Approaching a Polycentric and Compact Mode of Sustainable Urban Development: the Case of Shanghai

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Abstract

This paper discusses issues relating to the urban structure of contemporary megalopolises in China. As the urbanization rate is over 50% in China, the New Mode of Urbanization Planning (2014-2020) specifies new ways for Chinese cities to optimize their urban structure. Many Chinese megalopolises propose to focus future urban development plans on the polycentric and compact urban structure that would address sustainable development concerns. Shanghai is one of the cities taking the lead in adopting this mode.

This paper also reviews theories about both urban polycentric structure and compact city in order to identify new ways to integrate them. To understand how this integrated mode of urban development might work, an urban concept model is established to analyze the relationships between inner city, suburbs, new districts and new towns.

Taking Shanghai as an example and making reviews of its previous planning, this research explores the reasons and motivations for adopting the integrated mode and examines the effect of the spatial expansion of population and industry, as well as the role of the intervention and organization of government. This research also shows how Shanghai s urban structure has tra *monocentric system towards a polycentric structure with compact form.*

The paper s final section presents a quantitative and qualitative analysis of *stage of approaching the polycentric and compact urban structure. Preliminary findings indicates that,* for China s megalopolises, this development *mode is both sustainable and particularly well suitea national conditions.*

1. Introduction

1.1 Research background

1.1.1 Demand for optimization of urban spatial structure

Chinese cities have experienced profound changes since the period of reforms in the late 1970s, and in 2011, the urbanization rate reached 50% (Figure 1).Although the speed is so fast the quality is not satisfactory, some big cities spatial structure and urban scale is not reaso Chinese government enacted a New Mode of Urbanization Planning (2014-2020), in which new ways for Chinese cities to optimize their urban structure are specified. It emphasizes that the extensive way of developing should be changed, the scale of built area and the boundary of the city should be reasonably controlled, and the land use efficiency should be promoted.

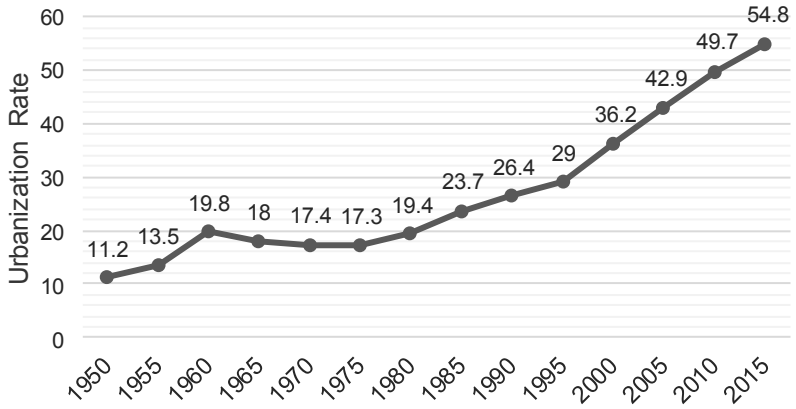

Figure 1. Urbanization Rate of China (Source: National Bureau of Statistics of China)

1.1.2 Trend of the polycentric structure and compact form

At present, the number of megalopolises that have fast growing population is still increasing in the process of urbanization in China. In addition, with limited resources, the extensive development approach makes cities sprawl unceasingly and disorderly, leading to many problems like traffic congestion, deterioration of ecological environment, and lack of green space, disease . In order to meet the demands of complex functions and promote the q many cities begin to evacuate pressure from inner city and develop new centers in different levels, thereby gradually changing the urban structure from monocentric to polycentric type. Cities like Beijing, Shanghai, Guangzhou, and Chongqing are proposing to establish a polycentric urban structure and apply the ideas of compact city in their new master plans.

1.1.3 Concerns for sustainable development

China is short of many resources though it s a big country, especially arable land because o population. What s more, McKinsey Global Institute (2008) predicted that there will be people living in cities in 2030, which give cities great pressure and a great amount of energy and resources will be wasted as a result of redundant construction unless they apply a sustainable pattern. But luckily, Chinese government has realized the disadvantages of extensive development mode and try to seek a sustainable one, which encourages intensive public transportation oriented development and advocates green traffic system with mixed land use.

1.2 Research problem and hypotheses

This study aims to explore the theories and practices about the urban development mode of polycentric structure and compact form, and also identify new ways to integrate them. As nowadays many megalopolises in China are facing great challenges of enormous population, scarce resources and ecological crisis, this mode of development may be a sustainable solution because of low energy consumption and high efficiency of land use.

1.3 Research objective and scope

The purpose of this study is to empirically test a polycentric and compact model of sustainable development in whole Shanghai city that comprises 16 districts and 1 county (Figure 2). To understand how this integrated mode of urban development might work, an ideal urban model is

established to analyse relationships between the inner city, new districts and new towns. Making reviews of the previous planning of Shanghai, the research shows how Shanghai s urban structure has transformed from a monocentric system to a polycentric structure with compact form. With a quantitative and qualitative analysis, this research also give an evaluation on stage of approaching this mode.

