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Spatial Correlation Analysis of 2013 Per capita GDP in the Area of Beijing, Tianjin and Hebei

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Abstract: This paper is based on the Moran's I coefficient and Geary's c coefficient, and with the support of SAS statistical analysis software, using the spatial analysis of Beijing-Tianjin-Hebei's per capita GDP and Geographical coordinates together. The research results show that the Moran's I coefficient is 0.098, Geary's c coefficient is 0.868, which is showing that there is a positive correlation between Beijing-Tianjin- Hebei region's city economy. But the degree of correlation is low, which is showing that Beijing-Tianj-Hebei collaborative development is still in the initial stage, and regional economic integration has not fully realized.

Keywords: Regional Economic Integration, Collaborative Development, Spatial Analysis

1. Introduction

There are 28 provinces and 4 municipalities directly under the Central Government in China mainland. Beijing and Tianjin are the two of the four municipalities, and Beijing is also the capital of China. Beijing also is the China capital of politics, economics, and culture, and it offer a lot of opportunities for the People. Beijing has a population of more than 21.15 million, which causes a lot of traffic, pollution and accommodation problems. However, things are a little different in Hebei Provinces, as it is ten times larger than Beijing but its population is only two times more than Beijing. Based on these problems, the central China government is promote a strategy of Regional economic integration on Beijing, Tianjin and Hebei. This paper is to investigate the status of the process of this economic integration.

The 2013 Per capita GDP data of this area and spatial autocorrelation analysis are used to measure the status of economic integration. The GDP is a comprehensive index, which can represent a lot of economic status. Considering the area of Hebei province is relative larger, Per capita GDP is used for analysis. Spatial autocorrelation is the correlation among values of a single variable strictly attributable to their relatively close locational positions. Tobler's first law of geography encapsulates this situation: "everything is related to everything else, but near things are more related than distant things." This paper use Moran's I coefficients and Geary's C coefficients to measure the Spatial autocorrelation in the Per capita GDP data for the study area. The definition of these two coefficients are explained below.

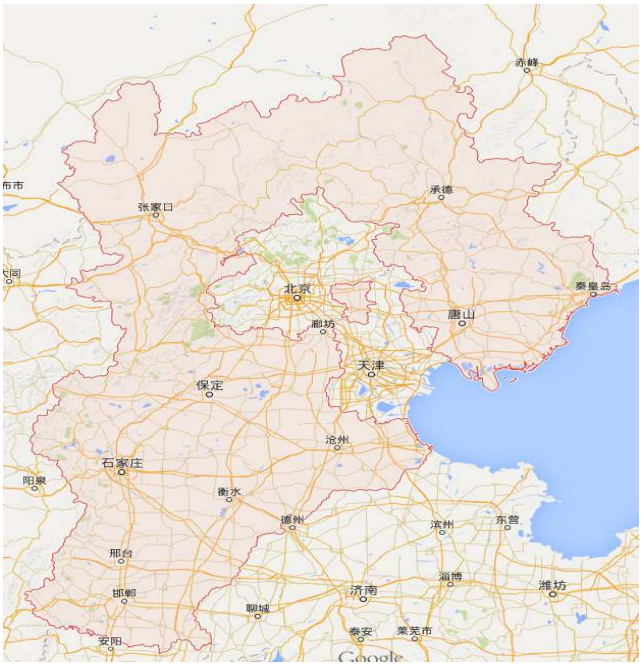

Figure 1. *The map of Beijing, Tianjin, and Hebei from Google map. The dash area is Hebei Province, and the area included by Hebei and Sea is Beijing and Tianjin, which have same area size.*

2. Data Description

The data used in this paper are collected from the website of sohu.com. The county data of Beijing and Tianjin, and city data of Hebei Province are used, which contains per capita GDP and longitude and latitude of the local government site. The whole data are listed in Table 1. As shown in the table, there are 16 counties in Beijing and Tianjin respectively, and 11 cites in Hebei Provinces. The distribution of per capita GDP values are displayed in the boxplot of Figure 2.

Table 1. *The 2013 per capita GDP data of Beijing, Tianjin and Hebei with the longitude and latitude data.*

