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Evolution of Jobs-housing Spatial Relationship in Beijing Metropolitan Area: A Job Accessibility Perspective

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Abstract: With the urban expansion and economic restructuring, the jobs-housing relationship has become an important issue in studies on urban spatial structure. This paper employed a job accessibility model, which is an evaluation instrument to measure the jobs-housing relationship in Beijing Metropolitan Area from a job accessibility perspective. The results indicate that the population in the central city is declining, whereas the population in the suburbs is consistently growing and forming new population centers. However, the distribution pattern of employment is still highly centralized. Job accessibility varies in different locations, but the inner-city areas (within the Third Ring road) have seen improved job accessibility over time while job accessibility in the suburbs (especially outside the Fourth Ring road) has decreased, and this has led it to become a primary area of residential and employment mismatch. At the same time, the new towns in the outer suburbs have not yet demonstrated great potential to attract more jobs. In addition we find that, to some extent, urban planning changes the jobs-housing relationship, but a polycentric urban spatial structure is not yet evident. The floating population and related housing policy also affect the jobs-housing relationship. We propose some measures to resolve the spatial mismatch as well as some future research directions.

Keywords: jobs-housing relationship; job accessibility; spatial mismatch; population density; employment density; Beijing Metropolitan Area

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1 Introduction

In recent decades, the urban decentralization process has taken an increasingly polycentric form, with a number of concentrated employment centers making their mark on both employment and population distribution, leading to changes in the urban spatial structure from a traditional, monocentric pattern to a polycentric structure (Anas *et al*., 1998). As an important part of the urban spatial structure, the spatial distribution of urban population and employment has attracted increased interest from scholars (Gobillon *et al.*, 2007; Horner and Mefford, 2007).

As concern has grown over urban sprawl and its potential impact, the issue of the relationship between jobs and the location of housing has been investigated using a variety of approaches, many of which are based on the spatial mismatch hypothesis proposed by Kain (1968; 1992). The hypothesis indicates that racial segregation in housing markets and spatial barriers between residences in the central city and employment opportunities in the suburbs have been the major causes of high rates

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of joblessness, lower wages, and longer commutes for black workers. Over the past 40 years, this theoretical standpoint has inspired a body of research that tests the geographical barriers to obtaining employment opportunities at different scales and that has been extended to many urban research fields (McLafferty and Preston, 1992; Ihlanfeldt and Sjoquist, 1998; Preston and McLafferty, 1999; Wang *et al*., 2011; Zhou S *et al*., 2013). The studies focus on theoretical models and for the most part they contend with the mechanisms of spatial mismatch (Gobillon *et al.*, 2007), welfare reform (Ihlanfeldt and Sjoquist, 1998), and commuting (Ong and Blumenberg, 1998; Zhou Suhong *et al.*, 2013). These studies not only support the spatial mismatch hypothesis, but also support the development of a jobs-housing relationship. However, they pay insufficient attention to the effectiveness of current or past urban planning responses to the spatial relationship between jobs and housing location (Blumenberg and Manville, 2004; Fan, 2012).

The research has provided a strong theoretical basis for the analysis of the jobs-housing relationship, and has produced useful measures of the spatial relationship between employment and residence. The simplest and most frequently used is the jobs-housing ratio, or the ratio of the number of employees to the number of households in a geographic area (Cervero, 1989). The measure has attracted criticism, however, for its failure to capture multidimensional opportunities for possible spatial interactions or differential access to employment, including a range of possible home or work locations (Horner and Marion, 2009). Some studies suggest that commuting time or commuting distance can be an inaccurate tool for the jobs-housing relationship (Gordon *et al.*, 1998; Horner, 2008; Horner and Marion, 2009). On the one hand, travel times have been determined by distance and mode of transportation, particularly by the reliance on mass transit. On the other hand, some workers may actively choose a longer commute for residential amenities such as high-quality schools, lower housing costs and environmental benefits. Job accessibility is related to the worker′s geographic proximity to available jobs or potential job opportunities, which have certain effects on employment probability (Wang, 2000; Perle *et al.*, 2002; Geurs and Van Eck, 2003). From the existing literature, job accessibility has been proposed as an indicator to explore the jobs-housing relationship and overcome these problems (Parks, 2004; Aslund *et al.*, 2010; Korsu and Wenglenski, 2010).

The decentralization of manufacturing and the continuing concentration of service employment in central cities increase the length of daily commuting trips of urban workers, and this spatial imbalance in the jobs-housing relationship has become prominent in China. With the disintegration of the traditional *danwei* (work unit) system, urban housing reform has fundamentally altered the jobs-housing relationship (Wang and Chai, 2009), which poses more challenges to Chinese cities. While housing suburbanization has accelerated in major cities like Beijing and Shanghai, urban jobs have not spread as quickly as the population. As urban housing has started to become detached from the workplace, the jobs-housing relationship has witnessed a shift from a ′spatial bond′ to a ′spatial mismatch′ (Wang *et al.*, 2011).

This study explores the changing jobs-housing spatial relationship from the perspective of job accessibility in the context of China′s transition from a planned economy to a market economy. We use Beijing as a case study to evaluate how the spatial relationship has changed between jobs and housing in the past decades, and to determine whether the revision of urban planning has improved the jobs-housing relationship. Suburbanization in Beijing is examined first by analyzing the changes in population density and employment density from 1990 to 2010. The evolution of the jobs-housing relationship in different periods of time is then evaluated. Finally, we look further at the influence of other factors on the jobs-housing relationship and propose possible solutions to the issue of deteriorating spatial mismatch.

