

(Section A: Planning Strategies and Design Concepts)

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Population Distribution Characteristics and Spatial Planning Response Analysis in Metropolises: *A Case Study of Beijing*

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Abstract: Focusing on trends in population and the causes of overpopulation, we analyse the distributional characteristics of the population in cities around the world. We analyse the countermeasures in spatial planning of various urban areas, which lays the foundation for our case study of Beijing. Beijing, which has unique attributes as the capital of China, faces challenges regarding population control and realization of the Main Functional Area Planning. We focus on the question of how spatial planning can help control population and the realization of urban functions in metropolises such as Beijing. We find that main functional area planning played a role in achieving the main functions and controlling the population of Beijing. Also, controlling the industrial structure is effective in changing population structure for metropolises such as Beijing. In addition, using guidance from spatial planning, we suggest establishing new urban areas or constructing new cities to form a multi-centre structure, to plan for old town renovation, and to improve the construction of the road infrastructure system.

1. INTRODUCTION

Spatial structures and the spatial distribution of urban populations interact. An urban population's size and structure can reflect its economic and social characteristics, as well as the characteristics of urban development and construction. The population's structure plays a key role in realizing a rational urban spatial structure, which impacts a city's sustainable development, that in turn forms the basis and premise of scientific spatial planning. Rational spatial planning can promote the optimal layout of an urban population's size and structure. It is thus important to analyse the spatial characteristics, changing rules, and existing problems of an urban population to understand urban development, and then perform rational spatial planning to control the spatial organization and urban population in order to realize the optimal layout of urban spatial structure.

Excessive population agglomeration and uneven spatial distribution are important problems in China. Ninety-six percent of China's very large

population lives in the land that lies below the "Hu line" (36 percent of the land area). That area's population density exceeds the limit as stipulated by the United Nations. Since 1990, many Chinese cities have experienced rapid growth of the urban area, as a frenzy of development zones and real estate construction swept across China (Li, Zhao, & Wang, 2015). The spatial development of China is increasingly askew, the allocation of resources is inefficient, and the demands of rising population on the environment is increasingly intense. As a result, China promulgated the "National Main Functional Area Planning" (MFAP) in 2010. When the economic development, industrialization, and urbanization of a country is accelerating due to the deviation of population flow in direction, volume and velocity, the problem of the population's uneven spatial distribution becomes more severe. At the same time, the development process of various industries and population is a process of self-strengthening because of the existence of an agglomeration economy (Ding, 2011). The rule of spatial agglomeration of economic development makes spatial planning an important issue in China to optimize the population's spatial distribution.

As Beijing's developing rapidly, population dispersal becomes imperative. Over the past thirty years of reform and opening up, urban construction in Beijing has been growing rapidly. Consequent changes in urban population development include population concentration, population redistribution, and the gradual change of urban space utilization from low level to advanced level (Yu & Zhang, 2006). As determined by the urban master plan in 2005, the total population of Beijing in 2009 exceeded the population development goal of 18 million in 2020 by 600,000. The population "red line" was thus broken.

There are many problems associated with rapid urbanization in Beijing. There is an irrational mismatch between its industrial layout and the urban population's spatial distribution and infrastructure: urban traffic is increasingly congested, urban space is spreading quickly, and the ecological environment start to be destroyed. In 2014, the government work report of Beijing pointed out that the population growth of Beijing was too fast, and the control of population scale should be strengthened. It called for further study of population control measures such as implementing city function positioning, optimizing industrial structure, controlling the allocation of resources, and strengthening planning guidance. The Central Committee of the Communist Party of China replied to the master plan of Beijing (2016–2035) and emphasized that greater control of the population in Beijing is necessary. By 2020, the size of the permanent population will be limited to 23 million and will be required to remain stable for a long time after 2020.

We analyse the population distribution characteristics of metropolises in the world, examining population trends, and the causes of overpopulation. We summarize countermeasures in the spatial planning of different metropolises. We focus on Beijing, taking into account the unique attributes of Beijing as the capital of China. We find its problems in population control in the main functional urban areas. We focus on the question of how spatial planning can guide population control and the realization of urban functions in Beijing. Our analysis generates suggestions for spatial planning in the future for Beijing, and for large urban centres more generally.

2. LITERATURE REVIEW

The correlation between urban population and urban spatial changes is very strong and can occur at various spatial scales. The largest scale is global: The contemporary world is shaped in an unbalanced way by the global flow of capital, information, technology, and products, etc., including the flow of labour, migrants, tourists and professionals, etc. The latter constitutes the flow of population on a global scale, which generally occurs between nations (Olds, 2002). The correlations occurring at medium scale include the spatial migration and flow of population between regions within a country, and most of these are manifestations of labour markets, because a labour force is regarded as a location factor, whose factor cost changes with location. Labour force flows are closely related to the spatial character of a regional social economy (Clark, Feldman, & Gertler, 2000). The micro spatial scale is generally the urban internal scale (Knox & Pinch, 2014). Research has mainly focused on the distribution and evolution in urban space of social and economic factors, such as population (Carr, 1997). As spatial differentiation occurs due to the uneven spatial distribution of population (Zhang, W. B., 2002), agglomeration and diffusion also occur, caused by the characteristics of population flow: the multi-centre city, the marginal city, the new suburbanization space and other urban space types have appeared (Jiang & Wu, 2014; Lang, Sanchez, & Oner, 2009; Wu, Zhang, & Webster, 2013; Orfield, 2011). The interpretation of urban spatial development and planning from the perspective of the spatial structure of population has become an important academic research direction.

The control of the population of metropolises through spatial planning must be regular and mandatory. Although large scale urban diseases can easily occur, metropolises are the objective and inevitable result of urbanization. Under effective planning and control, metropolises can not only enjoy higher quality of urbanization, they can also accommodate more people. The keys to mega-urbanization are population control and population redistribution (Chen & Huang, 2014). In general the control of population size is mainly about the control of its quantity, structure and distribution. But for metropolises, population size control mainly lies in optimizing urban functional zoning, optimizing the layout of the industrial population structure, and optimizing the population service management system (Lu & Li, 2014). The process of population dispersal is primarily concerned with the problems of poor connectivity in industrial transfer, the reintegration of populations, shortages in labour force, the complex relationship among multi-stakeholders and the aggravation of risks to social stability (Du & Hu, 2016).

Examples of problems with and countermeasures to spatial planning in population control have also attracted attention from scholars. Through comparisons between actual populations and the populations planned by urban planning in major developing countries, some scholars have found that underestimations of urban populations are a main reason why it is difficult to achieve effective planning for large cities. Reasons provided for the failure of a variety of plans used to control urban spatial expansion and urban population growth in large cities mainly include unsystematic and unscientific planning of cities, poor government implementation, along with rapid urbanization and economic development, such as in India, Laos, China and other developing countries (Tan, 2016). In the field of planning countermeasures research, the main concerns include the impact of population changes on spatial patterns, gross growth, spatial distribution and

population structure. Relevant planning measures have been proposed drawing from aspects of urban system construction, the equalization of basic public services and the population capacity reserve (Zhou, 2013).