Area	City/county	2013 per capita GDP (China Yuan)	Longitude	Latitude
Beijing	Xicheng	214888.72	116.372454	39.918191
	Dongcheng	172167.22	116.42276	39.934769
	Shunyi	135350.97	116.661085	40.136507
	Haidian	107130.87	116.309969	39.992281
	Chaoyang	102056.76	116.44976	39.92656
	Daxing	89256.80	116.348055	39.732472
	Shijinshan	56677.02	116.229563	39.911342
	Huairou	52460.73	116.638156	40.322312
	Fangshan	48514.85	116.149663	39.754185
	Fengtai	44576.20	116.292652	39.864803
	Miyun	41239.50	116.849711	40.382106
	Mengtougou	40990.10	116.10875	39.946234
	Pinggu	39928.91	117.12759	40.146966
	Tongzhou	37858.22	116.663214	39.91623
	Changping	29115.93	116.237897	40.226372
	Yanqing	29082.28	115.981706	40.462339
Tianjin	Binhai	304240.95	117.71713	39.009822
	Heping	202227.43	117.221184	39.123191
	Dongli	106618.20	117.320777	39.092262
	Xiqing	99185.50	117.015262	39.147496
	Beichen	97188.21	117.141985	39.23004
	Ninghe	92960.29	117.831069	39.336646
	Jinnan	85199.10	117.363487	38.943845
	Wuqing	75002.37	117.050707	39.389024
	Hexi	70411.77	117.229775	39.115759
	Jinghai	66853.93	116.980747	38.953441
	Baodi	55797.02	117.316431	39.723239
	Nankai	52679.38	117.156626	39.144152
	Ji	45804.40	117.414869	40.051473
Hebei	Hebei	44547.40	117.203344	39.153791
	Hedong	33369.21	117.258675	39.135023
	Hongqiao	28404.05	117.157216	39.173205
	Tangshan	79365.20	118.186678	39.636637
	Shijiazhuang	46828.20	114.521409	38.048234
	Langfang	44854.57	116.69041	39.544007
	Cangzhou	40571.77	116.845322	38.310336
	Qinhuangdao	38681.49	119.608614	39.941588
	Chengde	34107.95	117.969493	40.959115
	Handan	30827.71	114.545866	36.631195
	Zhangjiakou	29974.05	114.892592	40.774341
	Hengshui	25090.42	115.676782	37.745031
	Baoding	23609.42	115.47105	38.880045
	Xingtai	22321.45	114.511441	37.076789

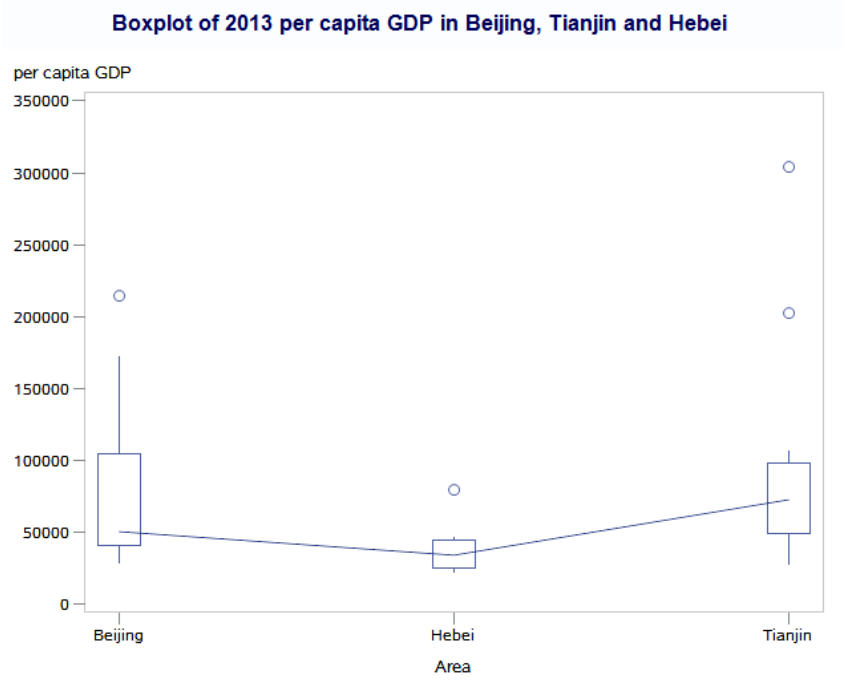

Figure 2. *The boxplot of 2013 per capita GDP in Beijing, Tianjin and Hebei.*

From the Figure 2, the median per capita GDP of the counties in Tianjin are the highest, and the counterpart of Beijing is in the second place. At the same time, the fluctuations in Tianjin's GDP data are larger than the remaining two areas. In the Figure 3, spatial distribution of 2013 per capita GDP data of Beijing, Tianjin and Hebei are displayed. Comparing Figure 1 and Figure 3, it can be found that the part with relative larger circles (39<x<40.5 and 116<y<118) are Beijing and Tianjin, and from the spatial distribution the spatial autocorrelations can be seen in the GDP data. The counties around and in Beijing and Tianjin area are tended to large values, while the counties , far away from this area are tended to be small values. To make an accurate inference, Moran's I coefficient and Geary's c coefficient are introduced in the next section.

