to scale in industrial production under the control of regional population; whereas Gaoyou City (in Yangzhou) is the only one with urbanization economies, benefiting from large urban markets. Also, only Jurong County (in Zhenjiang) has no evidence of localization and urbanization effects.

All in all, the preferential policies for foreign investment and non-state-owned enterprises accounted for rapid industrialization in the southern counties (cities) of Jiangsu. Furthermore, the disparities between those regions and the rest of Jiangsu have gradually increased as they enjoyed better investment environment, more capital and better human resources.

① The city in bracket is prefectural city, and the same below.

3.2.2 Tertiary industry

Fig. 5 and Fig. 6 show the geographical patterns of both urbanization and localization economies in the tertiary industry of Jiangsu in 1999. There are some evidences derived from them. Compared with the secondary industry, the economic activities in tertiary industry are scattered much widely over the geographical distribution. In addition, the spatial pattern of urbanization economies is moderately dissimilar to that of localization economies.

Inspired by MOOMAW, the counties (cities) with stronger agglomeration economies in Fig. 5 and Fig. 6 can be divided into three groups: 1) urbanization and localization economies; 2) only urbanization economies; and 3) only localization economies (MOOMAW, 1988).

The largest numbers of the counties (cities) with both urbanization and localization economies in the tertiary industry can be found in Fig. 5 and Fig. 6. At the same time, it might be of interest to notice that most counties (cities) were also involved in strong agglomerative activities of secondary industry at the same time, which indicates that the highly agglomerative economies of tertiary industry occurred mainly based on the similar economies in secondary industry. For example, some county has sufficiently strong industrial agglomeration, and then its wages and housing prices are relatively higher. Subsequently, the county will absorb more and more immigrants from other poorer regions, which brings about huge working opportunities for serving the immigrated people in the county.

As for group (2), 3 counties (cities) hold urbanization economies and no evidence of localization economies, namely, Taicang City (in Suzhou), Yangzhong City (in Zhenjiang), and Liyang City (in Changzhou). Due to less density of population or the geographical factors (for example, the Changjiang River), these counties (cities) could not obtain advantages from a larger number of purchasers and advanced services for consumers. Thus, the development of the tertiary industry in these counties (cities) to a large extent relied on their own markets. In other words, the transfer of population is one of the strategies of development in the tertiary industry of both counties (cities).

Group (3) consists of 3 counties (cities) with a presence of localization and an absence of urbanization, that is, Dafeng City (in Yancheng), Xiangshui County (in Yancheng), and Gaochun County (in Nanjing). Note that all of them are the less developed counties (cities) despite of the last one in Nanjing, and held a large number of residents within themselves. As a result, these counties (cities) had strong localization economies that were smaller in size and significance unless regional population was controlled.

Fig. 7 and Fig. 8 are the last two Moran scatterplot maps to describe the estimation of agglomerative economies in tertiary industry in 2002. Their estimated results illustrate that the counties (cities) with only urbanization economies of tertiary industry in 2002 are all situated in the southern Jiangsu, namely Wujiang City (in Suzhou) and Yangzhong City (in Zhenjiang). Besides, two counties (cities) with a presence of localization and an absence of urbanization can be found in the northern Jiangsu. They are Jianhu County (in Yancheng) and Jiangyan City (in Taizhou).

Comparing agglomeration economies in 1999 (Fig. 5 and Fig. 6) with the ones in 2002 (Fig. 7 and Fig. 8)