The research on population dispersion in Beijing has mainly focused on the motivations and solutions for population control. To sum up current research results, there are two main reasons for population control in Beijing. First, the current population scale has exceeded Beijing's water, land and other resources and environmental carrying capacity. Second, the size of the population exceeds the capacity of Beijing's public service facilities, such as transportation services and the disposal of refuse (Lin, 2015). The policy of population dispersion in Beijing can be divided into four categories: industry control, resource control, dispersion & entry ban and administrative consultation. Correspondingly, the most suitable method of population control in Beijing is to build a comprehensive population control system, which includes the following main parts: industrial planning, construction planning, population management and government promotion (Ge, 2013).

In general, the size and structure of an urban population will influence urban spatial development. At the same time, spatial planning not only can help to better achieve urban functions, but also play a role in population control. Therefore, to solve population problems in urban development, the corresponding spatial planning countermeasures should be put forward.

3. METHODOLOGY

3.1 Spatial Distribution Characteristics of population distribution

(1) Spatial distribution and trend analysis of population.

According to the availability of data, we use population density to describe population distributions, and how the population size changes to describe population trends. Population density is equal to population per unit area.

Data were collected from the statistical yearbooks of metropolises and from World Urbanization Prospects (2018). Data for Beijing is mainly drawn from Beijing census data and the statistical yearbook data of various districts of Beijing; what also included were data from the Beijing Municipal Bureau of Statistics.

(2) Population spatial structure analysis.

The structural indexes of population distribution refer to the Imbalance Index (U) and the Concentration Index (C) (Zhang, S., 2013), which are used to simulate trends in population concentration or dispersion. The formulas for these indices used in calculations are as follows:

$$U = \sqrt{\frac{\sum_{i=1}^n \frac{\sqrt{2}}{2} (x_i - y_i)^2}{n}} \quad (1)$$

$$C = \frac{1}{2} \sum |x_i - y_i| \quad (2)$$

Where n is the number of districts, x_i is the proportion of the population of district i to the total population of the study area; y_i is the proportion of the land area of district i to the total land area of the study area.

The smaller the value of U is, the more balanced the spatial structure of the regional population will be. The smaller the value of C is, the more balanced the spatial structure of the regional population will be.

3.2 Analysis of the Effectiveness of Spatial Planning in Beijing

The Main Functional Area Planning (MFAP) is China's initial exploration in spatial planning. It sets the plan for future population distribution, economic layout, land use and urbanization according to resource and environmental carrying capacity, existing exploitation density and the development potential of different regions. Land area is divided into four areas in the main functional area planning of Beijing: a Capital Functional Area, an Urban Function Development Area, a New Urban Development Area, and an Ecological Conservation Area. The various main functional areas have different main functions, and also different population control directions as see in [Table 3](#).

The analysis mainly consists of two parts: analysis of population industrial structure in each functional area, and the effectiveness of the guidance on population control through spatial planning in Beijing.

The realization of the main functions of the city can be reflected in the development of main industries. To focus on the population problem, we use the number of employees in different industries to represent the development of the industries. We use the percentage structure of the employees (percentage of employees in main industries) to describe the industry structure in the main functional areas. We also horizontally compare the function structures of different main functional areas in order to draw conclusions about the implementation effectiveness of main functions, that is, how the actual development of Beijing's functional areas deviates from planning objectives.

According to data availability, we merged 20 industries into Agriculture, Construction, Transportation, Public management, Mining & Manufacturing & Power, Commerce & Service (this refers to low-end labour-intensive services industries: wholesale and retail, accommodation and catering, leasing and commercial services), Technology & Education & Culture & Health, and Finance & Real Estate. These categories are understood to fit within urban functions: Production, Transportation, Political, Commercial, Technological and Cultural, and Financial.

The data was collected from two population surveys, one was taken before, and the other was taken after the release of the Beijing Main Functional Area Planning (MFAP), the 2010 Population Census in Beijing and the 1 percent Sample Population Survey of 2015, respectively.

4. POPULATION TREND, PROBLEMS AND PLANNING EXPERIENCE IN THE WORLD

4.1 Analysis on the trend of population in world metropolises

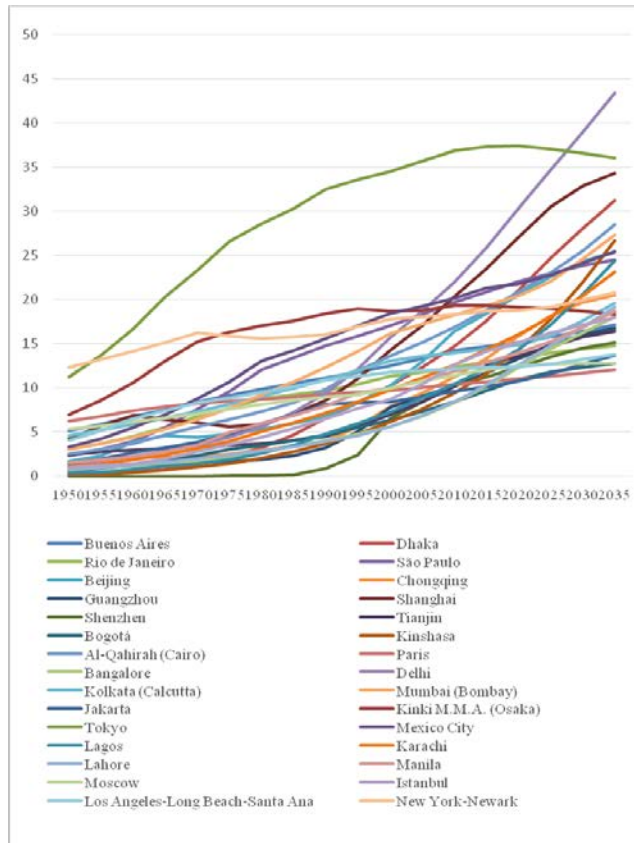


Figure 1. Population trend of 30 largest urban agglomerations in 2018

Data Source: United Nations, Department of Economic and Social Affairs, Population Division (2018). (<https://population.un.org/wup/>)

Figure 1 shows the population trend of the 30 largest urban agglomerations in 2018. Most of the population curves of world metropolises show non-linearity and volatility. Rates of population growth tend to slow down step by step, and also fluctuate during the process. The development stages of population changes can be generalized as follows: Agglomeration period, Peak period, Period of reduction, Regrowth period. From the perspective of spatial structure, in the early stages of urbanization, the main form of the city presents a single-centre structure. With the development of the city and the agglomeration of elements, a multi-centre structure gradually emerges. The government and planning experts in many countries and regions have proposed guiding the development structure of cities to a multi-centred one.