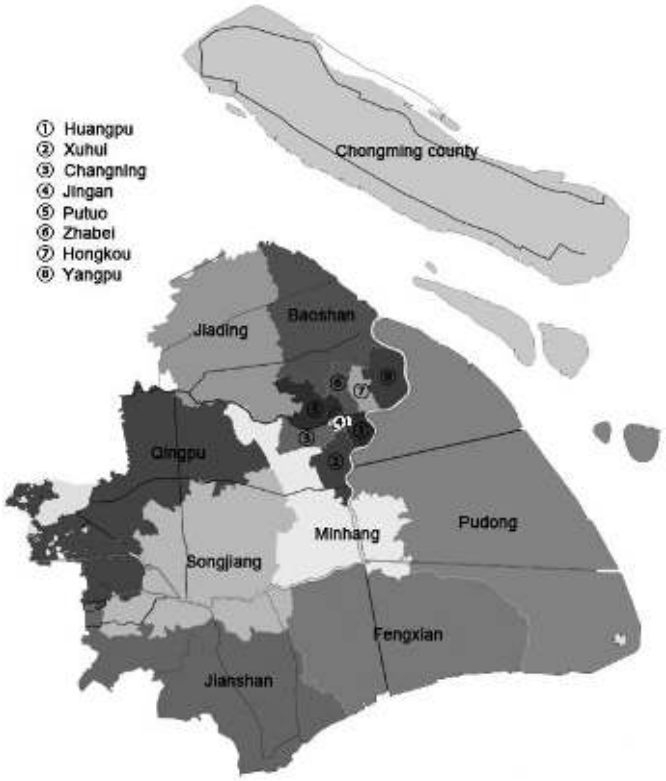

Figure 2. The Administrative Divisions of Shanghai (Source: Self-drawn based on Wikipedia)

2. Literature Review

2.1 Literature about the urban polycentric structure

Howard (1898) first suggested an embryonic polycentric urban system garden city , clai city should stop growing when it reaches a certain scale, the excessive part should be joined to adjacent cities to develop a new urban agglomeration. Later, "regional city" put forward by Mumford (1938; 1961) is also a support of polycentric spatial development pattern, which pushed on the ideas of Howard under the background of urban regions. He thought as a geographical presentation, multicenter in terms of spatial form can be measured quantitatively by the method of geography or morphology. Then, the organic decentralization theory proposed by Saarinen (1943) also maintained that population and employment should be decentralized to several districts that have their own characteristics, thereby transferring the disorder concentration to orderly decentralization. In addition, taking Tokyo as a case study, Kawakami (1988) studied how the polycentric structure could form and shape its characteristics, finding that the emergence of polycentric structure has close relation with the size of the city and its change of the transportation means. In regard to the measurement method, Bertaud (2004) proposes the population density, the gradient of the density profile and daily travel mode can reflect the degree of polycentric spatial form. Based on this, Wei Yaping (2006) proposed a quantitative method for spatial structure measurement through density performance, spread

performance, population density gradation performance and OD performance, and extended four modes of the polycentric network structure in the metropolitan area. Finally, taking 8 cities in northwest Europe as examples, Hall (2006), the leader of Sustainable Management of European Polycentric Mega-City Regions (POLYNET), made "grade-scale" analysis on urban functional areas about their degree of self-sufficiency and calculated commuter flows to measure their connection.

2.2 Literature about the urban compact form

"Compact city" is one of representative theories of controlling urban sprawl and promoting sustainable development in European countries, which was first put forward in Green pa environment (Commission of the European Communities, 1990). Later, many scholar researches about its mode, objective, strategy and so on. They think "compactness" is a spatial form with high density and mixed function (Glaster, et al., 2001; Mubareka, et al., 2011), is a development mode towards high density (Gaigne and Riou, 2012; Dempsey, et al., 2012). Furthermore, Jenks (1996; 2000) summarized the five aspects of compact city theory and its development in the first 10 years and discussed the sustainable development of urban form and the urban problems in the developing countries. Kaido (2001; 2007) introduced different theories about compact cities in Europe and the United States, finally discussed how to build compact cities in Japan. In 2012, Organization for Economic Cooperation and Development (OECD) made comprehensive assessment and comparison on the implementation and performance of the compact city policy among its member states, providing by far the most comprehensive definition of compact growth and valuable advice for policy makers. On the aspect of measurement and evaluation of compact city, Ma Li and Jin Fengjun (2011) from Chinese Academy of Sciences established a compact degree evaluation system according to Chinese condition and applied it to more than 120 cities, finding that 67.2% of Chinese cities are not compact and compactness has strong links with urban population and economy.

About how to integrate these two theories that may seems contradictory at first, the Network of European Metropolitan Regions and Areas (2010) provided a base that a polycentric metropolitan area can be a compact city if it has the identified characteristics. In addition, only Rogers (1997) roughly proposed a pattern of polycentric and compact urban structure for sustainable development (Figure 3). From the above statement, it can be learned that the integration of polycentric structure and compact form is less researched, in the following sections, we will analyse the case of Shanghai s development mode to understand how these two ideas can be combined for sustainable concerns.

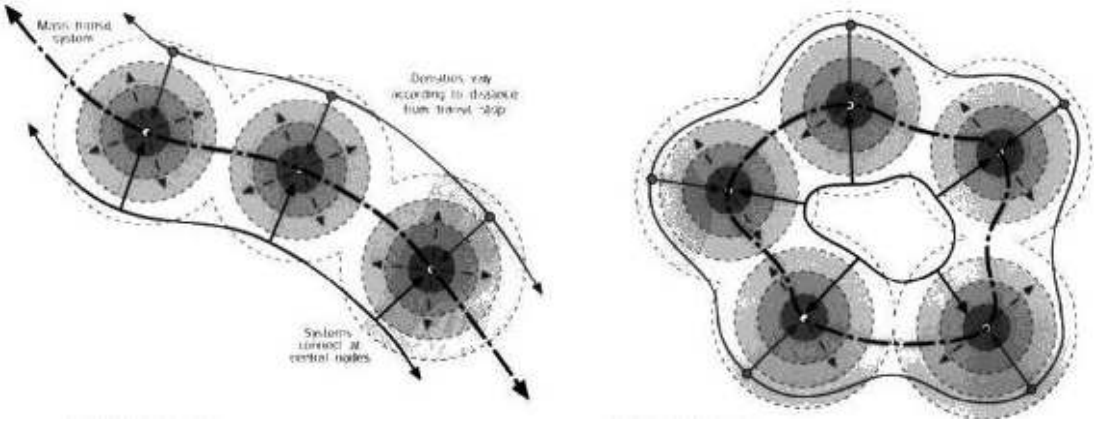

Figure 3. Rogers s Polycentric and Compact Urban Pattern (Source: Cities for a Small Planet, pp.39)

