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Polycentric Network Organization of Mega-City Regions in Yangtze River Delta

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Abstract

This paper investigates the polycentric network organization in Yangtze River Delta in 2001 and 2009 by morphological attribute and functional connection. The result shows that a morphological and functional polycentric network is in development in mega-city regions in Yangtze River Delta. In terms of morphological attribute, the rank-size feature of urban system has a tendency of decreasing. Meanwhile, network connection between cities in the mega-city regions in Yangtze River Delta tends to be frequent.

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Key Words: Mega-city Regions in Yangtze River Delta; Polycentric Network Organization; Functional Connection; Morphological Attribute

1. Introduction

1.1. Theoretical background

As a result of continuous development of globalization and rising of knowledge-based economy, the relationship of city—region is constantly adjusted. A new cognitive perspective researching the relationship of city—region is in development which is stemmed from the theories of World City^[1-2],

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World City Network^[3] and Global City Region^[4]. Hall and Pain^[5] described polycentric mega-city regions as the basic concept for mega-city region with frequent internal connection (Polycentric Mega-City Regions, PMCRS), and considered it as a new form of regional organization related to the space of flow^[6], namely one or several dominant cities gathering with 10-50 cities separated in morphological and connected functionally which could exist as independent entity and one part of wide functional city regions at the same time. And more, Hall and Pain^[5] pointed out that polycentric mega-city region (PMCRs) reflected the internal functional connection between the main city and secondary cities in its hinterland, which is synchronous with external connection with the cities beyond the mega-city region brought by globalization.

Though The concept of Mega-city region has been gradually accepted, there are diversified understandings for “polycentricity” from different aspects and scale definitions. There exists a trend to research polycentric spatial organization from the aspects of morphology and function^[7]. The typical research from morphology attribute was Hall and Pain’s^[5], they analyzed 8 mega-city regions in Europe through method of rank-size distribution. When coming to the related empirical study from function connection aspect, Limtanakool et al^[8] also studied polycentric network of city region through the calculation of entropy index for the polycentric net in the entire regional system.

1.2 Related research for Yangtze River Delta

It is amazing that research about polycentric structure of mega-city region of Yangtze River Delta in China arose. Yu Taofang and Wu Zhiqiang(2006)^[9] proposed the concept of global region. Luo Zhendong^[10] measured functional polycentricity degree in Yangtze River Delta by utilizing MU trains running among main cities in theregion. Zhao Miaoxi^[11] described features of linkage among cities and polycentric net of network based on data of branches of regional enterprises, measured the trend of multicore and divide hinterland scope of 15 central cities through network.

Totally, the research above made a significant attempt to explore the feature of mega-city region in Yangtze River Delta. However, these studies were incapable of revealing evolution feature of spatial organization systemically, because they mostly analyzed from single aspect (attributive analysis, alternative functional analysis) due to data and analysis techniques. This research wants to provide systemic analysis on spatial organization in this region both from morphological attribute and functional connection, in order to reveal the process of polycentric organization of mega-city region in Yangtze River Delta.

2. Research Method

2.1 Research Object

Yangtze River Delta consists of Jiangsu Province, Zhejiang Province and Shanghai City. As the fastest growing and the most economically advanced city region in China, it has gained tremendous social and economic development. This paper selected 16 cities which compose the core area of Yangtze River Delta, while picks up time period from China’s accession to WTO in 2001 to 2009 as time category.

2.2 Method for Morphological dimension

As Burger and Meijers^[12] pointed out, the main aspects involved in the morphological dimension include: firstly, clustering of centers which are relatively close expressed by morphology or spatial scale, but physically separate from each other; secondly, size-distribution which refers to the physical

hierarchies in regions. And this paper applied method of size-distribution to analyze the network organization of mega-city region in Yangtze River Delta.

There exists a classical method of size-distribution to measure the structure of urban system from morphological attribute, named sort city scale with Zipf's rank-size rule. The research compares relative scale of primate city and secondary city with Primacy ratio and Four-city index, on the other hand, distinguishes through rank-size model.

$$\text{Primacy ratio} = P1/P2 \quad (1)$$

$$\text{Four-city index} = P1/(P2+P3+P4) \quad (2)$$

P1, P2, P3, P4 represent the attribute of the first fourth Cities.

$$\text{Lg}(Pi) = \text{lg}(C) - q \text{lg}(Ri) \quad (3)$$

Pi and Ri represent size and rank of the ith city respectively, c is constant. The polycentric or monocentric trend in the urban system is analyzed by comparing the shift of q, the absolute value of the slope, in the rank-size regression equation. Generally speaking, the steeper the straight slope of regression equation, the more obvious trend of monocentric in this region appears. In contrast, the smoother the slope (the smaller slope absolute value is), the more obvious trend of polycentric organization feature appears.