2 Research Context

2.1 Jobs-housing spatial relationship: A comparison of cities in United States and China

Most of the previous empirical studies on the jobs-housing relationship have been conducted on cities in the United States (US) such as the Boston, Los Angeles, and San Francisco metropolitan areas (Shen, 2001; Kawabata and Shen, 2006). There is at least one highly significant difference between US and Chinese cities. In the US, low-skilled workers live in the central city, and low-skilled jobs are located in the suburbs. Workers may

face barriers to moving, such as lack of job-search information, poor public transit and increased commuting costs. The decentralization of employment, racial discrimination and residential segregation in inner cities are widely recognized as the major causes of this spatial mismatch (Xu *et al*., 2014). The mismatch between population and employment in Chinese cities displays the opposite pattern. In Chinese cities, there are more job opportunities in the inner city, but the workers can not afford a house there because of the high prices, so most working-class households (e.g., low, low-middle, and middle-income) live in the suburbs. Because they live in the suburbs, a substantial amount of time is spent commuting between work and home, which increases the level of stress (Korsu and Wenglenski, 2010; Wang *et al.*, 2011). All of these changes lead to serious traffic congestion and reduce the efficiency of urban operations (Steg and Gifford, 2005; Kawabata and Shen, 2006).

In the process of suburbanization in China, numerous high-rise apartment buildings have been constructed on urban peripheries, including many affordable housing projects that have been invested by the government. The low-price housing and low-rent housing increase the spatial imbalance between residence and employment (Xu *et al.*, 2014). The rapid suburbanization of major cities has changed the appearance of the suburbs, and inadequate infrastructure increases commuting difficulties. Urban sprawl, urban land and housing reform, and incomplete infrastructure drive the spatial mismatch in Chinese cities and limit the migration of low-income groups to the city center. The spatial mismatch differs from those cities in the US, where racial discrimination and residential segregation are its core causes.

2.2 Disintegration of traditional *danwei* system

Before the economic reforms of the 1980s, Chinese cities were organized as a hierarchy in which each work organization was a social ′unit′ in the system (Xie and Wu, 2008), which was called a *danwei*, the basic unit of Chinese urban social and spatial organization (Bray, 2005). Nearly all urban workers were the part of a *danwei*, which were self-sufficient communities providing jobs and housing, as well as a comprehensive package of welfare and services such as shops, factories, schools, hospitals and government departments (Chai, 1996; Wang and Chai, 2009). Most urban residents lived close to their workplace, and almost all of the dwellers′ daily needs were met within the *danwei*. This greatly reduced the frequency of traveling, and allowed for a jobs-housing balance between residential and employment areas. With the deepening of reforms and the opening policies since the 1980s, the market-oriented economy has exerted a significant influence on the *danwei*. As an important part of this urban transformation, the social and spatial changes of *danwei* institutions have also affected the development of Chinese cities (Chai *et al.*, 2011a). The employment, personnel, housing distribution and welfare systems of the *danwei* system have gradually weakened, resulting in the slackening of control in social stratification, urban structure and in other aspects.

In all of these aspects, urban land reform and urban housing reform have fundamentally transformed the traditional *danwei* system. Before the 1980s, urban land was largely free and allocated to various *danwei* by local governments, and its efficiency was relatively low. Since the implementation of urban land market reform, urban land can be bought and sold based on location, supply and demand (Wang *et al.*, 2011), which promotes the specialization and separation of urban functions. As different land uses, such as commercial, residential and industrial, began to be separated from each other, the spatial separation between workplaces and residences became common (Chai *et al.*, 2011b).

Urban housing reform gradually weakened the status of *danwei* in the cities from the latter half of the 1990s. In 1998, the termination of the welfare housing distribution system marked the disintegration of the traditional *danwei* system. Since then, *danwei* is no longer in charge of the allocation of housing to their workers, and employees are encouraged to buy their housing in the real estate market (Wang *et al.*, 2011). It is thus no longer necessary to purchase housing near the *danwei*, and residents have greater freedom to choose their home location according to housing price (Feng *et al.*, 2007). The low-income groups can no longer afford to purchase in the *danwei* area, and have been forced to move to the city outskirts (Zhou S *et al*., 2013). Consequently, reforms in urban housing distribution have improved the mobility of residents, which has changed the pattern of the jobs-housing relationship from one that was a bond to one of separation between residence and employment, in addition to significantly increasing the travel demand of urban residents.

2.3 Revision of Beijing City Master Plan

Over the past 50 years, the City Master Plan in Beijing has been revised multiple times, which has had an important impact on the urban spatial structure. In 1958, the government used a decentralized group of urban spatial pattern, planning to develop a number of satellite towns with the idea of locating industrial development in the satellite towns of outer suburbs. However, the urban construction in this period was developed as a planned economy, and because many factories were still concentrated in urban areas, the scale and function of the satellite towns remained relatively weak. The government thus proposed supporting policies that focused on developing the satellite towns in 1982.

The third revision of the Beijing City Master Plan clearly defined the function of satellite towns and created some promising policies for infrastructure construction in 1992. In this period, the suburbs would become the focus of city construction, allowing for the main function of satellite towns to be not only urban extensions but also political, economic and cultural centers in outer suburban areas. Compared with the previous City Master Plan, this plan reduced the number of satellite towns, but the size of the population were expanded, and the plan put forward planning guidance in formulating preferential policies, such as strengthening infrastructure construction and improving urban functions. In 2004, the government established a new urban spatial pattern focused on developing the different new towns as a polycentric structure where both population and jobs would be decentralized based on the existing satellite towns (Loo and Chow, 2011). In this plan, new towns would play a key role in population dispersal in the inner city. On the one hand, new towns have enough development space to accommodate the population and functions of the central city; on the other hand, internal collaboration among the new towns has increased their influence on surrounding regions.