3. Methodology and Analysis

3.1 Polycentric and compact urban concept model

3.1.1 The definition of multicenter

City center is an area of highly concentrated urban functions. As living and working are the two main functions of the city, the residential and employment center can be chosen to analyse the polycentric structure. Residential center refers to a geographical unit in which resident population or residential density is higher than a certain value, so does the employment center (Giuliano and Small, 1991). Furthermore, the essence of employment center is that it is the node of the information flow of economic activity and it can dominate surrounding employment, population and housing prices (McMillen and McDonald, 1998).

3.1.2 The definition of compactness

OECD (Organization for Economic Co-operation and Development) has given an authentic interpretation of compact city, they consider that the key characteristics of a compact city are dense and proximate development patterns, urban areas linked by public transport systems and accessibility to local services and jobs (Figure 4).And the report also proposes a set of 18 core compact city indicators that are considered essential for analysing compact city (OECD, 2012, pp.87). The indicators are selected to represent effectively the compact city and compactness as here d

Figure4. Key Characteristics of a Compact City (Source: Compact City Policies: A Comparative Assessment, OECD, 2012, pp.28)

3.1.3 The integrated model

In order to integrate these two concept, based on Rogers s pattern this study polycentric and compact urban model as shown in the figure below (Figure 5). As polycentric structure is the best city form for megacities when the population reaches 5 million (Bertaud, 2004), the largest radius of the city with 5 million population is about 12.6 km^2 according to indices for land area per capita (about 100 m^2/p in China). When the population is over 5 million, the city extends outward to develop new centers. The polycentric structure includes two aspects. First, within the scope of the whole city, the layout of inner city, new districts and new towns that have their own characteristics is polycentric. Second, the inner city even each new districts also have their own polycentric structure. Similarly, compact form also includes two aspects. First, all the centers have a compact distribution with some overlapped suburban areas, and second, the concept of compact city is applied to each center and they will keep appropriate scale of population and space. Thus, the urban agglomerations are not necessarily located contiguously but are not widely dispersed. Last but not the least, they must be linked together by public transport systems as proximity of urban cores is an important notion for a polycentric compact city (OECD, 2012). This mode emphasizes the spatial intensiveness, though the centers are separated with each other, the land use in each new district is compact.

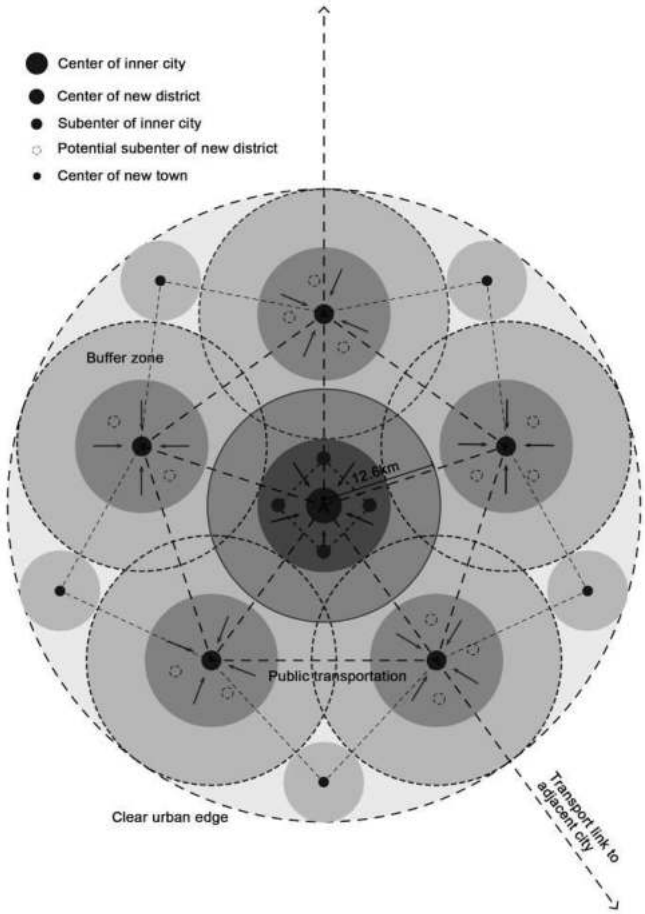

Figure 5. The Polycentric and Compact Urban Concept Model (Source: Self-drawn)

3.2 Mapping and planning review

The evolution of Shanghai urban spatial structure are closely related to urban planning and its implementation. From port opening to now, four strategic plans have significantly influenced the urban system of Shanghai, also deeply affected urban development. The four most important plans are City Planning of Grand Shanghai in 1946, Preliminary Views on Master Plan of Shanghai in 1959, Shanghai Master Plan in 1984 and Shanghai Master Plan (1999~2020) in 1999. The implementation of these four plans directly contributed to Shanghai today's urban system. Making a review of the development and evolution of Shanghai s spatial structure, we can easily find t historical periods.