2.3 Method for Functional dimension

By the research method of Zhao Miaoxi^[11], the method includes the following two aspects. Firstly, for any given city analyze enterprise branches mutually established in the internal area and other external cities. Secondly, analyze the proportion of connection between all of the external office linkages and that to the primacy city.

The research defines Tij as flow data in city i (where enterprise's headquarter located) of targeted connection region of city j (where branches located). This connection reflects oriented economic flow between city i and city j. While Tji is the opposite vector value and defined as the following to calculate total enterprise connection amount between i and j (i≠j) among n cities

$$O_i = \sum_{j=1}^n T_{ij} \quad D_i = \sum_{j=1}^n T_{ji} \quad (4)$$

Oi is the total enterprise amount establishing branches in regions outside i city in the equation above; Di is enterprise amount establishing branch in i city; (Ti,j+Tj,i) represents functional connection strength between i and j city without consideration of directional feature. Meanwhile, the sum Ni of Oi and Di is defined as nodositas of networking city i.

The research further divided the branches into two situations: local branch operation and external branch operation according to branch situation in and out of the city in terms of graph theory analysis method about network self- compatibility of Hall and Pain^[5], and represent regional integration process with percentage of urban extraversion connection. The situation that the headquarter and branches of enterprise are in the same city I is considered in the calculation and defined as Ti, so the extent of regional integration process involved with city i shall be calculated with the formula below:

$$L_i = \frac{N_i}{T_i + N_i} \quad L_e = \frac{T_i}{T_i + N_i} \quad (5)$$

Li represents the local connection proportion within the city. Le represents connection proportion with external city. The regional integration process shall be analyzed and inspected through calculation of change in Li and Le of city in different time section. The higher Le value and lower Li value show more obvious external functional connection and lower self- compatibility of city in this region.

2.3 Data Resource

The research adopted diversified data for measuring from different dimensionality for this paper. Data reflecting urban scale and attribute derived from statistical data bank of CEINET. For the aspect of network, the enterprise data comes from business directory supplied by Ebuy Information Company.

3. Polycentric Organization of Morphological Attribute

Using equation (1), (2), (3) and the data derived from statistical data bank of CEINET, the results of Primacy ratio, Four-city index/Primacy ratio could be got. The result of Four-city index/Primacy ratio is showed in tab.1, and the result of rank-size regression equation can be seen at Tab.2.

Firstly, if the total population of the urban area is adopted to measure them, the Four-city index of the Yangtze River Delta region declined from 1.634 in 2001 to 1.097 in 2009. At the same time, the Primacy ratio declined from 1.643 in 2001 to 1.366 in 2009. Similarly, in terms of the cities' GDP, both the Four-city index and Primacy ratio have declined. These results explain the polycentric structure of the Yangtze River Delta region in terms of morphological attribution.

Tab.1: the total urban area population, GDP, Four-city index and Primacy ratio of the Yangtze River Delta region

	Urban area population		GDP of urban area	
	Four-city index P1/(P2+P3+P4)	Primacy ratio P1/P2	Four-city index P1/(P2+P3+P4)	Primacy ratio P1/P2
2001	1.634	3.486	1.643	4.094
2009	1.097	2.441	1.366	3.655

Second, in the rank-size regression equation, we can see that although Shanghai is the primacy city both in terms of population and GDP scale. During this period, both the total urban area population and the GDP scale of non-primacy cities increased obviously from 2001 to 2009. And q, the absolute slope value in the regression equations, also decline. the value of the corresponding parameter q of regression of the total area population dropped from 1.280 to 1.017 in 2009, while the value of the corresponding parameter q of regression of the total area GDP scale dropped from 1.347 to 1.310 in 2009. Although the primacy-type characteristic of this region is evident (the absolute slope value in the rank-size regression equations exceeds 1), the sequence curves that reflect the two types of index of urban area have a tendency to go gently, which also proves that the urban area of the Yangtze River Delta region has a polycentric trend (Tab.2).