3 Materials and Methods

3.1 Study area

Beijing, the capital of China and one of the largest cities in the world, covers 16 districts and two counties and had 2.115×10^7 permanent residents in 2013, according to *Beijing Statistical Yearbook 2014* (Beijing Municipal Bureau of Statistics, 2014). The administrative region of Beijing is traditionally divided into three parts: the central city, the suburbs and the outer suburbs. The central city includes four districts: Xicheng, Dongcheng, Chongwen, and Xuanwu. In 2010, the Beijing Government proposed a new administrative division. The central city districts became two districts. Xuanwu was merged into Xicheng, and Chongwen was merged into Dongcheng. The suburbs include four districts, Haidian, Chaoyang, Fengtai, and Shijingshan, and the outer suburbs include eight districts and two counties, Tongzhou, Shunyi, Fangshan, Daxing, Changping, Mentougou, Huairou, Pinggu districts and Miyun and Yanqing counties. In 2006, a plan for regional development was approved by the Beijing Municipal Commission of Development and Reform, and Beijing was divided into four major functional areas: the Core Function Zone (including the central city), the Extended Urban-Function Zone (including the suburbs), the New Development Zone (mainly including Tongzhou, Shunyi, Fangshan, Daxing, and Changping), and the Ecological Preservation Zone (the remaining three districts and two counties). Given the rapid urbanization and expansion of Beijing in recent decades, fourteen districts were selected as the study areas for this paper (excluding Huairou, Pinggu districts and Miyun and Yanqing counties), which together are called the Beijing Metropolitan Area (Feng and Zhou, 2003; Sun *et al.*, 2012) (Fig. 1).

3.2 Data

Census data on jobs and population are used to analyze the spatial relationships between employment and residence. We choose data from 1990, 2000 and 2010, which allow us the possibility of detecting the influence of policy on the jobs-housing relationship after the revision of the Beijing City Master Plan in 1982, 1992 and 2004. The basic demographic data are obtained from *Tabulation on the Population Census of Beijing Municipality Town and Sub-district Volume* (*1990*; *2000*; *2010*) (Beijing Municipal Bureau of Statistics, 1992; 2002; 2012), whereas the jobs data are collected from *Beijing Basic Units Census Yearbook* (*1996*; *2001*) (Beijing Municipal Bureau of Statistics, 1998; 2003) and from an enterprise survey in 2010. We estimate the working population in 1990 according to the data from all districts and counties of Beijing in 1996, and use employment data from 1990, 2001 and 2010. Population data matching employment data in each sub-district in

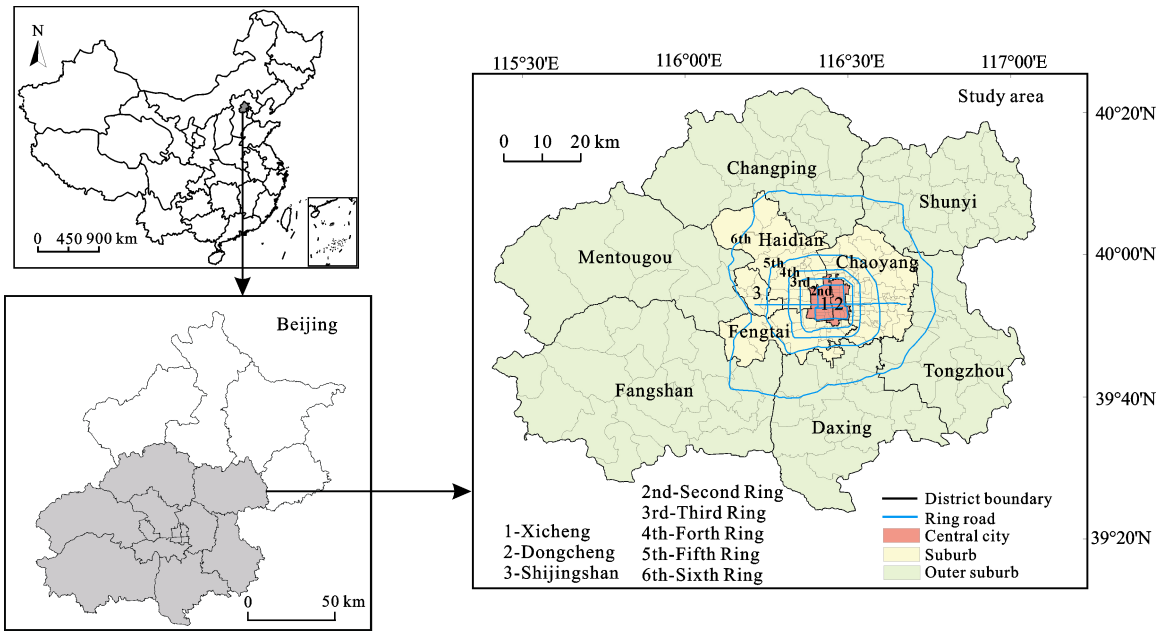

Fig. 1 Location of study area

the study are used because the trend growth of jobs is similar to that of 2001, and the jobs data in 2001 could be used to match the population data in 2000. In the past two decades, Beijing has experienced changes in its administrative divisions in a number of sub-districts, so we merge some sub-districts in 2000 and 2010 on the base of the number of 1990 sub-districts for the purpose of comparison. In total, 206 sub-districts are included in the analysis.

3.3 Methods

Liu and Wang (2011) calculated the impacts of job accessibility on the commuting time of urban residents in Beijing from a spatial mismatch perspective. In this study, the measure of job accessibility is based on Liu and Wang's basic method, but differs from it in three ways. First, we take into account the difference between linear distance and actual distance and amend the actual distance using a non-linear coefficient①, so the results are more accurate. Second, the calculation of job accessibility in the previous study adopted population data from 2000 and matched jobs data from 2004, and may have contained some errors, but in this paper, we obtain the more detailed data for jobs from 1990, 2001 and 2010. Finally, we study the evolution of the 2010. Finally, we study the evolution of the jobs-housing relationship, which is a better reflection of urban spatial structure in Beijing Metropolitan Area.