3.2.1 From the founding of new China to early 1980s: A typical monocentric urban system

After the victory of Anti-Japanese War in 1945, Shanghai government set up Shanghai Urban Planning Committee, and drew up a "Draft Report of Shanghai Master Plan in December of 1948.A the time, the population and economic activity was concentrated in the downtown area, three million people, 3/4 of the whole, lived in the city center that had just about 80 km^2, 9.6% of the total area. The report found that the central city capacity was limited and it was necessary to search a method that can evacuate population, thus proposing to build satellite towns near the city center, which had great influence on the later development of Shanghai city. After the founding of new China, Shanghai government authorized Works Bureau was responsible for the city planning, some architects and

engineers returnees adopted the new urban planning theories like organic decen
planning in the draft of Shanghai master plan (Figure 6).

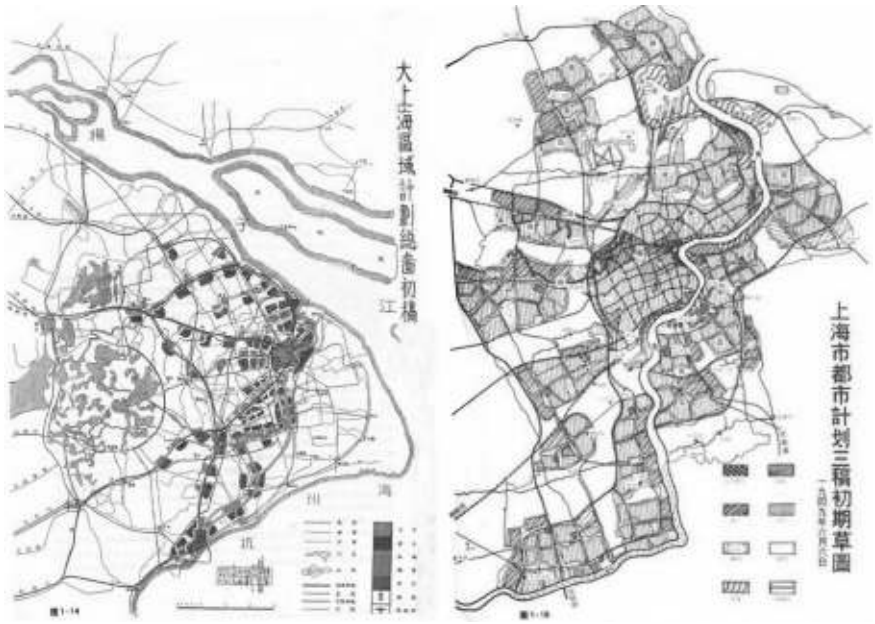

Figure 6. City Planning of Grand Shanghai, 1946~1949(Source: Shanghai Works Bureau)

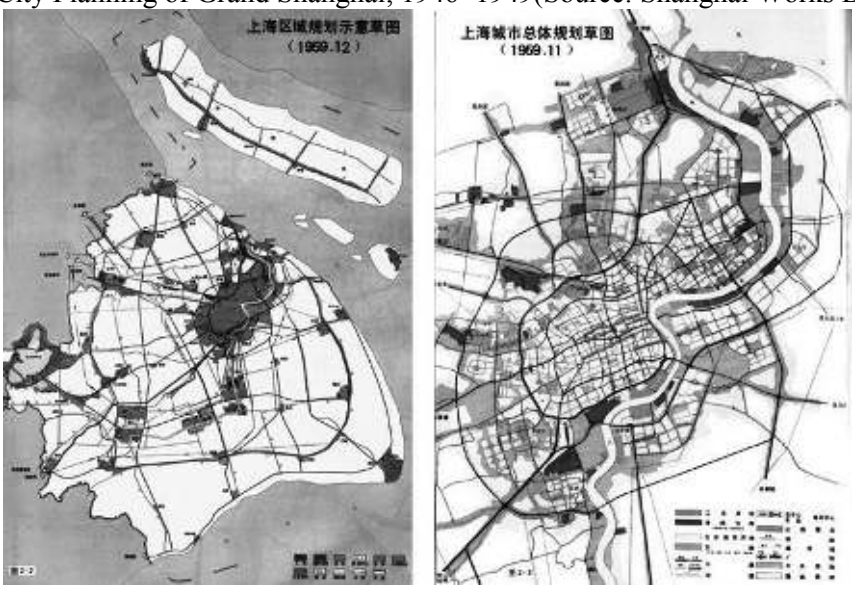

Figure7.Shanghai Master Plan, 1959 (Source: Shanghai Urban Planning and Design Research Institute)

Later, during the time when planned economy was dominated, Shanghai became a single-functional domestic productive center, gradually become China's important industrial base and financial support. In 1959, Shanghai Municipal Council invited the urban planning group of architectural engineering department to work on the Master Plan of Shanghai (Figure 7), which aimed to compress the old town, control the suburbs and develop satellite towns . After 1959, Shanghai st towns, by 1970s seven satellite towns were built, and in 1982, central Shanghai had 10 districts such as Huangpu, Luwan, and Hongkou, whose density was about 28000 hab / km^2.

In this period, Shanghai expanded around the inner city as a core, monocentric urban space layout was very obvious, but what cannot be ignored was that the ideas of decentralization was about to appear.

3.2.2 In late 1980s and 1990s: Transferring from monocentric to polycentric structure

After the Reform and Opening up, dominated by market economy, Shanghai s urban function had transferred to a multi-functional export-oriented economic center. In 1984, Shanghai Urban Planning Institute began to make a new master plan under the organization of the government (Figure 8). In this plan, urban system were divided into four levels: inner city, satellite towns, suburban towns and rural towns. In inner city, mixed functional districts were established to give people access to work, residence, recreation, social communication in their life. Each districts can be divided by green space, river, and railway but linked by convenient transportation. Then, the satellite towns integrity of urban function was stressed, which insisted that satellite towns should have its own leading industry and a well-developed environment for living and working. In addition, the suburban towns can be the political, economic and cultural center of the locality. Finally, the rural towns can be dispersedly distributed among satellite towns and the rural towns.

