Spatial pattern of urban spheres of influence in China and its changes, 1990-2007

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Abstract: Taking almost all cities in China(including Hong Kong and Macau) as the research object in the year 1990, 2000 and 2007, this article studies the urban spheres of influence by using gravity model. Based on overall grasp of the spatial pattern of Chinese urban spheres of influence, the spatial characteristics of urban agglomerations are paid close attention to. Urban agglomerations are national core competitive units, also they are the aeras with population and economy of highly gathered. The previous study of urban agglomerations mainly focused on the aspects of development stage, hierarchy, compactness, etc. From the viewpoint of urban spheres of influence, this paper brings forward four types of spatial pattern of urban agglomerations: namely, strings of beads, pieces of rags, semi-strings of beads, and semi-pieces of rags. Then some basic features are discussed such as cities' numbers, population and central cities of urban agglomerations by using GIS and statistics method. Major findings are as follows: different spatial patterns of urban agglomerations have different degree of development and structure, and evolve under external policy and location factors. The spatial types of urban spheres of influence in China are generally stable, and the developing trends vary with different region and policy.

Key words: China, urban spheres of influence, types of spatial pattern, changes
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1 Introduction

Urban spheres of influence reflect center-to-hinterland relationships, compared with the non-central region, the center assumes more complex economic functions, and provides more economic activities. Famous theoretical contributions to this research field are the Central Place Theory (Christaller, 1933), the extension to the Central Place Theory (Losch, 1954), and the modification to the Central Place Theory (Isard, 1956). Later, the verification and conceptual refinement of the classical literature developed. Then the study of urban spheres of influence focused on two types: the empirical research and the model research.

We can not deny the fact that, nowadays in Western countries, the study of urban spheres of influence is diminishing in general. This is largely because with a high degree of economic and social development, most developed countries have accessed or entered post-industrial society, and node-to-node interactions are dominant, therefore, the study of node-to-hinterland relationships is decreasing. However, for developing countries, they are still under pressure to develop the industry, and the node-to-hinterland relationships are distinctly dominant, therefore, more and more scholars from those countries begin to pay attention to the node-to-hinterland study. Taking China as an example, nowadays the study of urban spheres of influence is now and then emerging in the international academic community (Wang, 2001; Du, 2001; Liang, 2008). As for the domestic academic community, this study is becoming prosperous (Chen, 1987; Gu, 1991; Wang *et al.*, 2000; Liang and Bai, 2007; Wu and Chen, 2007; Pan *et al.*, 2008).

Former studies mainly concentrated in the spatial pattern of urban spheres of influence, including studies of delineating the city group, urban system, and economic zones, which were mostly based on experience. In this paper, focusing on all Chinese mainland cities (including Hong Kong and Macao) in the years of 1990, 2000 and 2007, the distribution pattern and evolution characteristics of urban spheres of influence, city scale in different modes, and the relationship between central and non-central cities were analyzed, based on the use of GIS and statistical methods. The main contents of this article are as follows: (1) arrange and review the research method of urban spheres of influence systematically; (2) illustrate in detail about the source and processing method of spatial data and attribute data, analyze the basic characteristics of changes in China's urban development, and point out the model and rule used in this paper in order to pave the way for the understanding about the overall pattern of urban spheres of influence; (3) based on overall grasp of the spatial pattern of Chinese urban spheres of influence, the spatial characteristics of urban agglomeration are paid close attention to. The previous study of urban agglomeration mainly focused on the aspects of development stage, compactness, etc (Song *et al*., 2006; Fang, 2008). Started from the widely accepted 23 urban agglomerations (Fang, 2005), the paper brings forward four kinds of urban spheres of influence through the spatial pattern of urban influential areas. Then on this basis, analyze and compare the basic characteristics of different modes; (4) Based on the relationship between urban spheres of influence and non-agricultural population, unravel the urban developing tendency in different modes; (5) Explore the change trend and the transformation of distribution pattern of Chinese urban spheres of influence.

2 Methods Review

Urban sphere of influence is a unique socio-economic system formed by the interaction of city and region. Flow patterns are the material foundation of the system as well as the important vehicle for interconnecting between city nodes and urban hinterland. These "flows" make scattered material and population become more agglomerate, make energy evolve from low-quality to high-quality, and make disordered information accumulate orderly (Gu, 1997). According to the type of indicators of urban spheres of influence and their different measure approaches, research methods can be divided into two categories: empirical method and model method.

2.1 Empirical method

Empirical method determines urban spheres of influence according to data features, regional characteristics and the comprehensive analysis of expertise on the basis of the selecting and accessing of urban and regional flow index (commuting data). For example, define the service scope of commercial centers depending on the shopping cost of consumers (Gambini et al., 1967); Describe the interaction between urban spaces (Griffith, 1982) using commuting data in travel and work; Describe urban spheres of influence in American through the services of regional delivery system (Huff, 1973); Determine the interaction and connectivity network between urban systems in Canada in 1999 through the collection of air flow, road traffic, telephone, population migration and emigration as well as such as the total volume of imports and exports (Simmons, 2005); Analyze Chinese spatial network of urban systems using air transport data (Zhou and Hu, 2003).

2.2 Model method

Model method describes the interaction between spaces using theoretical model, grasps the intensity and pattern of contact between cities, and determines urban spheres of influence. With improvement of the convenient of urban transportation and regional accessibility degree, contacts between urban and urban, urban and region become very complex. All kinds of data are inaccessible and are lack of comprehensiveness, which makes the model become the most important research tools (Du, 2001; Gu, 2008).

The most important theoretical basis for the division of spatial influence range is the gravity model(Reilly, 1929). In the model study of urban spheres of influence, Huff and Lutz made a great contribution. They used the model to delineate the urban spheres of United States, Ireland, and Ghana (Huff, 1973; Huff and Lutz, 1979, 1989, 1995). Not only was the gravity model itself, but also the breaking point model derived from it widely used by scholars (Chen, 1987). When the distance coefficient of the basic gravity model equals 2, the point which exerts equal forces from the other two points is called a breaking point.