The study defines job accessibility as the number of jobs that are accessible within a maximum travel distance for workers living in that zone, including the jobs in and potentially surrounding the sub-district. Job-accessibility formulas were proposed and developed by Ong and Blumenberg (1998), Shen (1998), Liu and Wang (2011) and expressed as follows:

$$A_i = \frac{E_i + \sum_{j=1}^{k} (E_j / d_{ij}^2)}{W_i} \quad (1)$$

where A_i is the job accessibility for workers living in sub-district i; E_i and W_i are the number of jobs and the working population living in sub-district i, respectively; E_j is the number of jobs in sub-district j; d_{ij} is the distance between sub-district i and sub-district j; and k is the sub-district surrounding sub-district i within a specific travel distance.

The job-accessibility equation considers two factors (Ong and Blumenberg, 1998; Shen, 1998; 2001). First, it

① The non-linear coefficient is an important index of highway network programming, which is defined as the ratio of actual distance and straight-line distance between two nodes. The definition of a non-linear coefficient is offered by urban road traffic planning and design specifications (GB50220-95).

takes into account the competition from workers in other sub-districts. Second, it includes a distance-decay effect, which results from the differences in access to job information among the employees, leading to a lower likelihood that workers will hunt for a job farther away from home. The travel distance is identified for sub-district *i* and for all other sub-districts whose centroids are within a specific distance. After referring to other studies that have been conducted on Beijing (Meng, 2009; Wang *et al.*, 2011; Zhao *et al.*, 2011; Liu and Wang, 2011; Meng *et al.*, 2012), we decided to use different thresholds of travel distance (6, 8, and 11 km)① to calculate the job accessibility of sub-districts in 1990, 2000 and 2010. The distance refers to the linear distance from the geometric center of each sub-district to other sub-districts, and thus, the actual distance must be greater than the linear distance. We amend the actual distance according to the related literature, so that the non-linear coefficient is 1.57 in Beijing (Wang and Li, 2007), and we chose a straight-line distance of 3.8 km, 5.1 km, and 7.1 km, respectively.

4 Results and Analyses

4.1 Changes in number of population and working population

Basic descriptive statistics on the population and working population (from age 16 to 64), including increment (INC) and average annual growth rate (AAGR), are shown in Table 1.

The table shows that the data of population and employment vary greatly between different layers. From 1990 to 2000, the population growth in the suburbs accounted for the largest proportion in the metropolitan area and the increment is 225.31×10^4, followed by the outer suburb, while the central city′s population decreased. From 2000 to 2010, the population in the central city had a smaller growth, the fastest growing area was still the suburbs but its proportion in the metropolitan area decreased. Compared with the previous stage, there was a large increase in the outer suburb with the increment being 264.41×10^4. In the light of the average annual growth rate of population, in the first stage (1990–2000), the suburbs experienced the highest population growth rate, while the annual growth rate in the central city was negative. In the second phase (2000–2010), the outer suburbs showed the highest population growth rate, and the central city had also the positive population growth. It showed that the central city will be faced with more pressure of population dispersal, for the new towns′ ability to attract new population in the outer suburbs has clearly improved, and the main carrying capacity of population has thus gradually expanded from the suburbs to the outer suburbs in Beijing Metropolitan Area.

The changes in working population are indicated in Table 1. The working population growth in the suburbs accounted for the largest proportion of metropolitan area between 1990–2000 and 2000–2010, whereas the increment of working population in the outer suburbs was the lowest in the first stage and the increment in the central city was the lowest during 2000–2010. From 1990 to 2000, the suburbs had the highest working population growth rate, but the trend changed during 2000–2010 and the working population growth rate increased significantly in the outer suburbs.

Table 1 Descriptive statistics for population and working population in Beijing Metropolitan Area (1990–2010)

	Population				Working population			
	1990–2000		2000–2010		1990–2000		2000–2010	
	INC (10^4)	AAGR (%)	INC (10^4)	AAGR (%)	INC (10^4)	AAGR (%)	INC (10^4)	AAGR (%)
Central city	–22.09	–0.99	5.51	0.26	31.87	1.83	9.02	0.46
Suburb	225.31	4.68	287.23	3.91	114.83	4.57	227.12	5.53
Outer suburb	53.24	1.58	264.41	5.57	18.88	2.55	128.37	9.65
Metropolitan area	256.47	2.45	557.15	3.91	165.58	3.31	364.51	4.89

Notes: INC is the increment and AAGR is average annual growth rate in different period between1990–2000 and 2000–2010

① Based on the four comprehensive traffic surveys of Beijing, respectively conducted in 1986, 2000, 2005 and 2010, we know from the investigation that the average trip distance for residents was 6, 8, and 11 km in 1986, 2000 and 2010, respectively. We therefore chose three different travel distance thresholds of 6, 8, and 11 km.

4.2 Changes in population density and employment density

4.2.1 Population density

As shown in Fig. 2a, the sub-districts with high population density are primarily located in the central city and suburbs (between the Second and Fourth Ring roads), and the population density outside of the Fourth Ring road gradually declines. Although the population density in general decreased from the center to the periphery, outer suburbs still have some hot spots with high population density, such as the Changping Town in Changping District, Tongzhou Town in Tongzhou District, Liangxiang Town in Fangshan District and Renhe Town in Shunyi District.

From 1990 to 2010, the trend of population density change was more evident. The greatest reduction occurred in the Qianmen sub-district in Dongcheng District, and the largest growth was in the Liulitun sub-district in Chaoyang District and so on (Fig. 2b). The sub-districts with decreased population density were primarily distributed in the old downtown and periphery of the metropolitan area, whereas the sub-districts in which population density increased were mainly in the suburbs and outer suburbs, and began to move to the Third Ring road from the central city, displaying a trend of an even more apparent population suburbanization.