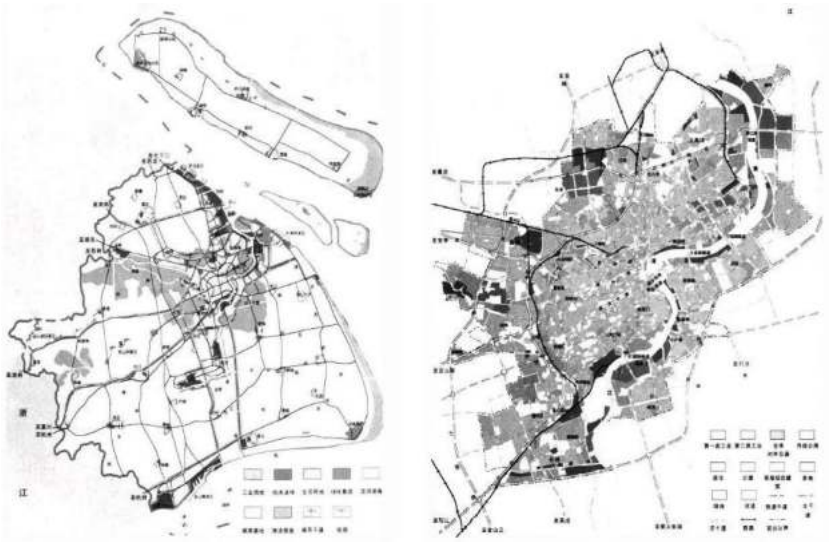

Figure 8. Shanghai Master Plan, 1984 (People's Government of Shanghai Municipality)

This plan strived to change the concentric spatial structure of Shanghai, to integrate the inner city, satellite towns, suburban towns and rural towns and to take the ideas of polycentric city with conglomerate structure as the important guideline for urban construction, thereby making Shanghai spatial structure gradually transfer from monocentric to polycentric type during this time.

3.2.3 Since the new century: Approaching a polycentric and compact development mode

In order to adapt to the development of Pudong area and the social and economic development of Shanghai, Shanghai Urban Planning Institute finished making the Master Plan of Shanghai (1999~2020) that was approved by the State Council in 2001(Figure 9). In the whole city level, a multi-axial, multi-level and multi-core urban spatial structure was fixed in this plan, and the urban system changed to inner city, new districts, key towns and common towns. And in the inner city level, the polycentric and open layout was adopted to shape the one center (Lujiazui and The Bund) and four sub enters (Xujiahui, Wujiaochang, Huamu and Zhenru) pattern. Besides, as satellite towns had gradually transferred to new towns that had larger scale and higher independence, urban spatial structure also was gradually developing towards polycentricism.

Shanghai continued to push forward the polycentric urban system in its "11th five-year plan (2006~2010)". A 1966 urban system was put on the table, namely a system comprised o

city, nine new cities, about 60 towns and about 600 villages, to take into full account the issues of population regulation, industrial development, infrastructure construction, resource utilization and environmental protection. The construction of the suburban towns was the key issue of this planning, which first clarified the specific number of them.

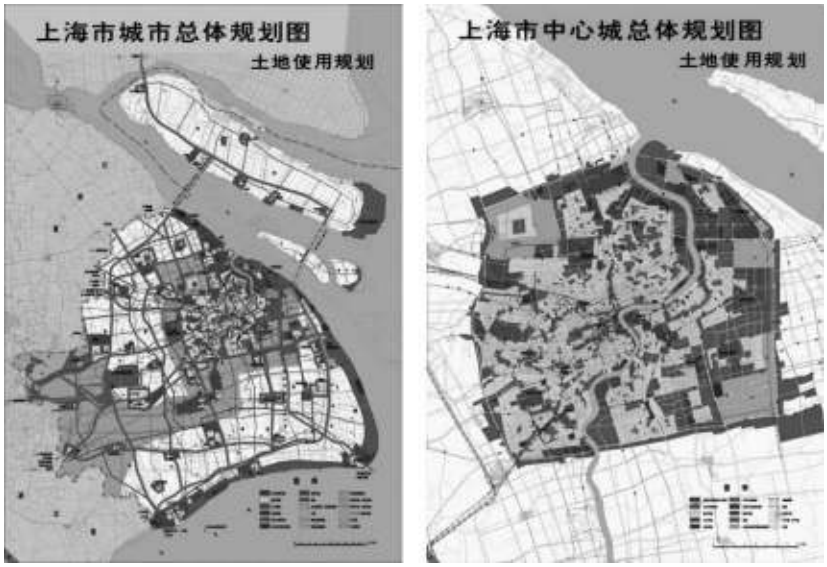

Figure 9. Shanghai Master Plan, 1999~2020 (Source: People's Government of Shanghai Municipality)

At present, government are preparing to make a new master plan for Shanghai 2040, they will take measures to strictly control the scale of the population and the land, for instance, decentralizing population from inner city and accelerating population aggregation in new cities and towns that are well developed, optimizing land use and prohibiting the growth of built area. The urban spatial structure still keeps polycentric and open and establish an intensive and compact network. As a result, Shanghai is approaching a polycentric urban structure with compact form.

3.3 Qualitative and quantitative analysis

3.3.1 Measurement of multicenter in Shanghai

The measurement of multicenter can be carried out in two ways: form and function. Based on the geographical spatial distribution, morphological multicenter can be described by three elements: average population density of built area, vertical density gradient and daily travel mode (Bertaud, 2004). Functional multicenter emphasizes the information communication of company s ir organization, which generally appears in the urban areas with a high integration of economy. It is only when different urban functions are complementary and specialized that it works (Hall and Pain, 2006). Based on population and employment density, I chose the former way to find out the distribution pattern and evolution characteristics of residential center and employment center respectively.