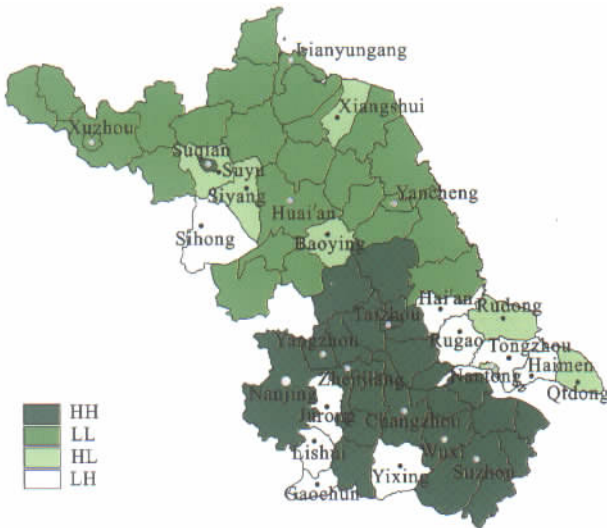


Fig. 5 Urbanization economies of tertiary industry in Jiangsu in 1999

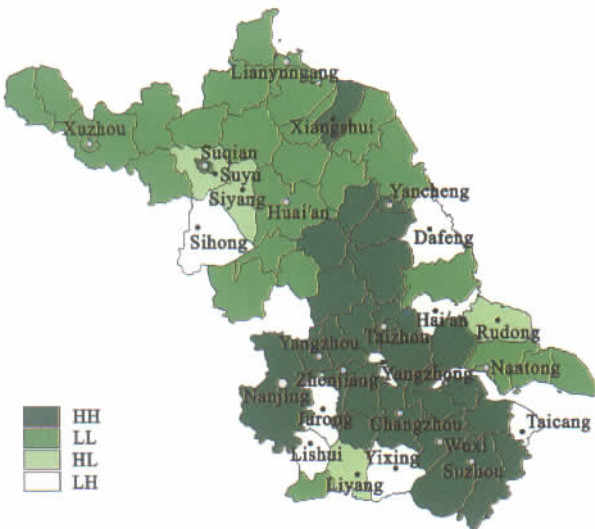


Fig. 6 Localization economies of tertiary industry in Jiangsu in 1999

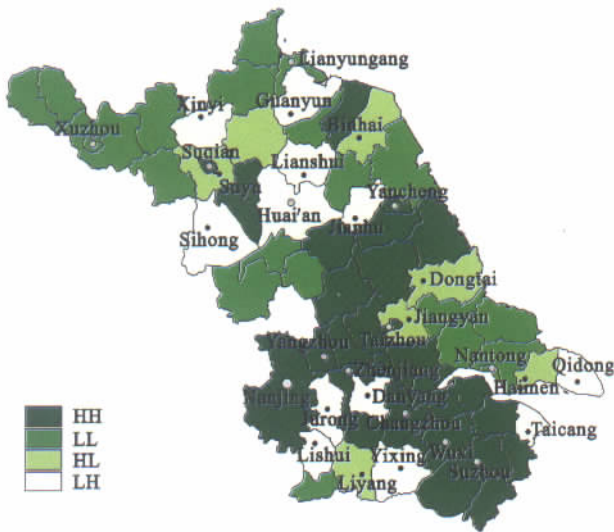


Fig. 7 Urbanization economies of tertiary industry in Jiangsu in 2002

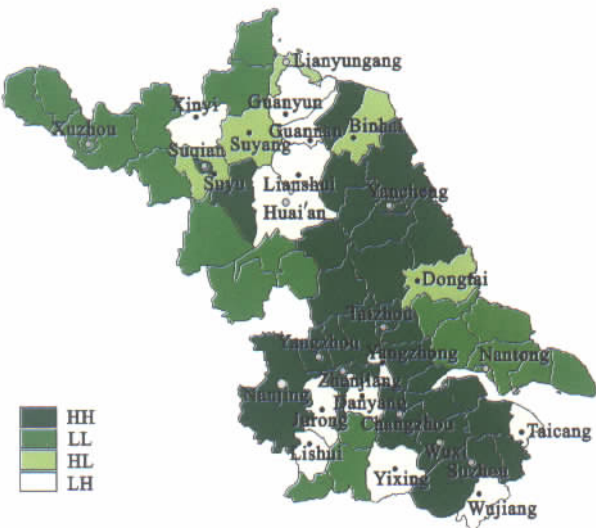


Fig. 8 Localization economies of tertiary industry in Jiangsu in 2002

suggests three general conclusions. First of all, the visual and clear geographic arrangements of the activities in tertiary industry have been gradually diverged from 1999 to 2002. That means the uneven development between the southern and northern Jiangsu to the extent has been broken in tertiary industry in spite of undeveloped industries in the northern Jiangsu.

Second, the counties (cities) with strong urbanization or localization of service industries have "moved" up from the southern to the northeastern Jiangsu. In other words, during the period of 1999 and 2002, the economic growth in the north part of Yangzhou and the whole Yancheng has been mainly dependent on the development of tertiary industry rather than secondary industry.

Third, some counties (cities) with high agglomeration of secondary industry have weaker agglomeration economies of tertiary industry, for example, the counties (cities) in Nantong, Taizhou, and even the ones near Shanghai and Nanjing proper. Recently, the decreasing population density in these counties (cities) accounts for the reason why they have weaker spatial clusters of economic activities in trade and service industries.

In addition, there is an increasingly growing number of the atypical counties (cities) (HL and LH quadrants) in the tertiary industry over time for that period of 1999 and 2002. That leads to the much lower proportions of counties (cities) with urbanized or localization economies in the tertiary industry than in the secondary industry. Furthermore, it can be observed that the localization and urbanization economies in the tertiary industry tended to appear in the metropolis cities because of larger urban markets and easy access to consumption and services. Explicitly, the urban districts of 13 cities with the exception of Xuzhou urban area and Lianyungang proper contained the urbanized and localized tertiary industries because they were social and economic centers.

4 CONCLUSIONS

The economic agglomeration is a key factor in the interpretation of regional development. Thus, it is significantly important to measure geographically agglomeration economies at the regional scale. Many indicators can be applied for estimating the degrees of agglomerative economies. However, they have not considered the spatial proximity as their portions. This study makes a newer attempt to apply a series of techniques of spatial autocorrelation analysis for estimating and distinguishing the economies of agglomeration in secondary and tertiary industries of Jiangsu in 1999 and 2002.

In terms of secondary industry, the estimated results obtained in this study are fairly consistent with the economic situations in Jiangsu during that time. Generally speaking, localization effects were more important than urbanization effects in the whole Jiangsu, but such importance went decreasingly down over time. Furthermore, the highly spatial clusters of economic activities have been limited within the southern counties (cities) of Jiangsu and the part of middle counties (cities) along the Changjiang River for that period. Note that the growth poles were located within the economic circle of Shanghai. By contrary, the rest of Jiangsu had weaker agglomeration economies.

On the whole, the tertiary industry has stronger urban-

ized effects than localized effects on regional economies in Jiangsu whether in 1999 or in 2002, but the trend has been gradually decreasing over year. That indicates this industry benefits from a larger size of market and advanced services for population. Moreover, at the county scale, it might be of interest to notice that the high levels of agglomeration economies in the tertiary industry can be found in the poor northeastern Jiangsu, which is helpful to narrow the regional disparities between the northern and southern Jiangsu. In addition, the highly economies of agglomeration in the tertiary industry easily occur in the social and economic centers, or the urban districts of municipalities.

ACKNOWLEDGMENTS

The authors are always grateful to Professor John MIRON, the Department of Geography at University of Toronto for throughout direction into regional economies, as being a visiting Ph.D. student in the Department of Geography, University of Toronto during the period 2002–2003. He presented his professional and academic skills to the author, and gave lots of suggestions in the studies of Chinese regional economies. Meanwhile, the authors also thank Dr. BAO Shu-ming for his program.

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