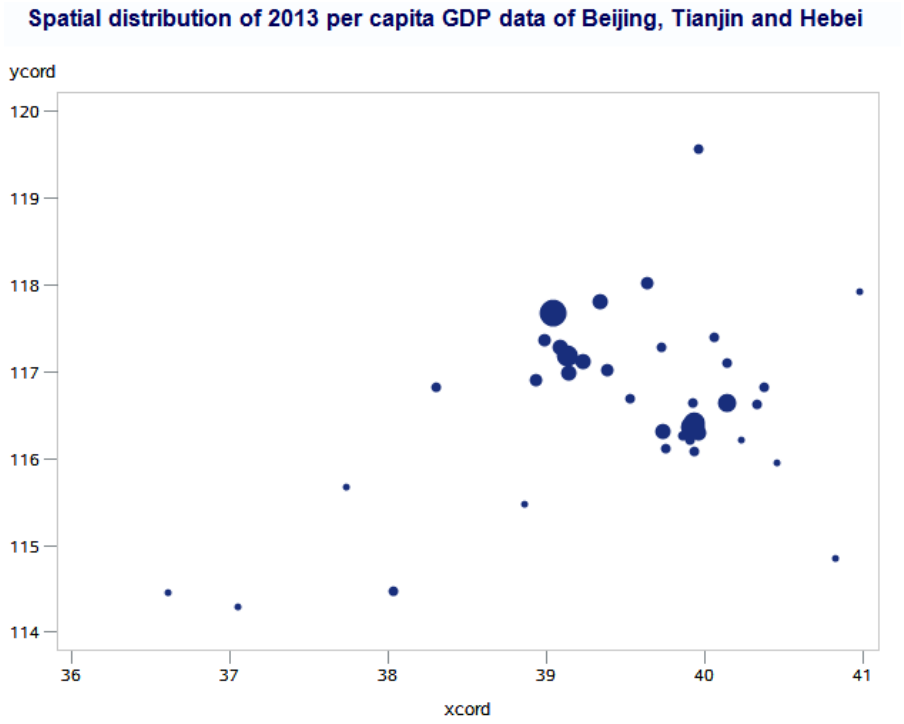

Figure 3. *The spatial distribution of 2013 per capita GDP data of Beijing, Tianjin and Hebei. The size of the circles represents the scale of the per capita GDP values in such counties.*

3. Moran's I and Geary's c

The Moran's I coefficient are defined as

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

and the Geary's c coefficient are calculated as

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

In statistics, Moran's I is a measure of spatial autocorrelation developed by Patrick A.P. Moran. Like autocorrelation, spatial autocorrelation means that adjacent observations of the same phenomenon are correlated. However, autocorrelation is about proximity in time. Spatial autocorrelation is about proximity in (two-dimensional) space. Spatial autocorrelation is more complex than autocorrelation because the correlation is two-dimensional and bi-directional. Negative (positive) values indicate negative (positive) spatial autocorrelation. Values range from −1 (indicating perfect dispersion) to +1 (perfect correlation). A zero values indicates a random spatial pattern. For statistical hypothesis testing, Moran's I values can be transformed to Z-scores in which values greater than 1.96 or smaller than −1.96 indicate spatial autocorrelation that is significant at the 5% level. The Z-scores transformation can be easily written as

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

Geary's C is also a measure of spatial autocorrelation or an attempt to determine if adjacent observations of the same phenomenon are correlated. Geary's C is inversely related to Moran's I, but it is not identical. Moran's I is a measure of global spatial autocorrelation, while Geary's C is more sensitive to local spatial autocorrelation. Geary's C is also known as Geary's contiguity ratio or simply Geary's ratio. The value of Geary's C lies between 0 and 2. 1 means no spatial autocorrelation. Values lower than 1 demonstrate increasing positive spatial autocorrelation, whilst values higher than 1 illustrate increasing negative spatial autocorrelation.

The Moran's I coefficient and Geary's c coefficient are calculated and shown in table 2. It can be seen that the 2013 per capita GDP data in the study area are displayed positive autocorrelation both from Moran's I coefficient and Geary's c coefficient, which means the per capita GDP data in the nearby counties or cities are tended to similar. The p-value of the spatial autocorrelation test are 0.3395 and 0.5725 for Moran's I coefficient and Geary's c coefficients respectively. However, at the same time it is also noticed that only week positive autocorrelation are found in the data, as the Moran's I coefficient are close to 0, and Geary's c coefficient are close to 1.

Table 2. *The Moran's I coefficient and Geary's c coefficient are computed from the 2013 per capita GDP in counties or cities in Beijing, Tianjin and Hebei.*

Spatial autocorrelation coefficients			
Assumption	**Coefficient**	**Observed**	**Pr > |Z|**
Randomization	Moran's I	0.098	0.3395
Randomization	Geary's C	0.868	0.5725

4. Conclusion

This paper use Moran's I coefficients and Geary's C coefficients to measure the Spatial autocorrelation in the Per capita GDP data for the study area to investigate the status of the process of the region economic integration. Based on the results from Figure 2 and Table 2, it can conclude that only week positive autocorrelation are found in this region, and the Per capita GDP value is high in Beijing and Tianjin area. It can be predicted that the center of region economic integration should be around in Beijing and Tianjin, hopefully it can gradually promote the whole area economics. From the Moran's I coefficient and Geary's c coefficient, it can find that the extent of region economic integration is still low and need more investments to increase the integration extent. Meanwhile, to solve the traffic and population problem in Beijing, the government should make more people and companies move to Hebei area by economic inspiring and better polices.

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