In order to avoid the overlap and gaps between urban spheres of influence, Voronoi diagram is considered to be a good tool to describe the interaction pattern of cities at the same level (Gold, 1992; Okabe et al., 2000). Ordinary Voronoi diagram is often used in spatial influenced region dividing, but it only takes the distance factor into account, can not reflect the attraction process and its differences characteristics between cities well. The limitations of the ordinary Voronoi diagram enables the gradually application of the weighted Voronoi diagram, in fact, a growing number of property factors are being introduced as weights(Boots, 1980; Gahegan and Lee, 2000; Mu, 2004). Weighted Voronoi diagram includes double-weighted, sum-weighted, coincide-weighted, and involution-weighted and so on.

2.3 Evaluation

Data collections of empirical methods are more complicated and not readily available; there is no available detailed city commuter statistical data. The empirical method is more accurate and realistic; however, it is commonly used as a test and supplementary. The gravity model is closely related to Voronoi diagram, especially has a great similarity with " divisor formula " weighted Voronoi diagram, both of them can reflect the spatial and attribute information of spatial objects, which is more consistent with the actual situation.

3 Data Preparation and Method Design

3.1 Data

Since reform and opening up, especially since the 1990s, China has experienced a rapid development period. In order to grasp the spatial pattern and change characteristics of urban spheres of influence in a national scale, year 1990, 2000 and 2007 are selected time segment and all cities (county-level and above) in these three periods are selected as research object in this study. In order to ensure the consistency of the meaning of indicators and statistical caliber, we choose non-agricultural population in urban areas as strength indicator of the city. Non-agricultural population in urban areas is not the only indicator which portrays the strength of a city, but it is the most credible and important statistical indicator to describe development potential and status of the city (Cui, 1992; Hamer, 1990; Hsu, 1994; Du, 2001). In China City Statistical Yearbook, till the year of 2007, the non-agricultural populations of each city in previous year have been published. Therefore, the data of non-agricultural population in 1990 and 2000 was taken from China City Statistical Yearbook 1991 and 2001 respectively (National Bureau of Statistics of China, 1991, 2001). The data of 2007 was taken from China Population and Employment Statistics Yearbook 2008 (National Bureau of Statistics of China, 2008). Hong Kong, Macau have deep and wide contacts with the Pearl River Delta (Cai, 1997), and this economic contact enhances apparently since the implementation of the reform and opening-up policy(Xue and Yang, 1997); The continuous integration of Macau and Zhuhai in spatial distribution and economic(Ye, 2000) makes Hong Kong and Macau occupy a very important position in the region development of Pearl River Delta. Therefore, Hong Kong and Macao are incorporated into the study areas in this paper. As they have different political systems and economic structures from mainland China, the urban population is chose as their data indicator.

The data was collected from Guangdong Provincial Bureau of Statistics 2008(Guangdong Provincial Bureau of Statistics, 2008), National Bureau of Statistics of China 2005 and National Bureau of Statistics of China 2009(National Bureau of Statistics of China, 2005, 2009).

The spatial data was based on the map (Albers projection) with scale of 1 : 100000 provided by National Geomatics Center of China. Then by using Grid module in ArcGIS, the grid map of 1000 m ×1000 m (1000 m approximately equal to 32") was generated, with the total size of 4846×4141, which is shown in Fig.1.

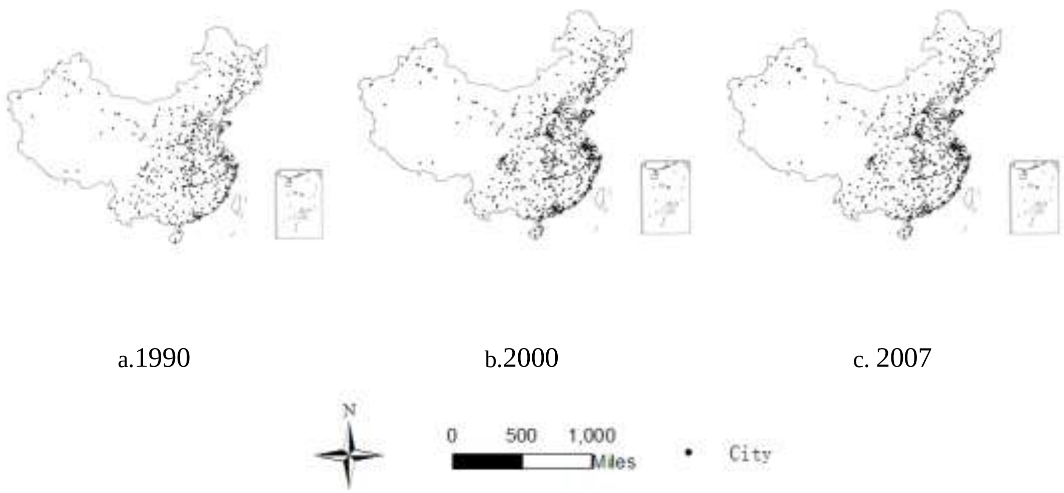


Fig 1. Defining the study areas

At the beginning of the establishment of the People's Republic of China, Chairman Mao Zedong stressed the importance of handling the relationship between coastal areas and the Mainland in "On the Ten Major Relationships", which is the first regional division of China. With the propose of regional policy "Eastern areas take the lead in development ", "the Development of the Western Region", "Revitalize the northeast old industrial base", "Rise of Central China", four major regional pattern of China have basically formed. As seen form the table1, urban non-agricultural population all over the country showed a steady growth trend, the non-agricultural population in 2007 is twice as much as what it was in 1990. The biggest increase is the eastern part, the central and western regions are the second, and the last one is the northeast region. Average growth rate of non-agricultural population in the two periods was basically the same, the average growth rate of the eastern part of is continuous climbing, the growth rate of central and western China is relatively stable, while the non-agricultural population growth of north-eastern part is relatively slow, its average growth rate has fall from 2.8% to 1.2%.