The analysis of the causes of such population changes can be modelled on the development experience of western developed countries. This development shows that during the initial stage of urban development, populations gather in a spontaneous and rapid fashion in cities. The main reason rests on the attraction of available employment and social public

welfare. During this period, the government usually pays less attention to restrictions on population growth. With the continuous expansion of the urban development boundary, the population density of cities decreases slightly. But the centripetal driving force of agglomeration still attracts the continuous accumulation of population. When the population of the city increases to a certain extent, the problems of transportation, housing and environment gradually emerge, and population-related problems grow, causing overpopulation, slumping, and so on. These are tied to the blocking of space flow and lack of management. At this time, government can take effective measures to disperse the population in the central urban area and slow down the further inflow of population. After several years of development, urban public services—transportation, housing, medical care, education, etc.—gradually improve, and population capacity may gradually increase. This leads to another population agglomeration due to greater efficiency in the spatial distribution of urban development and the abundance of urban space resources. Though population density will probably fluctuate, but it becomes increasingly stable in the future. In this way, the laws of centralization, decentralization, smooth development, recentralization hold, and so the urban development model shows a non-linear trend. The development of the population in metropolises like New York and Paris followed this model, witnessed by the phenomenon of re-urbanization that has appeared in the past 20 years.

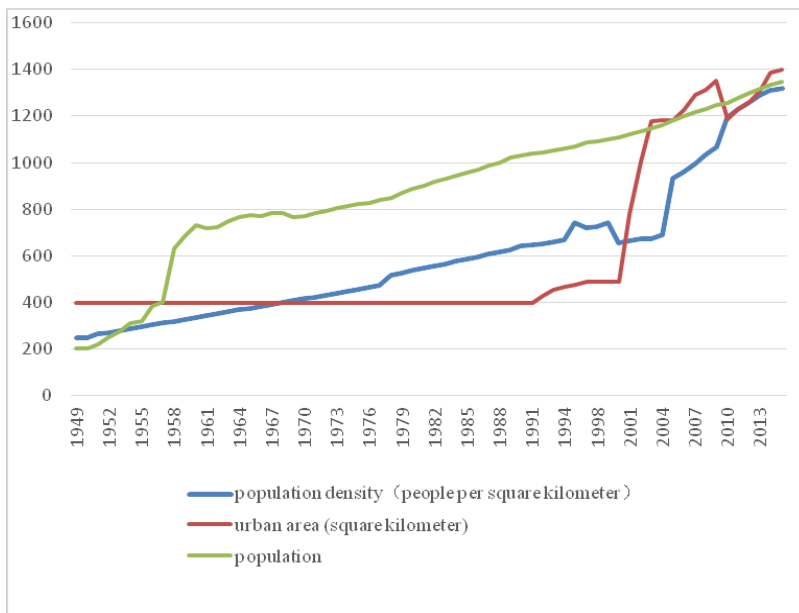


Figure 2. Population trend of Beijing

Data Source: Statistical yearbook of Beijing (<http://www.bjstats.gov.cn/index.html>)

In particular, according to data analysis of the total population of Beijing, the population density and the urban area of Beijing from 1949 to 2015 follow this trend. The growth in population is slowing down, as shown in [Figure 2](#). Thus, analysing the planning response of world metropolises to the problem of population change is of great significance to Beijing.

4.2 Response analysis of spatial planning in metropolises from the perspective of population control

In accordance with government function orientations and the development characteristics of different metropolises, city governments have taken various measures in population planning and control. The policies, measures, and experiences of urban population control efforts in Tokyo, New York, London and Paris make good references for the construction of a world city like Beijing. These efforts are summarized below ([Table 1](#)):

Table 1. Metropolises' response to population problem

Policies and Measures	Applications to Metropolises
Actively formulate governmental urban planning to control population. Carry out coordinated spatial and population plan.	<p>Paris: In 1965, Paris carried out the "Paris Territorial Development Plan", "Paris Land Development Plan and Urban Planning Guidance Outline: 1965-2000"(SDAURP). A concentric circular urban development mode was abandoned in the planning, and an axial belt development mode was applied instead. It should not be less than 15 percent of its own population. The metropolitan area Bureau was established to set up the basic plan every 8-10 years (Zhang, L. & Lu, 2009).</p> <p>New York: In 1968, the city guided the establishment of new city centres, at the same time, promoted rapid development of the new urban area through the rational planning of Grand New York (Shi & Huang, 2010).</p>
Set up new urban areas to divert urban population. Build satellite towns to form a multi-centre structure, which will help to absorb population and reduce population density.	<p>Paris: In 1965, the concepts of the axis of urban development and the new town were put forward, and a strategic transformation (new way of spatial development) from the city limits to the urban built-up area was realized. Along the important traffic arteries, 8 new towns with populations ranging from 300,000 to one million were built. The concept of multi-centre spaces was applied from the urban built-up area to the whole Paris area (Zeng & Wang 2004).</p> <p>London: The city put forward a planning mode of "controlling the downtown area and developing new towns." In the 1960s, the concentric circle, closed layout model of the greater London plan was changed to expand the city along the three main fast traffic arteries to form three corridors. The population in the southeast was divided into urban aggregates to form a multi-centre structure model (Sheng, 2012).</p>
Change the layout of industry to drive population flow. Through the implementation of preferential tax terms, guide labour-intensive industries to move out of the central urban area.	<p>In 1958, Tokyo dispersed a large number of people from urban centres by changing urban spatial structures and building new towns. In 1986, Tokyo promoted the formation of a multipolar and dispersed pattern of land development (Zhang, L. & Lu, 2009).</p> <p>New York: The government of New York has carried out different land price and tax price terms to limit urban industrial development and encourage rural industrial development, according to the requirements of urban planning (Shi & Huang, 2010).</p> <p>London: In 1945 and 1947, the United Kingdom</p>

Policies and Measures	Applications to Metropolises
	<p>formulated the Industrial Resettlement Act and the Urban Rural Planning Act to rebuild factories and expand areas in London; it also granted subsidies for the relocation of factories (Sheng, 2012).</p> <p>Paris: In 1956, the city planned evacuation of population in central areas and industrial enterprises unsuitable for development in central areas. Supports building satellite cities. In 1960, a "congestion tax" is levied on new offices in the central area. Also, an important financial subsidy is issued by the government, the subsidy for regional development based on industrial classification (Zeng & Wang 2004).</p> <p>Tokyo promulgated an industrial control law in 1958 to speed the transfer of labour-intensive enterprises. It also issued a plan to change industrial land to build residential and municipal facilities (Zhang, L. & Lu, 2009).</p>
Set up standard of living and encourage active migration of population. Solve the problem of inhabitation. Improve public facilities	<p>In 1968, the New York government stipulated minimum standards for rental housing, and put forward a new housing policy, which issued more stringent mandatory provisions to improve the quality of life of its migrant population. It improved service facilities in older areas, and compiled and implemented complementary public transportation planning.</p> <p>New York: In 1996, in a third metropolis plan, the city implemented five major campaigns focused on "vegetation, centralization, mobility, labour, management" to integrate the economy, and to promote equity and a clean environment to improve the quality of life in the region (Shi & Huang, 2010).</p>