4.2.2 Employment density

Employment density in 2010 had a highly centralized pattern in Beijing Metropolitan Area. However, some sub-centers were beginning to emerge, such as Zhongguancun sub-district in Haidian District and CBD in the Chaoyang District (Fig. 3a). Nevertheless, the new towns in the suburbs such as Changping and Daxing did not see much of an increase in employment density,

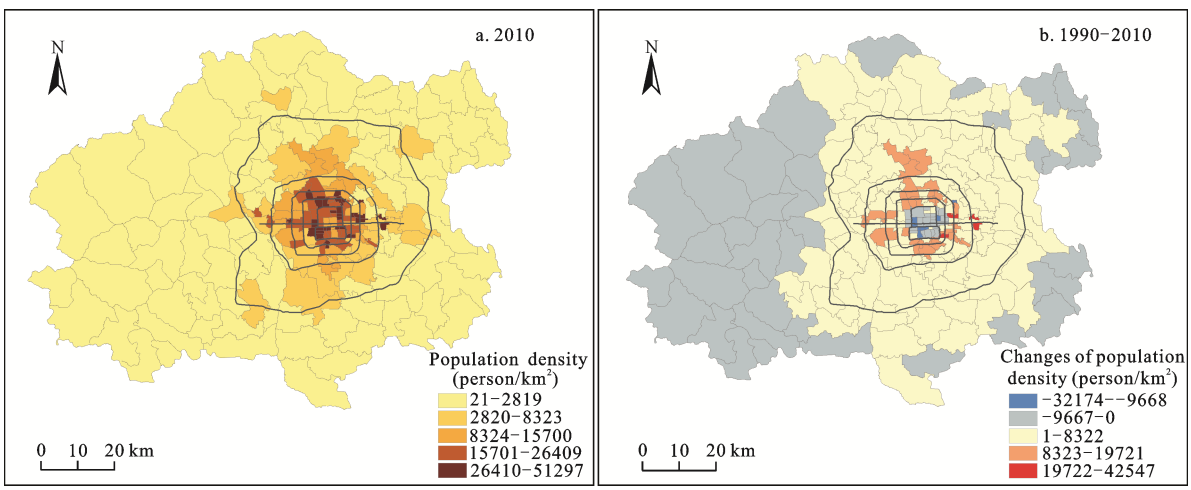

Fig. 2 Population density in 2010 (a) and changes of population density from 1990 to 2010 (b) in Beijing Metropolitan Area

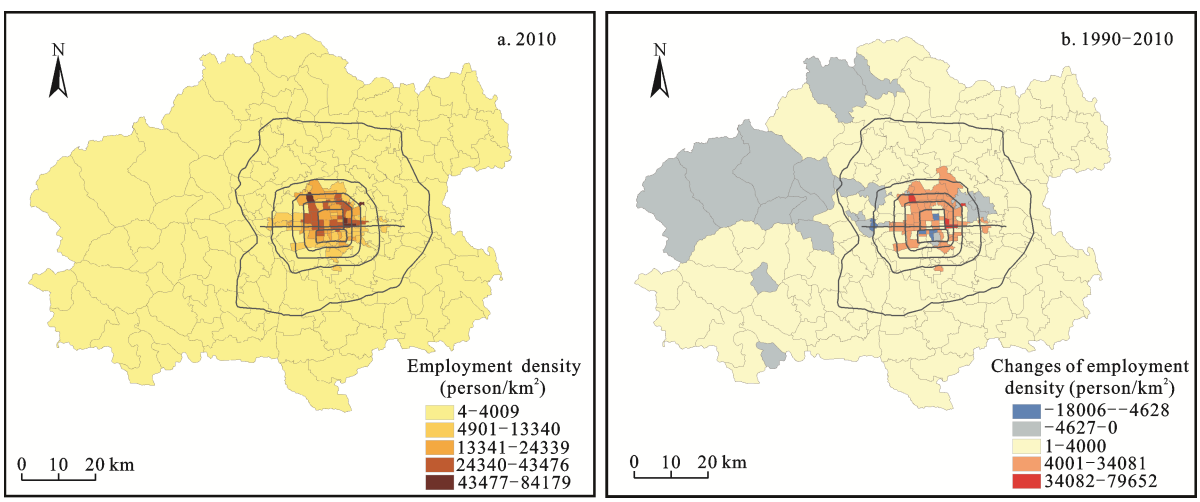

Fig. 3 Employment density in 2010 (a) and changes of employment density during 1990–2010 (b) in Beijing Metropolitan Area

indicating that the guiding function in the layout of the Beijing City Master Plan is relatively limited. The sub-districts with higher employment density were concentrated within the Fifth Ring road, but the overall employment spatial layout still displays a mono-centric spatial structure.

The employment density in Beijing Metropolitan Area changed significantly from 1990 to 2010 (Fig. 3b). The sub-districts experiencing the greatest change were Zhongguancun sub-district in Haidian District and Jianwai sub-district in Chaoyang District. These regions have a strong correlation to early urban planning. The Beijing City Master Plan in 1992 proposed the construction of the Central Business District (CBD) in Chaoyangmen and Jianguomen sub-districts from east Second Ring road to east Third Ring road. As the earliest window opening to the world in Beijing, it became one of agglomeration districts, serving as headquarters for the economy and has attracted a large number of employers. With the development of CBD, Chaowai and Jianwai sub-districts in Chaoyang District have become the districts of employment concentration. Moreover, Zhongguancun sub-district was a primary center for growth in innovation, with strong technology support from famous universities and research institutions that has helped it to become the most densely populated area of professional and intellectual employment.