Increase in the number of cities can be divided into two periods, the first is 1990-2000. In this period, there were about 20 new cities emerged each year. The number of new cities in eastern, north-east, central and western was 96, 23, 39 and 38. It can see that the new cities mainly concentrated in the eastern coastal region (49%), while the number of new city located in northeast was smaller (11%). During the period 2000-2007, the total number of cities decreases in, the reduction of which in the east is 13, the north-east and central regions remain virtually unchanged, and 7 new cities emerged in the west region. The decrease of the total number of cities was due to "district instead of city" around big cities, and this "district" is no longer considered as a statistical unit.

Table 1. Number of non-agricultural populations and city in different regions

Region	Non-agricultural population			Region	City number		
	1990	2000	2007		1990	2000	2007
East	6430	10402.58(6.1%)[a]	15859.25(7.5%)[b]	East	151	247	234
Northeast	3012.08	3841.75(2.8%)[a]	4171.97(1.2%)[b]	Northeast	67	90	89
Centre	3228.02	5055.09(5.7%)[a]	6582.94(4.3%)[b]	Centre	129	168	168
West	2971.11	4422.74(4.9%)[a]	5732.91(4.2%)[b]	West	122	160	167
Total	15641.21	23722.16(5.2%)[a]	32347.07(5.2%)[b]	Total	469	665	658

Note: ( ) [a]: average annual growth rate of non-agricultural population from 1990 to 2000;

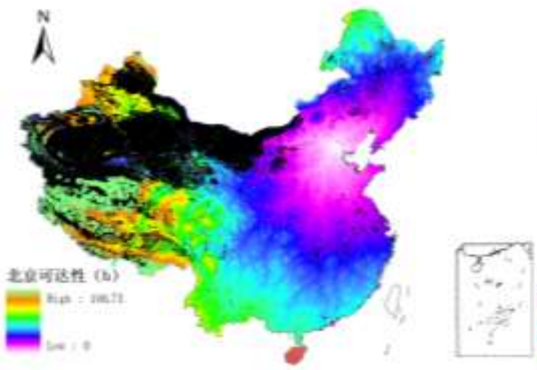
( ) [b]: average annual growth rate of non-agricultural population from 2000 to 2007.

3.2 Method in this article

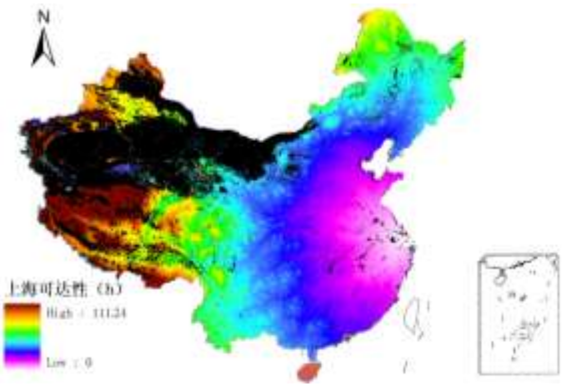
For the research of distance d , we mainly concentrated on the discussion of distance indicators, which is how to choose proper way to measure real distance. There are so many types of selection of distance: such as transport costs, railway distance, travel time, and comprehensive costs including tariff barriers, or directly with straight-line distance. Anderson think it can be closer to reality that different study object should take different distance measurement according to the features.

In this paper, we use road network to measure distance accessibility which includes the expressway, national highway, provincial highway, and railway, bearing the most main traffic volume. The average speed of these roads in order is 100 km/h, 70 km/h, 50 km/h, 70km/h. In addition, given the absolute barrier composed by the water body, wetlands, glaciers, desert, bare rock and desert, the traffic speed set to 0; considering the unique topography feature of the three stairs in China, the traffic speed within range of the first stair, the second stair and the third stair respectively is: 8 km/h, 10 km/h, 15 km/h. On the basis of the acquisition of the national grid speed map, we calculate the minimum time value through unit grid, namely T = length of unit grid / traffic speed of the grid. Finally, using the basic ideas of Dijikstra algorithm and "cost weighted" method in the shortest path analysis, it can be generated nationwide accessibility graph which respectively takes the city as the center all across the country.

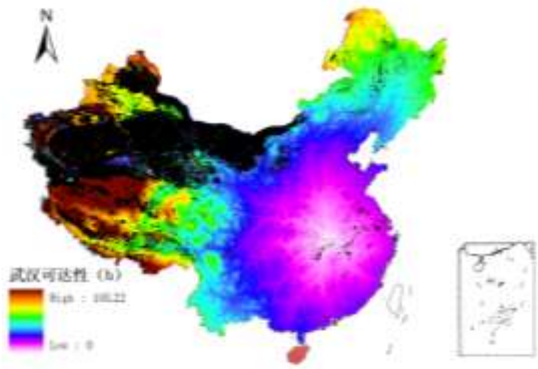
Figure 1. City Accessibility in the Whole Nation (Beijing, Shanghai, Wuhan, Xian, for example)



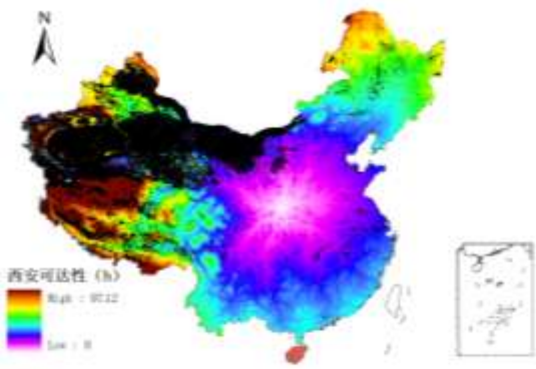
A Beijing



B Shanghai



C Wuhan



D Xian

In this paper, we used the pervasive gravity model to reflect the interactions between places (about the exponent of distance, we chose the value of 2 according to the usual practice). Obviously, the spatial interaction is directly proportional to the city size and is inversely proportional to the distance (Taaffe, 1962). The expression of gravity model is as follows:

$$F_{ij} = G \frac{P_i P_j}{r_{ij}^2} \quad (1)$$

F_{ij} represents the spatial interaction between *i* and *j*; G is the gravitational constant; P_i, P_j are the non-agricultural population respectively; r_{ij} is the distance between *i* and *j*.