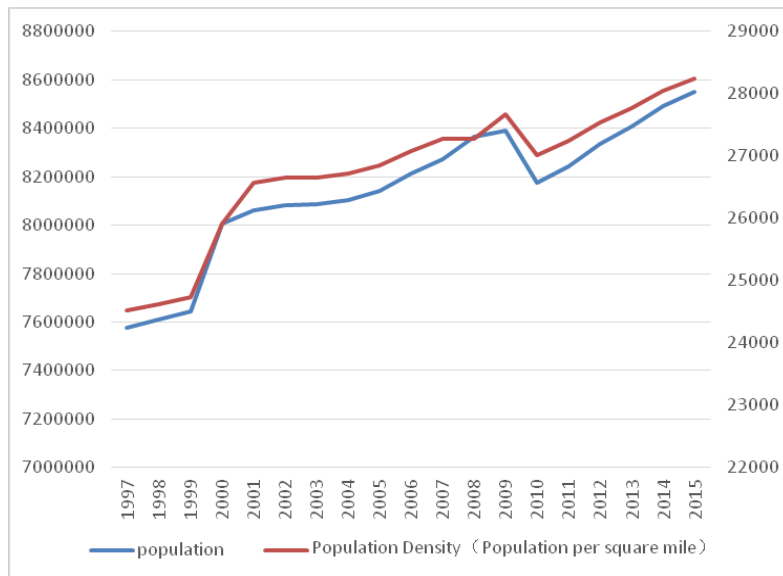


Figure 3. Population trend of New York City
 Data source: U.S. Census Bureau (<https://www.census.gov/>)

The effectiveness of New York City’s and Tokyo’s planning responses may be analysed by analysing the population trend and population density’s time series.

Figure 3 shows that in general the population density of New York City has been increasing, except in about 2009, which shows a significant decrease.

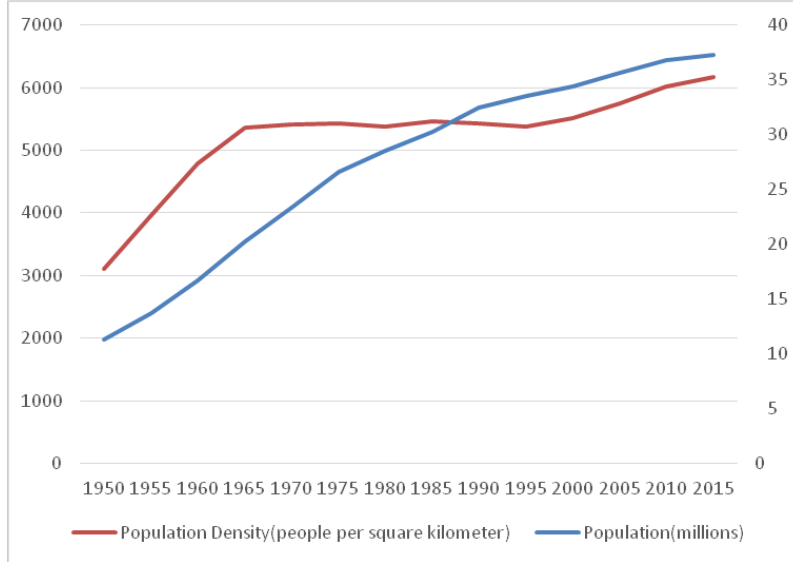


Figure 4. Population trend of Tokyo
 Data source: Tokyo statistical yearbook 1950-2015
 (<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>)

Figure 4 shows that fluctuation appears in the process of population growth. After 1965, the growth in population density slows down, from 116 people per square kilometer per year to 8.8 people per square kilometer per year. This suggests the planning response of industrial control legislation and new town building was effective, along with the land use control of 1972.

Furthermore, population control measures in major metropolises of the world related to the development stage can be summarized in Table 2 as follows:

Table 2. Population control measures in major metropolises

Development Stage			Cause of Dense Population	Measure
Time period	Spatial Structure	Function		
Agglomeration period ↓ Peak period ↓ Period of reduction ↓ Regrowth period ↓ Reduction period ↓	Single centre structure ↓ Multi-centres structure	Vague function orientation ↓ Clear function orientation	Deficiency in management	Formulate coordinated urban spatial planning and population planning. Establish a reasonable minimum standard of living, improve living conditions of mobile population, provide affordable public housing.
			Employment attraction	Change the industrial structure and layout, promote population diversion

Development Stage			Cause of Dense Population	Measure
Time period	Spatial Structure	Function		
..... ↓ Stable period			Public service attraction	Build new public areas with sound public service and infrastructure systems
			Spatial flow blockage (high traffic time and high economic cost)	Improve the efficiency of transportation infrastructure, reduce the cost

5. THE EFFECTIVENESS OF MAIN FUNCTIONAL AREA PLANNING IN GUIDING POPULATION CONTROL IN BEIJING

5.1 Analysis of the Spatial Distribution Characteristics of Population in Beijing

5.1.1 Spatial distribution and trend analysis of population

In recent years, the population density of Beijing has remained stable, but the population distribution shows differences in density among 16 districts. The population is highly concentrated in the central urban area, especially the core functional area of the capital, as shown in [Figure 5](#) and [Figure 6](#). The population density of the Capital Functional Area and the Urban Function Development Area is much higher than that of the Urban Development New Area and the Ecological Conservation Area.

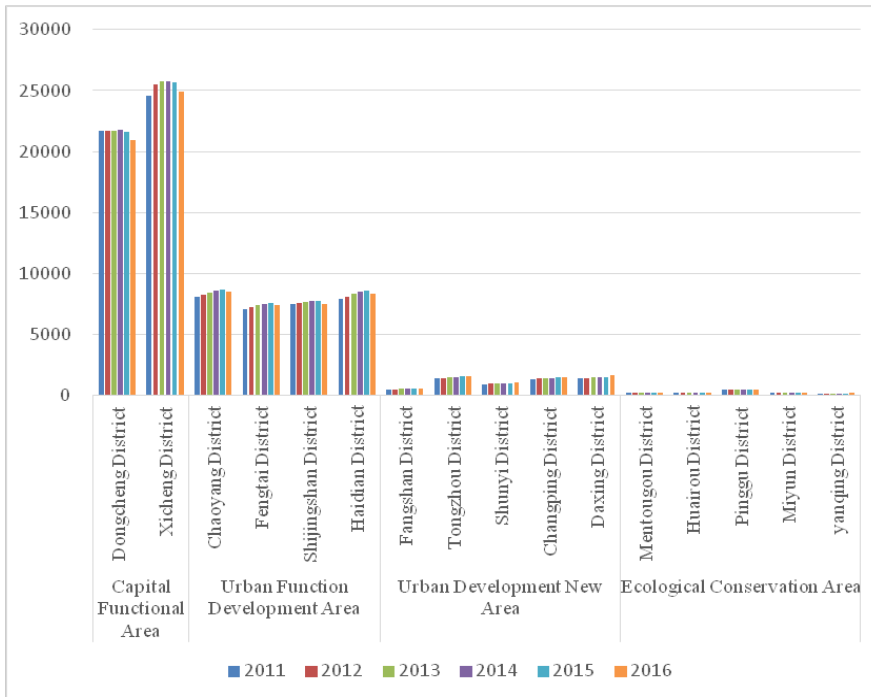


Figure 5. Population Density Distribution in Each Functional Area

Data Source: Beijing Municipal Bureau of Statistics (<http://www.bjstats.gov.cn/index.html>)