The sub-districts with reduced employment density were found primarily in Mentougou and Shijingshan districts, the central city and areas of the urban fringe. In the planned economy period, the rapid development of the Capital Iron and Steel Company① and other heavy industrial enterprises laid the foundation for the development of Shijingshan District, which led to the growth in education, medical, commercial, and other service industries. The new City Master Plan led to the re-employment of a large number of workers and reduced the employment density of the Mentougou and Shijingshan districts. With the continuous expansion of the spatial layout in Beijing, the reconstruction of the downtown and policies that suppress second industries and develop third industries, some workers have been encouraged to move to the periphery of the old city or suburban areas.

4.3 Job accessibility

We calculated the job accessibility of each sub-district to analyze the jobs-housing spatial relationships in Beijing Metropolitan Area in 1990, 2000 and 2010. Mean job accessibility increased consistently from 1990 to 2010, with significant differences among the central city, suburbs and outer suburbs. The central city had the highest job accessibility, with a value of 7.23 in 2010. At the same time, the average job accessibility in the outer suburbs was 0.43. From 1990 to 2010, the job accessibility in the central city increased from 3.79 to 7.23, whereas the job accessibility grew from 0.25 to 0.43 in the outer suburbs. Job accessibility results are shown in Fig. 4 and Fig. 5.

Job accessibility varies in different sub-districts (Fig. 4). From 1990 to 2010, job accessibility increased by different degrees, but there were clear differences within the metropolitan area in different years. First, the sub-districts with high job accessibility were mainly concentrated within the Sixth Ring road in 1990 and 2000 and within the Fourth Ring road in 2010, and job accessibility increased from the periphery to the central city. Second, there were large gaps between the central city and the suburbs, indicating the spatial mismatch between jobs and housing in Beijing Metropolitan Area. Although traffic conditions had greatly improved between satellite towns and the inner city, the public transportation system was still fails to meet residents′ travel demands, and the majority of workers have a long commute. Third, job accessibility was high in most sub-districts located in the eastern Second and Fifth Ring road areas, because the Central Business District in Beijing had more jobs and better transportation services. We also found that the sub-districts with a better spatial matching relationship between housing and employment were mainly concentrated in the inner city, CBD and nearby regions from 1990 to 2010, indicating that potential employment opportunities were still more concentrated. Fourth, for individuals in the suburbs and the outer suburbs, job accessibility was considerably lower in most zones, and relatively high accessibility was only found in a limited number of sub-districts, such as Nankou sub-districts in Changping District and Datai sub-districts in Mentougou District in 1990 and Fangzhuang sub-district in Fengtai District in 2010.

① Capital Iron and Steel Company is the fourth largest steelmaker in China, and it has been one of the largest employers in Beijing, whose workers accounted for 40% of employees in Shijingshan District.

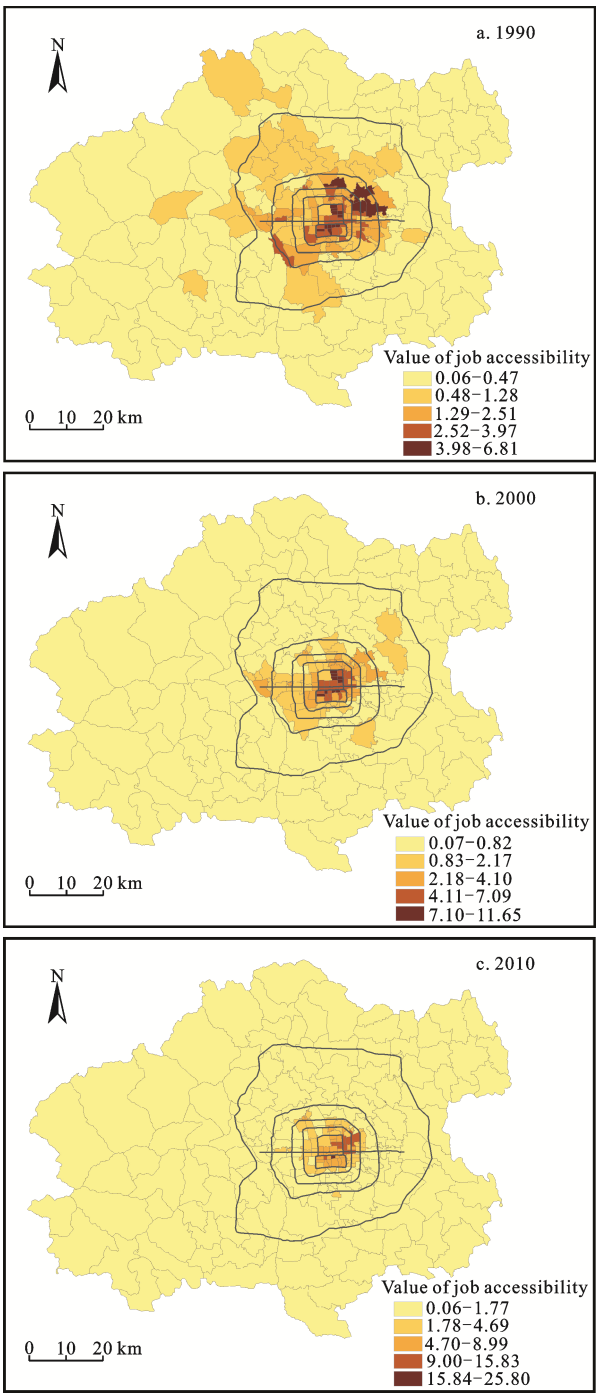

Fig. 4 Job accessibility for each sub-district in Beijing Metropolitan Area (1990, 2000, 2010)

Figure 5a illustrates that the temporal changes of job accessibility from 1990 to 2000 differed significantly among sub-districts. It is clear that job accessibility increased greatly in some sub-districts but declined in others. The increase in job accessibility reflects the growing number of jobs in these zones with respect to the number of workers competing for these jobs, and the decrease in job accessibility indicates a declining number of jobs, with some workers being unable to find a job in these sub-districts. Furthermore, changes in job accessibility vary among the central cities, suburbs and the outer suburbs. The increase in job accessibility was concentrated mainly in the central city, such as Financial Street, Qianmen, and Chaowai sub-district within the Third Ring Road and the decrease in job accessibility was focused in the suburbs between the Fourth Ring and Fifth Ring roads. This pattern indicates that many residents migrated to the suburbs from the central city, but their worksites were still concentrated mainly in the central cities. For the entire metropolitan area, the differences in job accessibility between the north and south were clear, and the decreased job accessibility was mainly concentrated in the northern metropolitan area.