In order to delineate the urban spheres of influence, apparently, the direct idea is to use the gravity model to obtain the interaction values between each given hierarchical city and every coordinate of point in the study area of the map. Then in each hierarchy all values related to one place are compared, and the highest interaction value decides this place belongs to which city's spheres of influence. In this paper, we just determined the coordinates of the points that had equal interaction values with more than one city in each hierarchy, then connected these points into lines, which represent the equilibrium of the spheres of influence of each city. For a given city, these related lines form the boundary of its spheres, and within the lines of boundary, this city has the greatest influence relative to other cities. Thus, the areas within the boundary are the urban spheres of influence of each city.

Let X be a point on the equilibrium lines of the city P_i, and P_j. According to the gravity model, the spatial interactions between this point and the two cities are as follows:

$$F_{iX} = G\frac{P_i P_X}{r_{iX}^2}, \quad F_{jX} = G\frac{P_j P_X}{r_{jX}^2} \qquad (2)$$

Because in the point *X*, the interactions are equal, thus

$$F_{iX} = F_{jX} \qquad (3)$$

Combine the formula (3) with (2). Finally, we can obtain the boundary point by determining the distance that it from each related city:

$$\frac{r_{iX}}{r_{jX}} = \sqrt{\frac{P_i}{P_j}} \qquad (4)$$

Every coordinate point was measured one by one through the formula (4), and all the points satisfying the conditions were determined. Through connecting all the points, the spheres of influence were obtained as well as the boundaries. In essence, the results of this method are the same with the method used by Huff (Huff, 1973).

4 Result and Discussion

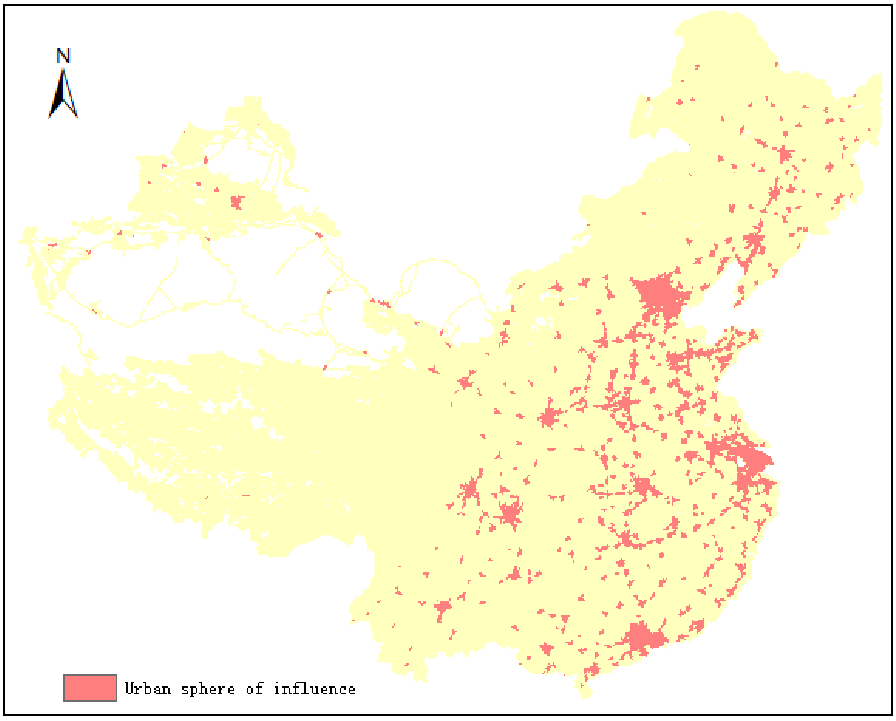


Fig 2. Sphere of influence of 2007

Figure2 indicates that the density decreases by a constant slope from eastern to western China. Since the year 2000, the density of urban places located in the eastern portion of China has mushroomed, due to the larger numbers of cities with prosperous economic profiles. In contrast, urban places in the western portion of China are sparse, and central cities, especially the capitals of provinces, are supported financially by national government, thus the areas encompassed within the urban spheres of influence in the central cities are much larger than those of cities located in the hinterland (Huff, 1979). In reality, even though the central cities in the western portion of China have the bigger geographical reach of their influence, the economic radiations from the central cities to periphery areas are limited. In general, the urban spheres of influence in China are comparatively steady from 1990 to 2007.

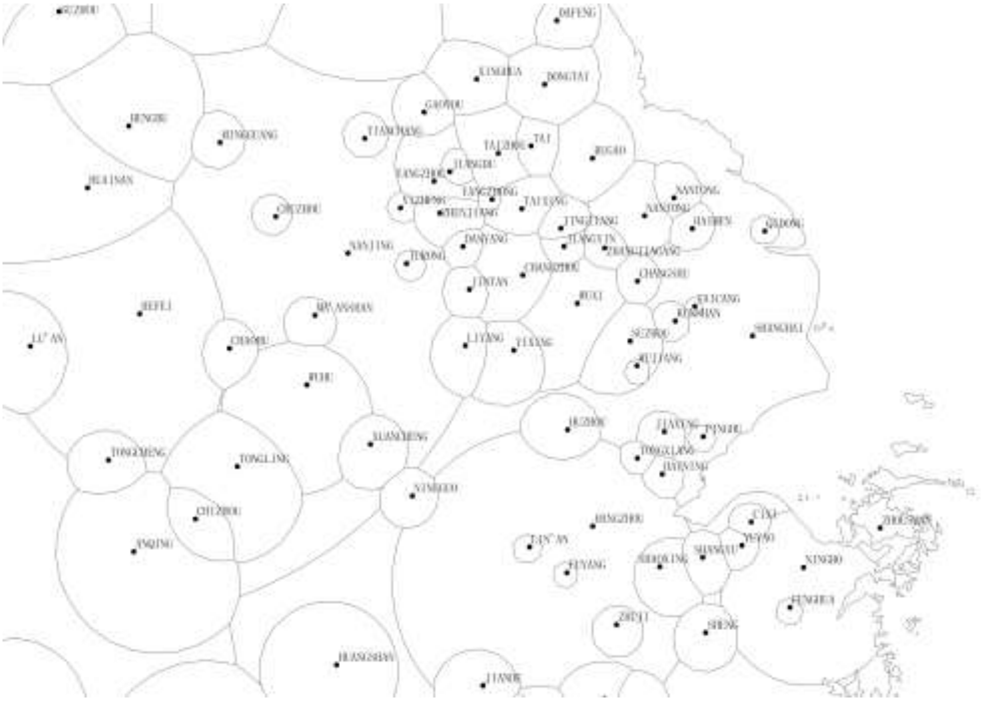
Based on overall grasp of the spatial pattern of Chinese urban spheres of influence, the spatial characteristics of urban agglomeration are paid close attention to. Started from the widely accepted 23 urban agglomerations (Fang, 2005), the paper brings forward four kinds of urban spheres of influence through the spatial pattern of urban influential areas:

(1) "Strings of beads": this group consists of 5 Urban Agglomerations in the Yangtze River Delta, Pearl River Delta, Jing-Jin-Ji Metropolis, Shantung Peninsula and Liaotung Peninsula. These large urban agglomeration regions, which play an important role in Chinese economic development, are comparatively advanced megalopolis with the longer developing history. The Yangtze River Delta, including such cities as Shanghai, Nanjing and Hangzhou, was the biggest economic synthesis, whose GDP (Gross Domestic Product) was 4686.007 billion Yuan at the year of 2007. Moreover, with the high-speed process of urbanization and industrialization, urban spheres of influence in the Yangtze River Delta resemble "strings of beads" (Huff, 1977). The example of this group is shown in Fig.3a.

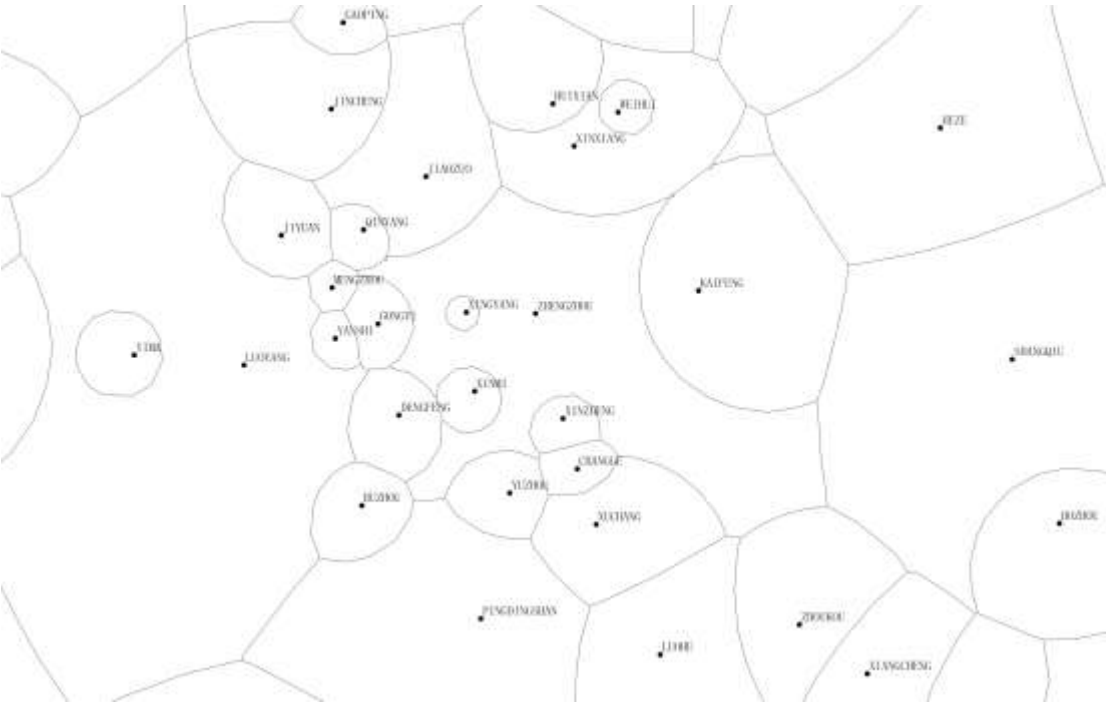
(2) "Pieces of rags": this group is composed of 6 Urban Agglomerations in the Chengdu-Chongqing region, Metropolitan Regions in Central and Northeast China. One central metropolitan city within those regions often plays a primary role in such aspects as investment and policy, thus this primary city obtains more economic opportunities than other cities. Specifically, Chinese northeast industrial bases are characterized by lack of inner economic momentum; Chinese central metropolitan regions gain limited advantages from national investment and policy. In other words, plentiful resources, industrial agglomeration and superfluous government budget within the central urban places would result in the disparity between the core and hinterland cities. Moreover, medium or smaller-sized cities around the central city gain less economic radiation, even resulting in the stagnancy in those urban places. This is particular true in the Chinese central metropolitan regions. For instance, with the polarity of the city Zhengzhou, the urban influential regions of periphery cities decline tremendously, even characterized by the pattern of "fragmentation". The example of this group is shown in Fig.3b.

(3) "Semi-strings of beads" this group constitutes Western Coast of the Taiwan Straits, Chang-Zhu-Tan regions and so on. As for the spatial scale, every single city within this group has the almost similar-size area. This is apparent in Hu-Bao-E regions, in which there is no metropolis. In general, limited to the numbers of cities, the pattern does not completely resemble "strings of beads". The example of this group is shown in Fig.3c.

(4) "Semi-pieces of rags" this group mainly constitutes Urban Agglomerations of the Chinese western regions with such cities as Xi’an, Kunming, Lanzhou, and Guiyang and so on. Contrast to the "pieces of rags", the central city within this group has the limited urban size and weaker economic connection with fewer periphery cities. The example of this group is shown in Fig.3d.