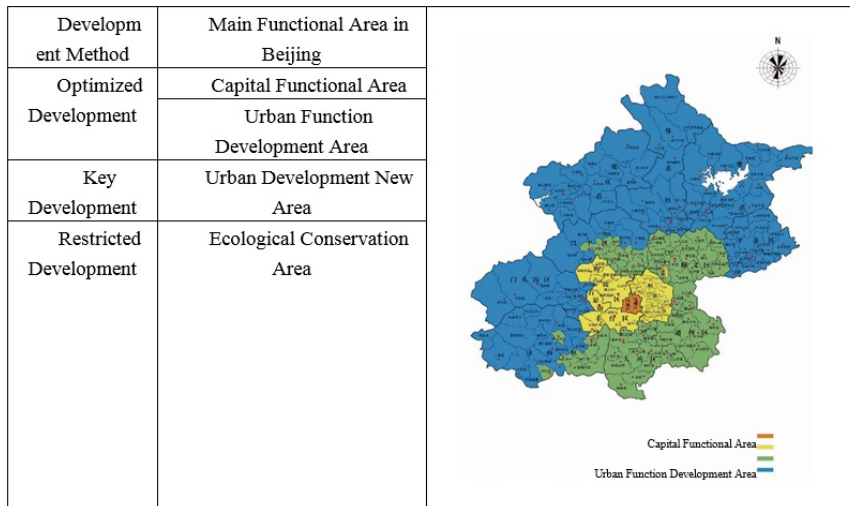


Figure 6. Map of Main Functional Area in Beijing
 Data source: The Main Functional Area Planning of Beijing (2012)
 (<http://zhengce.beijing.gov.cn/zfwj/25/26/421256/12603/index.html>)

5.1.2 Spatial structural analysis of population

Calculate Imbalance Index (U) and Concentration Index(I) from Formula (1) and (2):

$U_{2011}=0.1326$	$C_{2011}=0.3510$
$U_{2012}=0.1321$	$C_{2012}=0.3498$
$U_{2013}=0.1323$	$C_{2013}=0.3499$
$U_{2014}=0.1326$	$C_{2014}=0.3501$
$U_{2015}=0.1319$	$C_{2015}=0.3479$

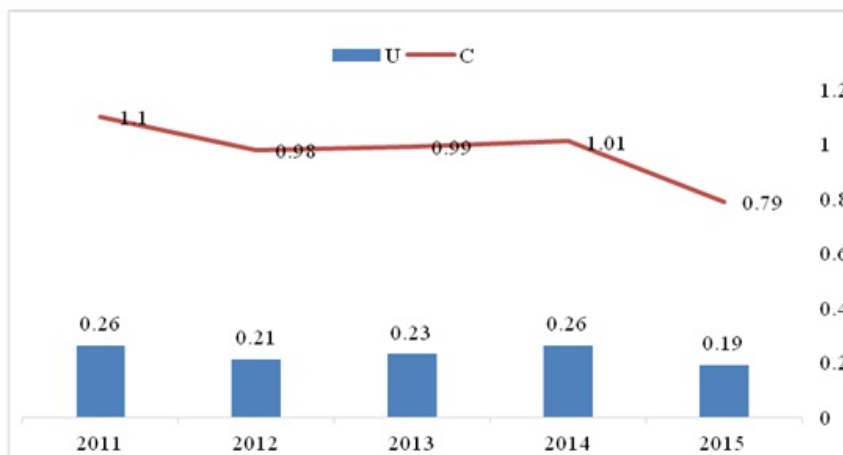


Figure 7. The Imbalance and Concentration index of population spatial distribution in Beijing

According to the calculation results of the Beijing Statistical Yearbook 2011-2015, the Imbalance Index (U) has remained in a relatively stable state, from 0.1326 in 2011 to 0.1319 in 2015. The Concentration Index (C) shows a slow downward trend, from 0.310 in 2011 to 0.3479 in 2015, indicating that the problem of spatial imbalance in Beijing's population distribution has not been solved, but the population of population-

concentrated areas has tended to decline (*Figure 7*). Therefore, in order to conduct a more in-depth study about the population structure, in following analysis we classify population by the industries in which people work.

5.2 Effectiveness of the guidance on population control through spatial planning in Beijing

5.2.1 Analysis of industrial population structure in each functional area

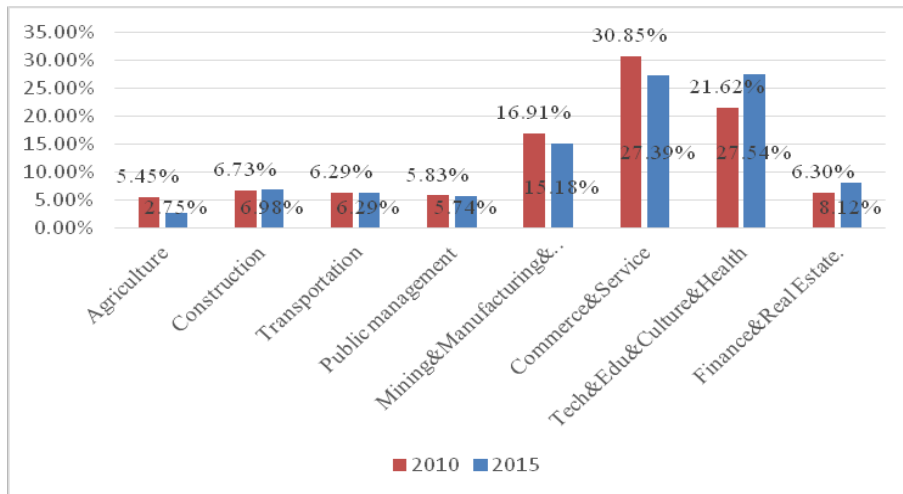


Figure 8. Changes in the proportion of the employed population in various industries

As shown in *Figure 8*, in general the proportion of the employed population in production function industries dropped significantly in 2010-2015. The proportion in Agricultural declined from 5.45 percent in 2010 to 2.75 percent in 2015, while the number of employees in the Mining-Manufacturing-Power sector also dropped from 16.91 percent to 15.18 percent. The proportion in Commerce & Service declined from 30.85 percent to 27.39 percent, but the proportion in Finance & Real Estate increased from 6.30 percent in 2010 to 8.12 percent in 2015. Also, the number of Tech & Edu & Culture & Health employees who represent the functions of Technology and Culture increased from 21.62 percent in 2010 to 27.54 percent. Overall, between 2010 and 2015, when the political function is relatively stable, industrial transfer of production and labour-intensive industries is evident and the higher-end tertiary industries (such as Finance & Real Estate, Tech & Edu & Culture & Health) have been strengthened.