There is some spatial variation in the temporal change in job accessibility from 2000 to 2010 (Fig. 5b), but the spatial variation differs between 2000–2010 and 1990–2000. The zones where job accessibility increased lay primarily in the east Second Ring and Fourth Ring roads, which are in the Central Business District where there are more employment opportunities, such as Sanlitun and Chaowai sub-districts in Chaoyang District. Similar trends of decreasing job accessibility are found in the Jiangtai sub-district in Chaoyang District compared with 1990–2000. Another zone with clearly reduced job accessibility is the Gucheng sub-district in Shijingshan District, and this is largely because Capital Iron and Steel Company′s relocation led to a loss of jobs. Sub-districts with reduced job accessibility are located primarily in the suburbs and some town edges, whereas job accessibility in most of outlying suburbs is increasing. On the one hand, new town projects were proposed in the Beijing Master Plan 2004 that strengthened the polycentric structure in Beijing, and these have become important population centers of concentrated such as Dongxiaokou, Huilongguan in Changping District and Laiguangying–Wangjing in Chaoyang District. On the other hand, the agglomeration of the service industry inhibits the multi-centralization process present in the early diffusion brought on by the manufacturing industry, and the suburbs have experienced an imbalance between jobs and housing. Finally, because of the external migration of most enterprises in the inner city and the impact of polycentric policies, the outer suburbs have gradually become a new zone of industrial

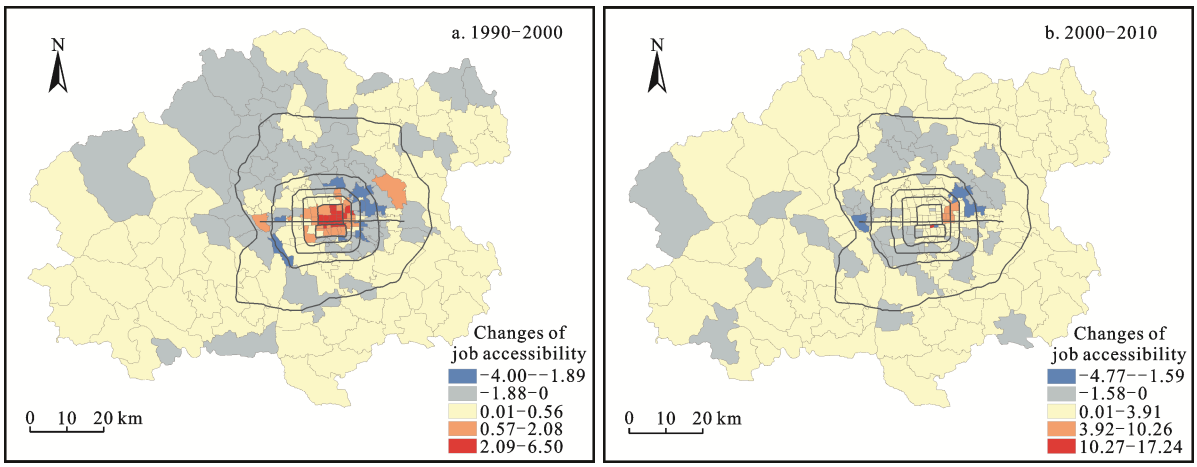

Fig. 5 Changes of job accessibility in Beijing Metropolitan Area (1990–2000 and 2000–2010)

centralization development with rising job accessibility. The government′s encouragement of the labor force to find work locally improves the relationship between residence and workplace to a certain extent. However, the differences between the inner city and outer suburbs remain important urban problems.

5 Discussion

The suburbanization process has profoundly altered a range of urban landscapes (Preston and McLafferty, 1999). In this paper, we choose Beijing as a case study and examine the evolution of the jobs-housing relationship. Our findings illustrate the changing dynamic between population density and employment density. Employment density displays a highly centralized pattern in Beijing, but population density still shows the decentralization trends. In the past two decades, the areas with high population density gradually shifted to the periphery from the old urban district, the population density of the inner city began to decrease under population dispersal policies, but the dispersal pressure remains strong. In addition, the outer suburbs have become sub-centers of population distribution and the new towns have played a positive role in receiving the migrant populations. Compared with the suburbanization of the population, the trend of employment decentralization is not clear.

The functional layout of Beijing leads to jobs staying concentrated in the urban center, but the construction of new towns with medical, education, cultural and commercial facilities and other urban service functions does not match, and is not enough to attract the population of the central city. As a result, population movement is not synchronized with jobs, which leads to a spatial mismatch between population and employment and generates continuing, long-term pressure on traffic and the environment. There are several possible reasons for this. For one thing, the jobs-housing relationship was influenced by urban planning. The City Master Plan in Beijing has been revised many times, affecting both the satellite towns and new towns, and aimed at transforming the urban spatial structure to a polycentric structure. However, urban planning frequently emphasizes the expansion of population and the increasing of efficiency, while failing to consider coordination between the industrial layout and city functions. This has led to the phenomenon in which population live in a residential area but work in an industrial zone, which in turn has led to the spatial mismatch between residence and employment. In addition, new towns have played an important role in population dispersal from the inner city, many of these new towns that have a single function are known as, for example, the industrial park or the sleeping city, with a more serious separation of housing and employment. Moreover, public service facilities such as public transportation, medical facilities, and education resources in the suburbs are often inadequate. For example, the population within the Third Ring Road accounts for approximately 30% of Beijing′ total, while the number of key elementary schools accounts for 70%, which means that the supply and demand of public service facilities does not match, leading to longer commutes and traffic congestion.