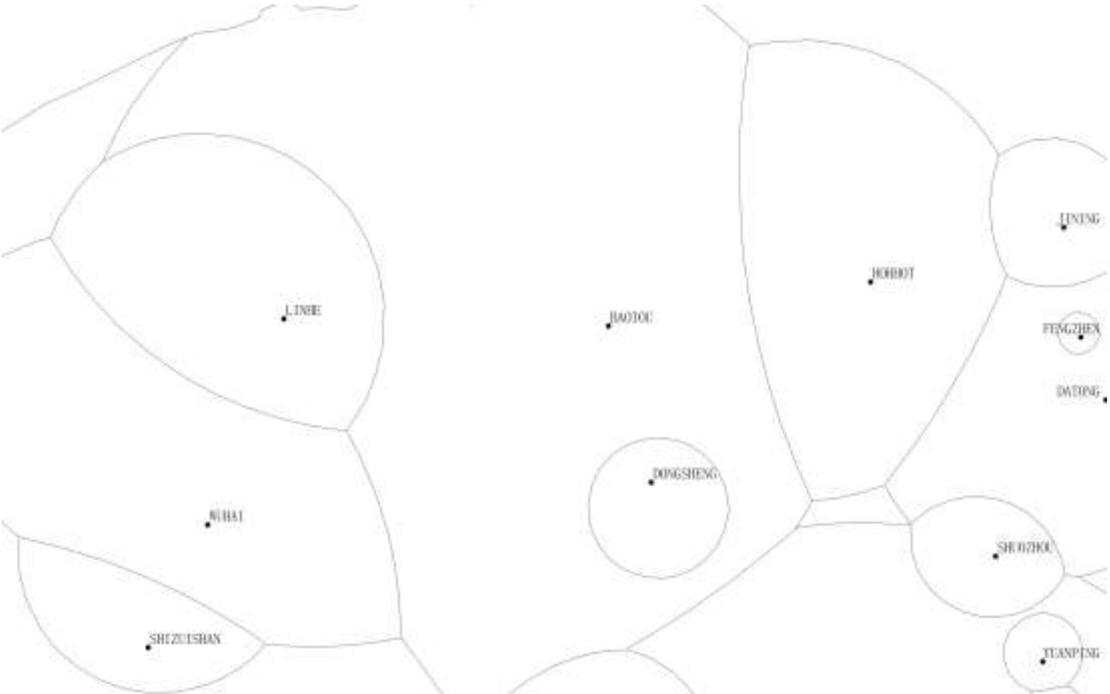


a. Yangtze River Delta

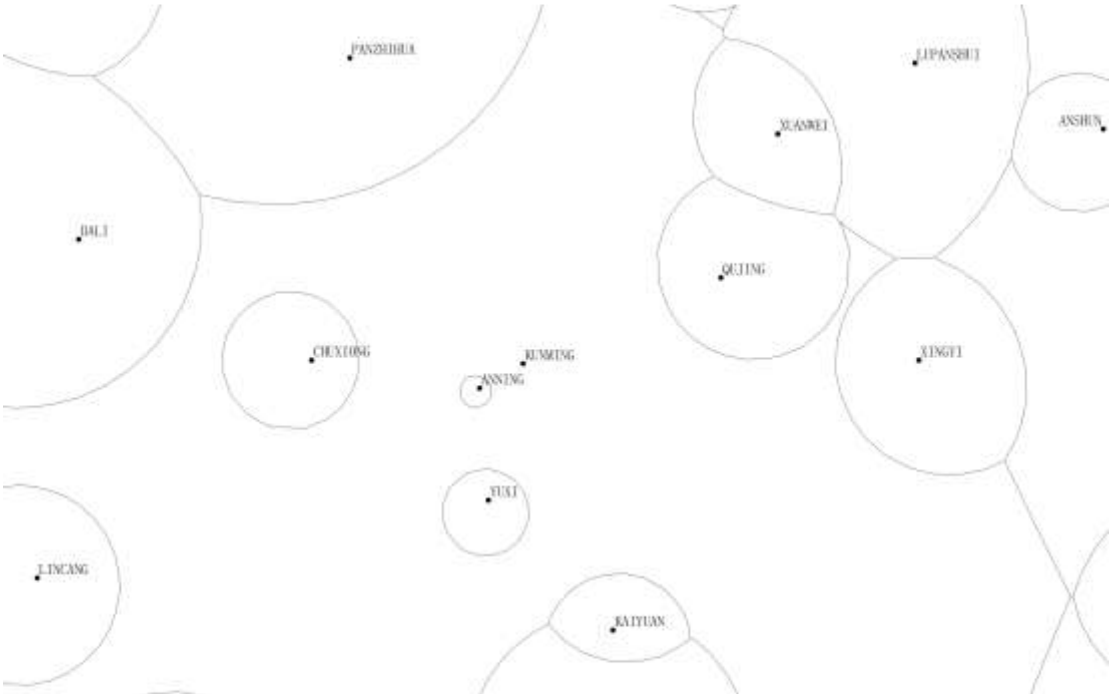


2007

b. Zhongyuan



c. Hu-Bao-E



d. Central Yunnan

Fig 3. Urban sphere of influence of different kinds

Table 2. Number of non-agricultural population and city number in three years

Distribution pattern	The name of urban agglomerations	Non-agricultural population			City number		
		1990	2000	2007	1990	2000	2007
Strings of beads	Pearl River Delta[a]	1094.10	1768.55	2687.46	11	25	19
	Yangtze River Delta[ab]	1734.46	2718.08	3936.02	31	52	49
	Jing-Jin-Ji Metropolis[a]	1500.19	1934.29	2544.64	19	29	28