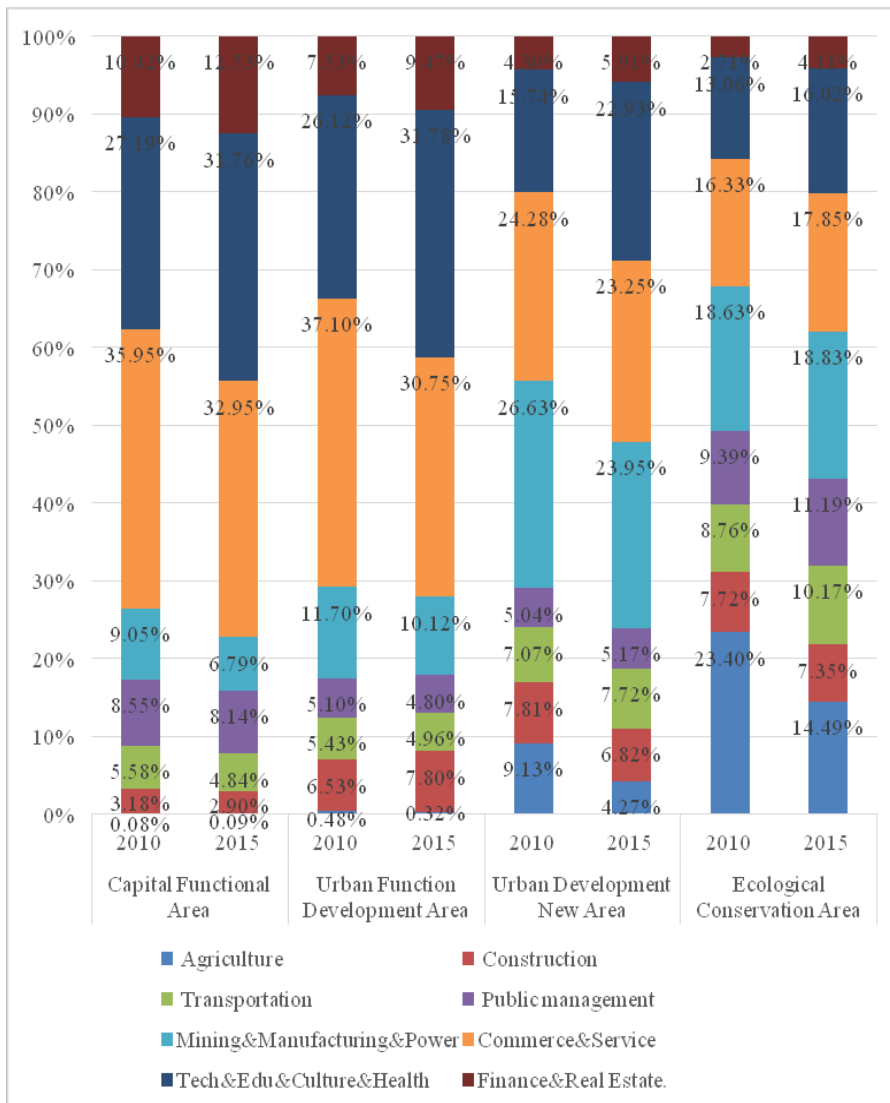


Figure 9. Industrial structure of each functional area

Data source : The 2010 Population Census in Beijing and the 1percent sample population survey in 2015

In the Capital Functional Area, the proportion of people engaged in the relatively labour-intensive Commerce & Service sector decreased from 35.95 percent in 2010 to 32.95 percent in 2015. In the same period, the population proportions in the Finance & Real Estate category and the Tech & Edu & Culture & Health category both increased, from 10.42 percent to 12.53 percent and from 27.19 percent to 31.76 percent, respectively (Figure 9).

In the Urban Function Development Area, the industry with the highest proportion in 2015 was Tech & Edu & Culture & Health, accounting for 31.78 percent of the employees in the whole functional area. And the second highest proportion, Commerce & Service, dropped significantly from 37.10 percent to 30.75 percent in the period, followed by Finance & Real Estate, which increased to 9.47 percent. (Figure 9).

In the Urban Development New Area, the proportion of manufacturing and commerce stays in a relatively high level, with the percent about 23 percent. Then the data of Tech & Edu & Culture & Health increased from 15.74 percent in 2010 to 22.93 percent in 2015, while Agricultural fell from 9.13 percent to 4.27 percent (Figure 9).

In the Ecological Conservation Area, the number of people engaged in Agriculture, compared with that in 2010, decreased from 23.40 percent to 14.49 percent. But the proportion remained the highest among the four functional areas, which reflected the fact that the Ecological Conservation Area mainly undertook the agricultural production function of Beijing. And the Tech & Edu & Culture & Health industry accounted for 16.03 percent of the functional area (*Figure 9*).

In general, it can be seen that the industrial employment structure of the main functional areas in Beijing changed greatly before and after the release of the Planning (2012) report, based on the analysis of industrial employees.

5.2.2 Effectiveness of the guidance on population control through Spatial Planning in Beijing

This section analyses the planning measures of the current main spatial planning (the MFAP) in Beijing and the corresponding industrial population layout requirements. It also analyses the effectiveness of the existing planning in guiding population, and then makes suggestions for responding to spatial planning and the guidance role of population control in Beijing. This section separates the Technology (IT and Research) industry from the Tech & Edu & Culture & Health industry to describe the functions of the Capital Science and Technology Centre.

Table 3. Main functions and the guidance direction of population control in Beijing's Main Functional Area Planning

Main Functional Area in Beijing	Districts and counties	Industrial function	Population control guidance
Capital Functional Area	Dongcheng Xicheng	Political Centre Commerce	Dispersal
Urban Function Development Area	Chaoyang Fengtai Shijingshan Haidian	Technology Culture	Dispersal
Urban Development New Area	Fangshan Tongzhou Shunyi Changping Daxing	Mining- Manufacturing-Power Construction Commerce Finance & Real Estate	enhancement
Ecological Conservation Area	Mentougou Huairou Pinggu Miyun Yanqing	Transportation Agriculture Mining- Manufacturing-Power Construction	Limit

From 2012 to 2016, the proportion of employees engaged in Commerce and Finance & Real Estate in the Capital Functional Area was relatively high, as shown in *Figure 10*, and it has been on the rise, while the transportation industry has declined significantly. In the MFAP, the optimized development area will vigorously promote the high-end agglomeration of the modern service industries, like Finance & Real Estate, consolidate the status of the national financial centre, and form a financial industry cluster with strong international competitiveness. The intensity of development and construction has been properly controlled, and population and function have been effectively dispersed. But according to the current situation, the employment of the labour-intensive commercial industry is not conducive to population dispersal, and the development of innovative

industries, such as science research and technical services, should be improved.