Tab.2. The population (left picture) and total GDP (right picture) of the urban area of the Yangtze River Delta region in 2001 and 2009, rank-size distribution

Data Type	Year	equation
Population	2009	Y=-1.017x+3.104
Population	2001	Y=-1.280x+2.922
GDP	2009	Y=-1.310x+4.210
GDP	2001	Y=-1.347x+3.648

In general, Shanghai has evident advantages both in terms of population and city GDP, but since China joined WTO in 2001, the secondary cities of the Yangtze River Delta region have a rapid development, during the nearly ten years, urban system of the whole region has had a transition tendency towards polycentricism.

4. Function-linked polycentric organization

4.1 General structure of city network

Using equation (4), respectively calculate the variable T_{ij} of the enterprise network-linkage and the sum of T_{ij} among different areas in 2001 and 2009, and divid the linkage strength into four levels of strength—the top 5%, 5% to 10%, 10% to 20% and the rest of the linkage strength, choose the first three levels and draw corresponding data distribution picture of city network flow (Fig.1)

We can see that in the top 5% flow linkage, the greatest enterprise linkage among the 16 cities of the Yangtze River Delta region both in 2001 and 2009 was the quantity of branch institutions of enterprises between Shanghai and Suzhou, followed by enterprise linkage between Shanghai and Hangzhou, with enterprise linkage between Shanghai and Nanjing, enterprise linkage between Shanghai and Ningbo 3rd and 4th respectively..

Similarly, in the city-linkage of the 5% to 10% strength level, we can see that the linkage of Shanghai—Changzhou, Shanghai—Jiaxing and Hangzhou—Ningbo were in a relatively stable state. In the aspect of major changes, apart from the strength level changes of linkage of Shanghai—Nantong and Nanjing—Suzhou, both the linkage of Wuxi—Taizhou (Jiangsu) and Yangzhou—Taizhou (Jiangsu) declined obviously. In general, the linkage of the middle of Nantong and Taizhou (Jiangsu) has declined to an evident extent, and the linkage of the

linkage of the cities alongside the

the Shanghai - Nanjing railway--Nanjing, Suzhou, Wuxi—have increased obviously.

4.2 City network integration

Using equation (5) continues to analyze the proportion of linkage whose institution branches are established in the external cities to the linkage of total institution branches.

We can discover that the proportion of the outward linkage of the 16 cities increased to an evident extent from 2001 to 2009. During this period, external linkage of Taizhou(Zhejiang Province), Shaoxing and Nanjing increased most obviously, apart from the two cities of Taizhou (Jiangsu) and Yangzhou which had higher external linkage (the two cities belonged to the same regional before 1996), the proportion of outward



Fig.1 Enterprise linkage strength in Yangtze River Delta in 2001 and 2009

Tab.3 Change in proportion of external linkage (Le) for each city of the Yangtze River Delta region in 2001 and 2009

City	2001(%)	2009(%)	Increased proportion (%)
Shanghai	7.5	16.4	8.9
Nanjing	29.6	45.2	15.6
Zhenjiang	16.7	38.2	21.4
Changzhou	18.2	29.2	11
Wuxi	24	29.8	5.8
Suzhou	29.2	42.6	13.4
Yangzhou	36.4	45.6	9.2
Taizhou (Jiangsu)	43.7	60.5	17.8
Nantong	17.8	31.6	13.8
Hangzhou	32.5	42.6	10.1
Shaoxing	19.7	37.5	17.8
Huzhou	17.5	35.2	17.7
Jiaxing	16	30.8	14.8
Ningbo	29.7	30.2	0.5
Zhoushan	22.7	34.2	11.4
Taizhou (Zhejiang)	28.4	49.9	21.5

linkage of the cities of Nanjing, Suzhou, Hangzhou, Ningbo, etc, was obviously at a relatively high level.

5. Conclusion

A deep analysis was taken in polycentric network organization mode of Yangtze River Delta region through rank-size method, and affiliate networks methods from the morphological dimension and functional dimension. The results showed that the Yangtze River Delta mega-city Region tend to be polycentric and networked. Nanjing, Hangzhou and Suzhou rose sharply which made Shanghai-Nanjing and Nanjing-Hangzhou already formed a zigzagging giant multi-core area. In summary, the frequent networked cities' combination in Yangtze River Delta was a systemic self-organizing optimizing process, which implied that the urban region had transferred to a horizontal open urban area.

Viewing from the efficiency of source allocating, mono-centricity model often strongly depend on the central city's portal function, while the over concentrated public service function's mono-centricity model weakens the competitiveness of secondary-size cities; The polycentric network urban system had open internal and external connection which can furthest enhance the externality of urban network and avoid the limitation of city size in some extent, and can therefore achieve complementary of urban function in polycentric and networked mode.

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