	Shantung Peninsula[a]	792.69	1350.77	2047.76	23	35	35
	Liaotung Peninsula[a]	1335.21	1667.28	1804.99	20	30	30
Pieces of rags	Wuhan City Circle[b]	564.53	835.41	1362.40	15	17	17
	Chengdu-Chongqing[b]	732.84	1293.53	1805.84	20	34	31
	Zhongyuan	475.47	758.02	949.37	16	24	24
	Ha-Da-Chang	1064.11	1335.42	1468.80	24	28	27
	Around Poyang Lake [b]	242.93	358.54	457.74	11	15	15
	Jinzhong	224.55	333.11	416.63	5	10	10
Semi-strings of beads	Western Coast of the Taiwan Straits[a]	201.74	343.88	601.12	9	14	14
	Hu-Bao-E	211.15	258.61	293.96	5	5	5
	Chang-Zhu-Tan integration[b]	394.21	540.39	645.44	15	17	17
	Jianghuai[b]	384.81	579.36	735.97	13	15	15
	Jiu-Jia-Yu	26.05	38.05	44.03	4	4	4
Semi- pieces of rags	North Tianhan Mountains	160.8	242.70	325.50	5	8	9
	Yinchuan	73.16	115.40	159.03	4	5	6
	Lan-Bai-Xi	203.35	265.68	313.18	4	5	6
	Central Yunnan	145.25	210.73	241.75	4	5	5
	Central Guizhou	170.16	238.11	279.21	5	8	8
	Nanning	96.53	156.74	213.29	4	6	7
	Guanzhong	326.46	462.61	603.35	8	11	11

Note: ( ) [a]: urban agglomerations in coastal areas;

( ) [b]: urban agglomerations along the yangtze river.

As seen form the table2, the number of non-agricultural population in the "strings of beads" and "pieces of rags " urban agglomeration regions ranks the first ($t=6.98$, $p<0.01$)[i] and second ($t=4.53$, $p<0.01$) respectively, although it grows rapidly in all kinds of urban agglomeration regions. As for the average growth rate, it is more than 0.05% in such urban agglomeration regions as the Yangtze River Delta, Pearl River Delta, Shantung Peninsula, Western Coast of the Taiwan Straits, Wuhan City Circle and Chengdu-Chongqing. The first four regions, located in Coastal Provinces, contain a great portion of China's urban population with the prosperous economic development and national policy support. At the same time, the other two regions, located in the central and western regions of China, own a super metropolis and regional economic hub respectively. The average growth rate is less than 0.05% in Liaoning Peninsula, Ha-Da-Chang regions, Hu-Bao-E regions. Due to the disadvantage of locational factor, all of them grow slowly, whose growth rate rank the last after the year 2000.

The numbers of cities in the "strings of beads" and "pieces of rags" urban agglomeration regions ranks the first ($t=6.98$, $p<0.01$) and second ($t=4.53$, $p<0.01$) respectively. As for the new cities from 1990 to 2000, 53% of them are located in the "strings of beads" regions, 33% in the "pieces of rags" regions and 23% in the Chinese western urban agglomerations. Such relatively quick growths of new cities in Chinese eastern regions are almost matched by their costal location, support of national policy and investment. Moreover, Since the year of 2000, the increasing cities are mainly located in the "semi-pieces of rags" urban agglomeration regions, although the total numbers of cities did not change a lot ($t=-0.5$, $p>0.05$). Also, more policies towards Chinese Middle and West regions' development has come out, in order to improve investment environment, spur the central cities' economic radiation and enhance regional development ability. In addition, such administrative adjustments as "turning a city into districts" lead to cities' growth rate decreasing in Chinese eastern and northeast regions, as well as Chengdu-Chongqing regions. Part of the reason for this adjustment was to eliminate the system obstruction and resource constraints of central cities, finally optimizing the land use allocation and enhancing urban agglomeration regions' economic abilities.

Since the year of 1978, China has formed a macroeconomic pattern- the shape of a "T", the coast and the Yangtze River serving as first-class axis. To be specific, 6 urban agglomeration regions, with the shape of "strings of beads", assemble in the Chinese costal regions. In comparison, the Yangtze River, in which 6 urban agglomeration regions are located, strengthens the ties between Western and Eastern China. Because of differentiation between the core and hinterland, the development of urban agglomeration regions, with the shape of "strings of beads", "semi-strings of beads", "pieces of rags", changes during different regions and phases. Finally, urban agglomeration regions in the coast and the Yangtze River have a greater numbers of non-agricultural population ($t=5.4, p<0.01$), numbers of cities and new cities' growth rate($t=6.4, p<0.01$； $t=3.1, p<0.01$).

Table 3. Chang of non-agricultural population in central city in three years

The name of urban agglomerations	Central cities	The rate of non-agricultural population in central city to total non-agricultural population			The rate of increased non-agricultural population in central city to total increased non-agricultural population	
		1990	2000	2007	1990-2000	2000-2007
Pearl River Delta (PRD)	Guangdong、Shenzhen、Hong Kong	0.82	0.66	0.63	0.40	0.57
Yangtze River Delta (YRD)	Shanghai、Nanjing、Hangzhou	0.62	0.49	0.48	0.27	0.46
Jing-Jin-Ji Metropolis (JJJM)	Beijing、Tianjin	0.69	0.63	0.57	0.44	0.37
Shantung Peninsula (STP)	Jinan、Qingdao	0.37	0.27	0.31	0.13	0.38
Liaotung Peninsula (LTP)	Shenyang、Dalian	0.40	0.36	0.37	0.21	0.49
Wuhan City Circle (WCC)	Wuhan	0.58	0.53	0.61	0.42	0.73
Chengdu-Chongqing (CC)	Chengdu、Chongqing	0.54	0.47	0.56	0.38	0.79
Zhongyuan (ZY)	Zhengzhou	0.24	0.21	0.21	0.15	0.22
Ha-Da-Chang (HDC)	Harbin、Changchun	0.39	0.36	0.41	0.25	0.88
Around Poyang Lake (APL)	Nanchang	0.45	0.37	0.38	0.22	0.41
Jinzhong	Taiyuan	0.68	0.56	0.56	0.29	0.56

(JZ)						
Western Coast of the Taiwan Straits (WCTS)	Xiamen、Fuzhou	0.63	0.52	0.45	0.36	0.36
Hu-Bao-E (HBE)	Hohhot	0.77	0.74	0.71	0.60	0.46
Chang-Zhu-Tan integration (CZT)	Changsha	0.28	0.27	0.28	0.22	0.38
Jianghuai (JH)	Hefei	0.19	0.19	0.23	0.18	0.38
Jiu-Jia-Yu (JJY)	Jiuquan	0.62	0.61	0.56	0.58	0.23
North Tianshan Mountains (NTM)	Urumqi	0.65	0.54	0.50	0.33	0.38
Yinchuan (YC)	Yinchuan	0.49	0.49	0.47	0.49	0.40
Lan-Bai-Xi (LBX)	Lanzhou	0.59	0.56	0.59	0.46	0.77
Central Yunnan (CYN)	Kunming	0.78	0.71	0.72	0.57	0.75
Central Guizhou (CGZ)	Guiyang	0.60	0.55	0.56	0.42	0.60
Nanning (NN)	Nanning	0.75	0.63	0.63	0.44	0.61
Guanzhong (GZ)	Xian	0.60	0.55	0.54	0.42	0.53