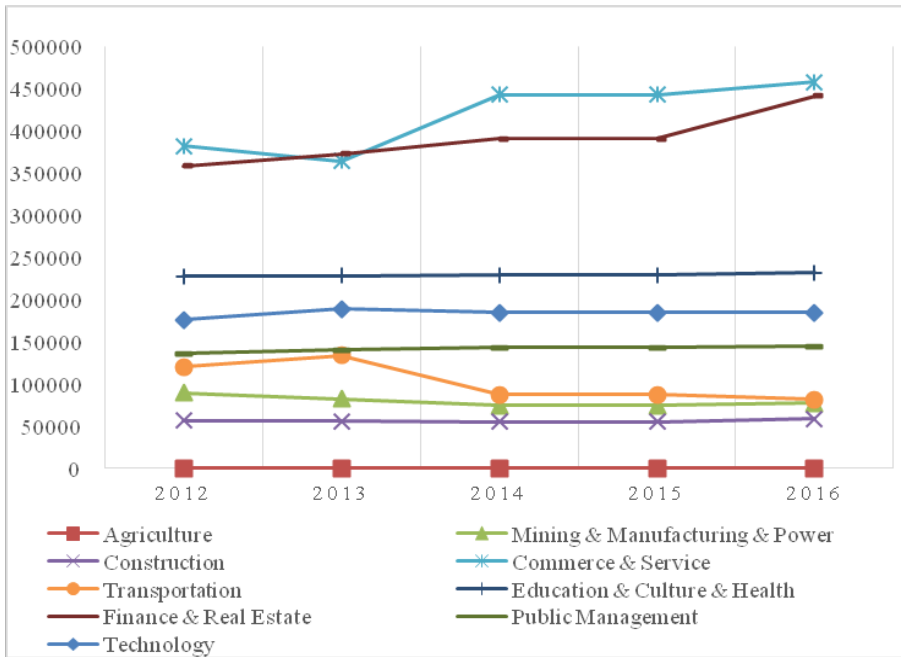


Figure 10. Distribution of employees in various industries in the Capital Functional Area
Data Source: Dongcheng and Xicheng District website*

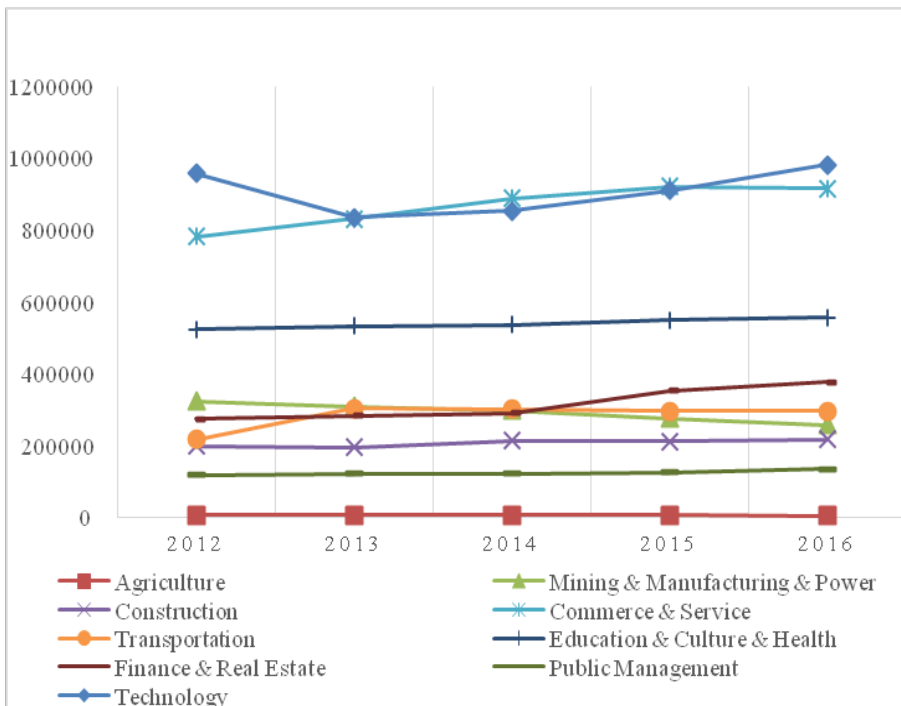


Figure 11. Distribution of employees in various industries in the Urban Function Development
Data Source: Chaoyang, Fengtai and Haidian District website.*

The Urban Function Development Area includes the three high-end industrial functional areas of Zhongguancun Science Park, the Business Centre District and the Olympic Centre District. The employees in the area

are engaged in a higher proportion of Commerce, IT & Science. As shown in [Figure 11](#), there was a rise in the Finance & Real Estate industry, while the construction industry and the transportation industry were declining. This area includes four districts with relatively high development intensity but is not fully urbanized. The main function is to focus on development of high-end industrialization, internationalization and urban-rural integration, and also to optimize and upgrade the relatively high-end industrial functional areas, such as the CBD and Zhongguancun Science Park. The main functions also include population dispersal, industrial agglomeration and ecological agriculture transfer. In terms of population control in planning, it should improve the ability of community and population service management, and appropriately reduce the proportion of residents according to the MFAP.

The population in the Urban Development New Area mainly engaged in Mining-Manufacturing-Power, and the population of other industries were also on the rise. The Transportation, Education & Culture & Health category is growing rapidly, as shown in [Figure 12](#). This area has five districts with the greatest potential for development and urbanization. As a key development area, it is an important area to carry the population and industries, and also carry transferred urban functions from the optimized development areas (Capital Functional Area and Urban Function Development Area). It is the area gathering high-tech manufacturing industries and strategic emerging industries, the modern agricultural production and demonstration base, and the international transportation and logistics centre. Its main functions undertaken include the enhancement of population carrying capacity, industrial agglomeration and ecological agriculture.

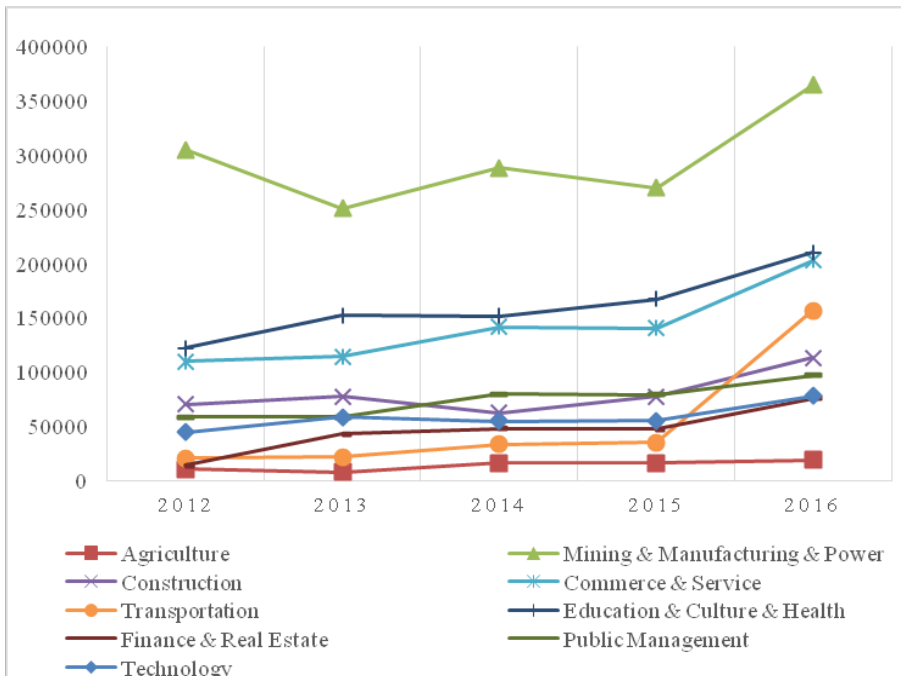


Figure 12. Distribution of employees in various industries in the Urban Development New Area. Data Source: Fangshan, Tongzhou, Shunyi, Changping and Daxing District website*

In the Ecological Conservation Area, the number of employees engaged in Mining-Manufacturing-Power has declined rapidly, and the Construction industry has also shown a downward trend, while the numbers in

Commerce, Transportation and Education & Culture & Health have gradually increased, as shown in [Figure 13](#). This area is an important area to guarantee the city's ecological security and water conservation. The main function is to limit development and to limit large-scale high-intensity industrialization and urbanization. It is necessary to focus on cultivating tourism, leisure, recreation, cultural and creative industries, and promote the construction of new towns and rural areas. Its main functions undertaken are the enhancement of population carrying capacity, the industrial agglomeration function, and the ecological agriculture function. In terms of population control in planning, the restricted development area should control population appropriately and equalize basic public services according to the MFAP.