On the aspect of residential population distribution, most is concentrated in the inner city with a little agglomeration in Minhang, Songjiang, Jiading, and Chuansha in the suburb in 1996. Before 2005, population soared in inner suburbs and was stable in the outer suburbs. But after 2005, the outer suburbs like Jiading, Baoshan, Qingpu and Songjiang also showed a sharp growth of population. Generally, the changes in the population indicated a trend that it decreased in inner city and increased in suburbs. Population density dropped sharply in the central area, and had a rapid growth in the inner suburbs and Jiading, Songjiang and Qingpu in outer suburbs, but inner city was still the main residential center (Figure 10).

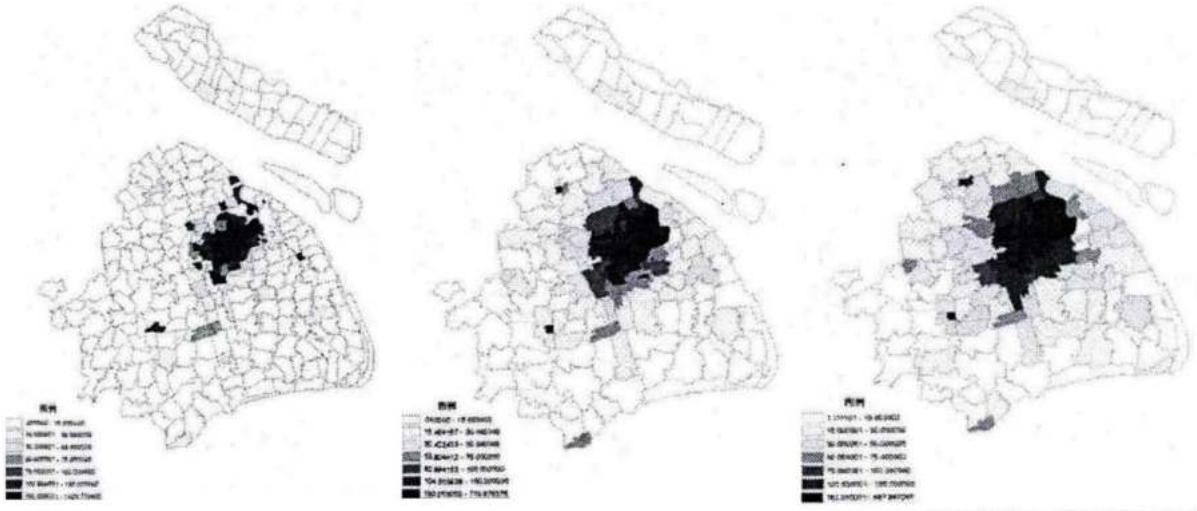

Figure 10. Variation of Residential Population Density in Shanghai 1996, 2005, 2010 (Source: Shanghai Bureau of Statistics)

If we further analyse the change of the employment population since 1996, we can find in different stages, the employment population increased in different ways. Before 2004, we saw the decrease in the core area of inner city and part peripheral area, also most of Chongming County. Meanwhile the employment population showed a trend of rising in suburbs, especially the inner suburbs. After 2004, the main declining area was still the inner city, but suburbs still kept increasing, with the key growth point transferring to some outer suburbs like Songjiang, Jinshan and Fengxian, approaching a trend of polycentricism (Figure 11). Here we found a big difference from residential population is that employment population spread along transportation lines while the residential population sprawled concentrically.

Figure 11. Variation of Employment Population Density in Shanghai 1996, 2004, 2008 (Source: Shanghai Bureau of Statistics)

3.3.1 Measurement of compactness in Shanghai

As developing countries have unlike backgrounds and characteristics of urban development, the content of compact city is different. Referring to the indicators of compact city put forward by OECD (2012) and combining with China's national conditions, this research proposed a compact degree

evaluation system from three dimensions: form, structure and efficiency (Figure 12). On the form aspect, it reflects the saving of urban scope, namely having reasonable population capacity and economic activities as much as possible in a limited area, and occupying less arable land and green space. Structure dimension mainly refers to the structure of roads and land use, which should match the growth of population and economy. Efficiency dimension is comprised of the accessibility of transportation, public facilities and infrastructure with efficient use and less energy consumption.

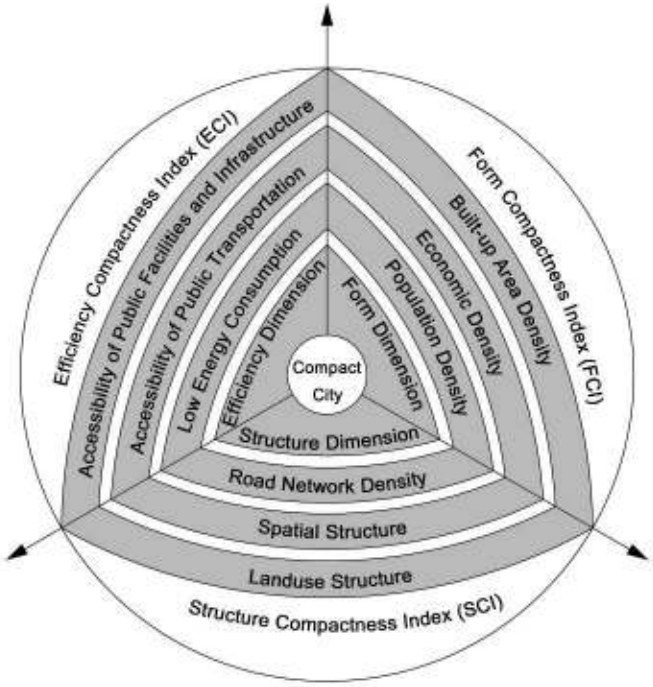

Figure 12. The Compact Degree Evaluation System from Three Dimensions (Source: Self-drawn)