In this section, conclusions are given with regard to the central cities’ non-agricultural population numbers and rate, as seen form the table3. Firstly, the central cities support a higher non-agricultural population density. In other words, the rate of non-agricultural population to total population is above 40% in most of urban agglomeration regions (73%). At the same time, the urban agglomeration regions with the rate of non-agricultural population to total population below 30% include Shantung Peninsula, Chang-Zhu-Tan regions and Jianghuai regions, in which the central cities grows moderately with less tendency towards centralization. Secondly, The rate of increased non-agricultural population in central city to total increased non-agricultural population in the "pieces of rags " and "semi-pieces of rags " is more than that of "strings of beads" and "semi- strings of beads" ($t=2.1, p<0.05$). Since the year of 2000, central cities in the "pieces of rags" share a similar non- agricultural population growth pattern with those in the "semi-pieces of rags" ($t=3.4$, $p<0.01$). In contrast, central cities in the "strings of beads" and "semi-strings of beads " do not show a pattern of "rapid growth", even a "slow growth" ($t=1$, $p>0.05$). The central cities in the "pieces of rags "regions tent to dominate the limited resources and developing opportunities, thus exert a "backwash" impact on their hinterlands. On the other hand, a great number of medium and small-sized cities located in the "strings of beads" urban agglomeration regions are growing comparative rapidly and accompanied by the "spreading" growth. The Yangtze River Delta can match the trend with more than 73% cities located in, which has more than 20 million non-agricultural populations. Thirdly, central cities in the "strings of beads", support more non-agricultural population than those in the "semi-strings of beads" ($t=10.9$, $p<0.01$); central cities in the "semi-pieces of rags" share the similar pattern with those in the "strings of beads", supporting more non- agricultural population than those in the "pieces of rags" ($t=3.9$, $p<0.01$).

5 Conclusion and Forecast

Firstly, based on the Chinese non-agricultural population at the year of 1990, 2000 and 2007, this article studies the Chinese urban spheres of influence in the way of the gravity model. By analysis on the spatial characteristics of urban influential areas, the paper brings forward four kinds of urban spheres of influence: "strings of beads", "semi-strings of beads", "pieces of rags" and "semi-pieces of rags ". Urban agglomerations in the shape of "strings of beads" are located in the Chinese eastern costal regions, in which cities have grown up into metropolis; Urban agglomerations in the shape of "pieces of rags", located in the Chinese middle and northeastern regions, have such fast growing cities as Wuhan and Shenyang; those in the shape of "semi-pieces of rags ", located in the Chinese western regions have the characteristics of growing up initially and immaturely (Fang, 2005, 2008).

Secondly, the author delineates such basic features as cities' numbers, and population of urban agglomerations regions in the four shapes by GIS and statistics. It is studied that the spatial patterns of urban agglomerations regions in China from 1990 to 2007, in aspects of the relationships between the urban spheres of influence and the non-agricultural population. Major findings are summarized in the following: the spatial patterns of urban spheres of influence are generally stable; although the urban agglomerations are centralized, the developing trends vary with different region and kind. In general, the fundamental reason of metropolitan agglomerations is the central cities' strong economic influences on other cities. It is especially true in the central cities of "strings of beads" urban agglomerations regions. In contrast, central cities in the "pieces of rags" urban agglomerations regions had a "backwater" effect on the hinterland cities due to their monopolizing confines in economics and politics.

Cities in the Chinese middle and western regions will gain more momentums with the increasing numbers of national policy. Spatial patterns of urban agglomeration regions will also be various in the process of urban agglomerations' development. First of all, it is irrational that great amounts of megalopolis are located in the Chinese western region in accordance with the protection of natural resources and the limitation of population containment. Thus the Chinese western urban agglomeration regions will not turn the shape of "semi-pieces of rags" into "strings of beads". In the other hand, it is of importance to develop both of the central cities and hinterland cities, in that the regional coordination plays an important role in promoting Chinese western development. At the same time, it is not easy to break up the barrier of "back water" effect from central cities, with which hinterland cities hardly compete, therefore urban agglomeration regions in the shape of "semi-pieces of rags" might not grow up into the shape of "semi-strings of beads". In addition, urban agglomeration regions in the shape of "strings of beads" might not be the final pattern of those in the shape of "semi- strings of beads". For instance, the city of Changsha with its adjacent cities (Zhuzhou and Xiangtan) in the Hunan urban agglomeration region has the opportunity to become one megalopolis, due to its short transport distance. Accordingly, the shape of "semi-strings of beads" in the Chang-Zhu-Tan region will turn into the shape of "pieces of rags".

Finally, it will be steady that the pattern of "strings of beads" and "pieces of rags" in the urban agglomeration regions, even if the numbers of cities are increasing or declining tremendously. Urban agglomeration regions in the shape of "strings of beads" are the global main markets of labor, capitals and logistics. At the same time, urban agglomeration regions in the shape of "pieces of rags" located in the Chinese middle and western plains, such as the Wuhan City Circle regions, Zhongyuan regions and Chengdu-Chongqing regions, will be the key economic dynamic regions in which national urbanization policy will be exerted.

Further research will be valuable on the development progress of urban agglomeration regions, the cities' hierarchy and relationships inner urban agglomeration regions. Furthermore, the uneven spatial distribution of different urban agglomeration regions needs to be studied in the future.

Notes

[1]. The data is compared within each group by using t-test method. For example, compare the non-agricultural population in the "strings of beads" regions with other regions, the credibility that the former is greater than the latter is $t=6.98$; $p<0.01$. The implications in brackets below are similar to this, although they have different forms.

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