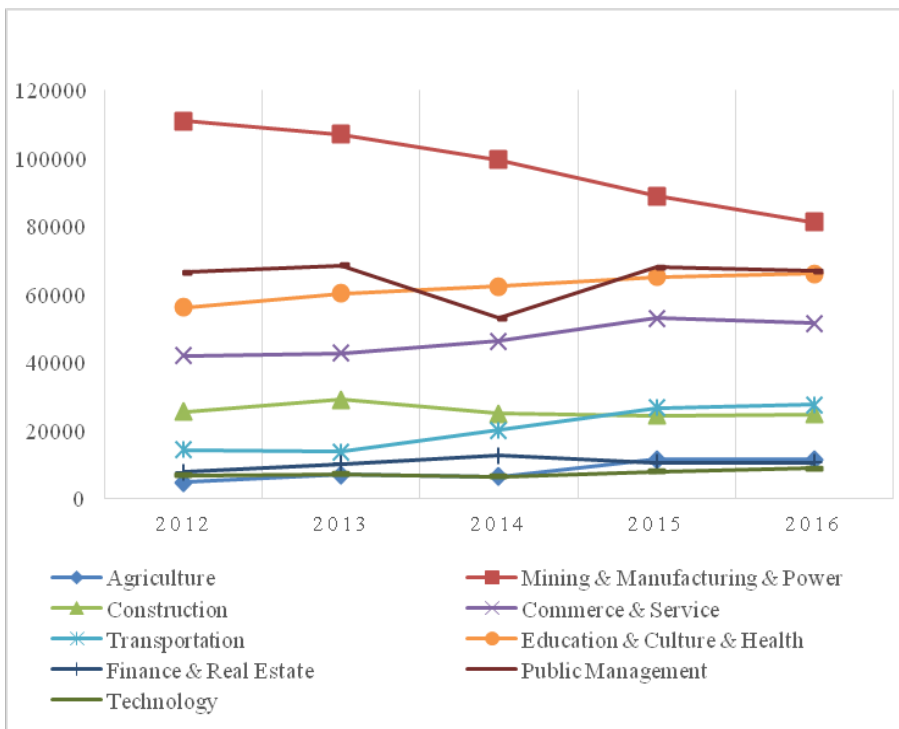


Figure 13. Distribution of employees in various industries in Ecological Conservation Area (lacking data of Shijingshan District.). Data Source: Mentougou, Huairou, Pinggu, Miyun and Yanqing District website*

In general, the demographic changes in Beijing basically evolved in accordance with the objectives of the MFAP. According to the requirements of the main function planning, the Urban Development New Area needs to develop industries such as Mining – Manufacturing – Power, Construction, Commerce, Transportation, Finance & Real Estate, etc. (as summarized in [Table 3](#)). At present, the commercial and financial industry agglomeration functions are insufficient. The population dispersal needs to be strengthened in the Capital Functional Area and Urban Function Development Area.

The MFAP of Beijing controlled the distribution structure of population quite effectively by planning the distribution of urban functions and the development of industry. The MFAP can be a good foundation for future spatial planning development.

6. CONCLUSIONS

Through an analysis of the changes in the industrial population structure of each functional area after the implementation of Beijing's Main Functional Area Planning, population structure has changed greatly in accordance with the direction of planning. The result reveals that it is effective to change the population structure by controlling the industry structure in spatial planning for metropolises like Beijing. Furthermore, based on international experiences and the actual situation in Beijing, and also the spatial planning response to Beijing's population problem, the following general recommendations to metropolises are made:

Firstly, to establish new urban areas or build new cities for forming a multi-centre structure, which can disperse population and reduce population density. Secondly, to plan for old town renovation. Based on a long-term development perspective, the old areas should be planned together, the spatial functions of each area need to be clarified, and the old town reconstruction projects should be set with a strict floor area ratio according to the functions of different areas to protect the old town and control population density. Thirdly, to rationally plan the industrial function, change the industrial layout, and guide industrial migration out of the old town by economic means and policies, such as taxation and subsidies. Through the migration of labour-intensive industries, the population will be dispersed. Fourthly, to set the minimum standard of living, including the minimum standard of housing, and improve the living quality of the urban residents, and encourage the population to flow. Actively promote the diffusion of high-quality infrastructure and service facilities in the old urban areas to the peripheral areas, reduce the spatial differences in the quality of life in the city, and provide the motive force for the population. Fifthly, to improve the construction of the traffic infrastructure and reduce the commuting time of migrant workers living on the periphery of the city. This entails efforts to guide the workers to live in the periphery of the city by reducing the time and the cost of the traffic, so as to reduce the population density of urban centres and alleviate the urban problems caused by overcrowding.

Through the analysis of the effectiveness of the Main Function Area Plan in Beijing, it can be seen that it is reasonable and effective to guide urban function realization through spatial planning, also to guide population distribution. Therefore, to solve population problems from the perspective of urban function realization, related research is needed in the future on urban function accounting, including production, living, ecological functions and rational allocation, and transaction principles.

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*Statistical data of districts in Beijing are collected from Governments website as listed below, data of Shijingshan District is not available:

District	Website
Dongcheng	http://www.bjdch.gov.cn/n2001806/n2917385/n2917389/index.html
Xicheng	http://dzsw.bjxch.gov.cn/XICXXGKIndex/XICXXGKtjxx/XICXXGKsjfb.yes
Huairou	http://www.chystats.gov.cn
Fengtai	http://www.bjft.gov.cn/n_list.html?XXGK/TJXX/
Haidian	http://www.bjhd.gov.cn/xinxigongkai/haidianshuju/tongjixinxi/
Fangshan	http://www.bjfsh.gov.cn/zjfs/fsjj/sjtj_17721/
Tongzhou	http://www.bjtz.gov.cn/bjtz/xxfb/tjsj/tjsh.shtml
Shunyi	http://www.bjshy.gov.cn/web/zwgk/tjxx/index.html
Changping	http://www.bjchp.gov.cn/cpqzf/xxgk2671/tjxx/ydtj/index.html
Daxing	http://www.bjdx.gov.cn/zwxx/tjxx/tjsj/index.html
Mengtougou	http://www.mtg.bjstats.gov.cn
Pinggu	http://www.bjpg.gov.cn/pgqrmzf/zwxx0/tjsj0/index.html
Miyun	http://www.bjmy.gov.cn/affair/statistics/data/
Yanqing	http://www.bjyq.gov.cn/yanqing/zbm/1718459/tjsj/2016/index.shtml