3.3.2 Measurement of compactness in Shanghai

This study selected the whole Shanghai city as research object, including 16 districts and 1 county. After zero-mean normalization, data about these 17 zones can be used for factor analysis. Since there are 9 items in this evaluation system, so the scores of each item in each zones should be calculated. But now I only chose the 3 items in form dimension because of the limitation of data collection. Taking the covariance score as the weight of each factors to calculate comprehensive score of each zones, I got the form compactness degree score of these 17 zones after 0-1 normalization (Figure 13).

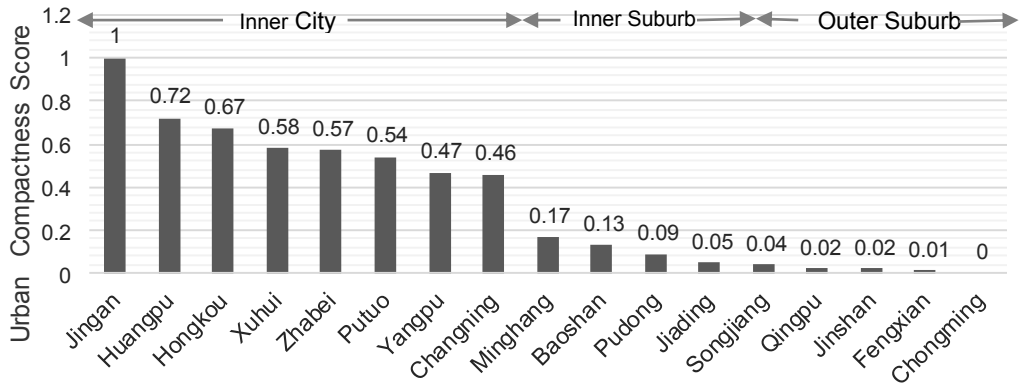

Figure 13. Urban Compactness Score (Source: Self-drawn based on Shanghai Statistical Yearbook)

4. Findings and Discussion

4.1 The advantages of polycentric compact urban structure

The model above shows that the most significant advantage of polycentric compact development mode is that it can control urban sprawl efficiently. More precisely, the advantages of this integrated mode are as followings. First, from the perspective of resources consumption, compactness is beneficial to saving resources, including fuels, water, materials, products, manpower and time, it also reduces pollution at the same time. In one word, it saves individual and social cost of travel, which are the negative externalities of environmental pollution and traffic congestion. Second, it helps improve the quality of life. This compact polycentric structure can improve the convenience for social communication, enjoying services and making use of various facilities, which will make people inspire creativity and understand each other better, thus promoting social development and harmony. Third, it increases the density so as to improve the utilization efficiency of urban space. This kind of high density is a suitable high density that does not have negative impacts such as overcrowdings. Compact urban development will first develop the urban land that has not been fully developed and redevelop existing buildings or previously developed areas while subdividing, transferring, consolidating and expanding. Finally, polycentrism means networked, it will neither causes overloads of the inner city, nor creates excessive dispersion. Polycentric compact structure is a basic urban spatial form in information society. Linked by highway network and information network, cities will develop a regional constellation structure for specialization and cooperation (Figure 14).

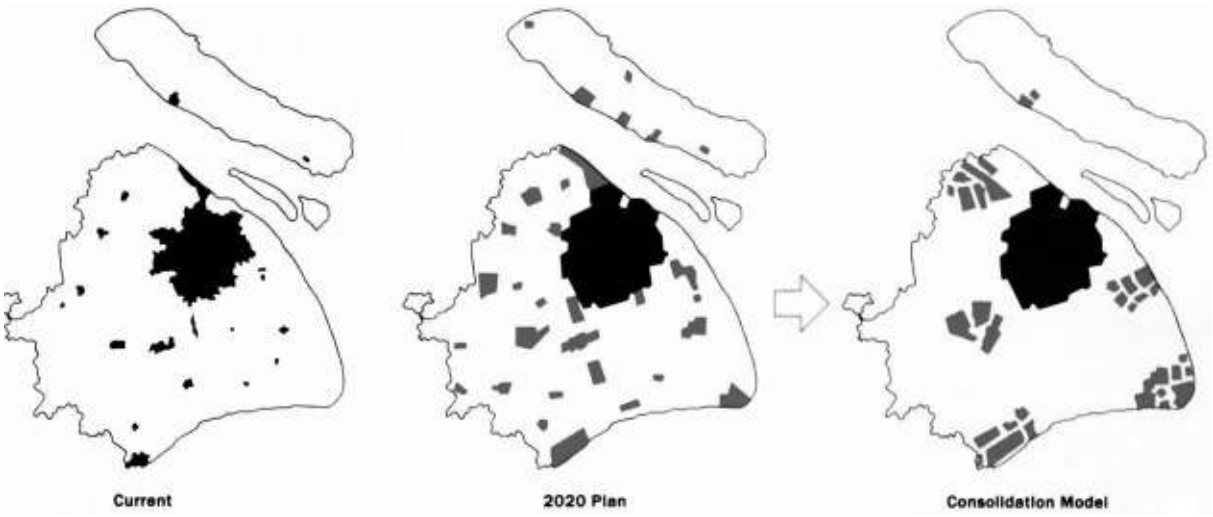

Figure 14. A Regional Constellation Structure (Source: Rem Koolhaas s proposal for future Shan in 2003)

4.2 The economic explanation and strategic drive of polycentric compact development mode

Almost all cities started growing from the center of downtown. The centripetal force brought by agglomeration is the original power of urban development, the game between the centripetal and centrifugal force push on the development of urban system (Fujita, Krugman, and Venables, 2000). The process of urban extension is the result of the scale effect and agglomeration effect of the growth poles, the marginal revenue will increase with the growth of scale, but decline when scale reach to a certain size (Figure 15). When marginal cost equals the marginal revenue for second time (P3), it indicates that all the residents in the city gain the maximum net benefits, in other words, the whole city reaches the best scale with reasonable compactness. When the average cost is equal to the average

revenue for second time (P4), the urban scale reaches maximum. If the city continues growing, the increase of marginal cost caused by long commuting time and traffic congestion will exceed the marginal revenue produced by agglomeration effect, leading to that population and the economic elements will spread to the surrounding areas and develop a new growth pole. Gradually, the city will transfer to a polycentric structure.

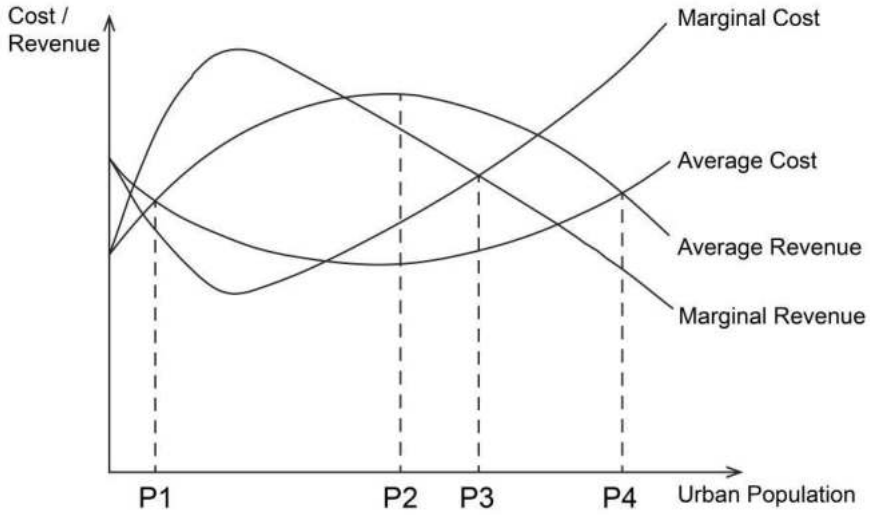

Figure 15. The Economic Explanation of Reasonable Urban Scale (Source: Urban Planning Forum)

On the other hand, the strategy of polycentric compact structure can make maximum urban comprehensive benefit, whose success depends on the effective correction of the external negative effects of the market from the government. In other words, the essence of this strategy is a game between the market and the government behaviour that regards the maximization of urban comprehensive benefit as the value orientation. From the past plans, we can see the intervention of government or even legislation is very essential. Therefore, the development of polycentric compact structure of Shanghai is not a product of the market economy, it needs governm involvement and organizations. As urban planning is a policy instrument to execute the will of the government, it should stand up in new town construction and play a positive role in pushing on the process of polycentric compact structure evolution.

4.3 Evaluation on Shanghai s development stage of approaching *the integrated mode*

Based on the spatial evolution of the residential and employment centers in Shanghai, some conclusions can be made. First, suburbanization process has begun in Shanghai, and the residential and employment centers are gradually developing in the suburbs. Second, in term of residential density or employment density, monocentric structure still exists, the polycentric structure is not well developed in the whole city, but as Songjiang and Jiading are becoming two powerful sub enters and several potential residential and employment centers also formed in outer suburbs, the monocentric structure is being broken. Finally, compared the connection between each districts and the inner city with the result of Europe POLYNET program (Hall and Pain, 2006), Shanghai is in a phase of the transition from monocentric to polycentric structure. Besides, with the improvement of road network and subway system, polycentricism is expected to be further improved.

In term of form compactness degree, it is relatively high in the inner city and the inner suburbs and outer suburbs is low, which is almost in line with the model. Specifically, Jingan District shows the highest form compactness degree, which is lowest in Chongming County. It also indicates that the

more the economy is developed, the higher is the intensiveness of the land use, conversely, the intensiveness of the land use is low in where the level of economic development is also low as the result of cheaper land price. Above all, the compactness degree in Shanghai still have space for improvement, especially the suburbs .

5. Conclusion

In this paper we have analysed the polycentric and compact development mode of Shanghai. This integrated mode also has been the hot pursuit of many metropolises and areas with limit resources. In this mode, polycentric and compact concept are embodied in both the whole city level and each districts, as it can save resources and promote land use efficiency because of high density, it is particularly well suited to Chinese national conditions for sustainable development under the background of stringent constraint of resources. For instance, restricted by the regulation, the built area of Shanghai cannot increase any more, this mode will become the inevitable choice of Shanghai, which also can give some reference to other metropolises in China.

There also exist some limitations in this paper. The paper used a method of generalization and induction when explaining the model, lacking quantitative detail. The concept model of polycentric and compact structure is abstract and it must be modified if used into practice and it is hard to find what proper high density is. The method of multicenter measurement just takes care of the morphological one, and the method of compactness measurement only gives a relative value from internal comparison, they still needs promotion. Other problems existing in this paper also need improved. In the future, more works can be done around the model this paper proposed, including seeking strong links between this mode and sustainable development, searching better ways to measure multicenter and compactness, and exploring how this integrated mode can provide reference for other cities in different conditions.

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