China has been subject to the interaction of its socialist planning system and its new market-orientated system, which has played an important role in determining the spatial structure of its cities. It is thus important to consider some other factors, such as floating population and traffic conditions, which also exert influence on the jobs-housing relationship. In 2013, the resident population was 2.115×10^7 in Beijing, with 8.03×10^6 residents belonging to the floating population, which represents the main factor contributing to growth in the resident population. However, most of the floating population does not receive equal treatment with regard to public services because of the restrictions of the *Hukou* (*Hukou* refers to the household registration system, which operates as a barrier to the migration between rural areas and urban areas in China. If one have not the *Hukou* in urban areas means that the resident can not enjoy many benefits such as education, health benefits) policy related to education and social welfare. The causes and mechanisms for spatial-mismatch problems are different for urban low-income residents than for floating populations. For households of low-income urban residents who were working in the old city centre because of its greater job opportunities, high prices prevent them from buying a flat. Additionally, the supply of low-income housing was controlled by the local government, which did not take into account the location and availability of services when assigning housing (Zhou S *et al*., 2013). This resulted in long-distance commutes between residences and workplaces. Compared with low-income urban residents, the floating population was primarily distributed in the urban-rural fringe where there are convenient transportation conditions and a ′village in the city′ in the districts of Haidian, Chaoyang and Changping, for example, and where they could be engaged in business services and small industries. The jobs-housing relationship of the floating population is complicated because of this different residential pattern. Generally speaking, the accumulation pattern of the floating population may be divided according to whether or not there is a complete reliance on the industry (Zhai and Hou, 2010). The first pattern results from a reliance on primarily one or two dominant industries that attract the floating population, with enough working and living space for them. These might develop, for instance, around a construction site or building materials market. In this pattern, living and working in the same compound, workers need only to commute on foot or by bicycle, and the jobs-housing spatial relationship is thus well balanced because of its shorter commuting distance and cheaper rents. However, with regard to quality of life, the floating population in this pattern has sacrificed much (e.g., environment and public security) in exchange for commuting efficiency. The second gathering pattern is similar to that of low-income urban residents in which the work is in the inner city by day and the residences are in the suburbs which are reached by public transit, leading to a spatial mismatch between home and workplace.

Some institutional factors, such as housing policy (including low-income housing and affordable housing) also influence the jobs-housing relationship. Public housing for low-income groups, provided by the government, determined their living space and caused forced commuting behavior. After the urban land reforms and urban housing reforms in the 1990s, commercial housing construction dominated by real estate developers provided the primary housing supply in Beijing (Zhang *et al.*, 2003). However, *danwei* compounds have not completely disappeared. Instead, with commodified residential communities, they coexist in the urban space, forming a pattern of concentrated employment and dispersed residence (Chai and Liu, 2003). For all housing types, policy-related houses have the lowest job accessibility, and this is the result of the current affordable housing policy, which has led to higher commuting costs for residents of policy-related housing (Liu *et al.*, 2009).

Improvements in traffic conditions may also cause changes in the jobs-housing relationship. People who have access to reliable rapid transportation can easily commute between home and work even if home is physically far from workplaces. On many levels, the spatial mismatch is a problem of mobility, and the availability of transportation determines the extent to which people are affected by it (Fan, 2012). For the majority of workers in China, public transit, electric bicycles, walking and buses are still the main commute mode, and traffic facilities differ in their convenience depending on their location, posing significant barriers to employment for different groups. Residents who choose different trip modes may thus have restrictions on their jobs-housing relationship (Zhou S et al., 2013; Zhou *et al.*, 2012).

6 Conclusions

Using spatial and temporal data in 1990, 2000 and 2010, we reanalyzed the job accessibility for the Beijing Metropolitan Area and evaluated the current spatial relationships between employment and residence.

By calculating changes in population density and employment density, different areas of the Beijing Metropolitan Area have been shown to exhibit distinct characteristics. The population in the central city has been declining, whereas the suburban population has continued to grow. In the central city, the concentration of employment persists and continues to have a highly centralized spatial structure.

The results reveal that job accessibility differs in different locations and time periods. A noteworthy finding is that mean job accessibility increased from 1990 to 2010, which may be related to the improvement in traffic conditions and the adjustment of urban planning in the past two decades. Still, our results indicate a spatial imbalance between jobs and housing in Beijing Metropolitan Area. The rising housing and land prices have led to more residents purchasing their house far away from their jobs, so the suburbs appear to be the primary area of residential and employment mismatch, while the towns in the outer suburbs have not yet demonstrated great potential to attract new jobs. Urban planning can to a certain extent change the jobs-housing relationship, however, as jobs and other public services are not synchronized with population movement, a stable and strong polycentric spatial structure has not yet formed.

The study has some limitations. We considered just the employed population and did not focus on the unemployed population (or new population) and vacant jobs (or new jobs). In addition, we chose the commuting distance thresholds to measure job accessibility with some possible limitations. Future research could go in two directions. The first is to improve the methods themselves in order to obtain better data. The extensive application of Location-Based Services information technology and social networks offer the possibility for obtaining individual spatial-temporal data at a large scale, and volunteered data provide a new channel to the understanding of urban spatial structures (Qin *et al.*, 2013), which improve on questionnaires and statistical data (Long *et al.*, 2012; Zhen *et al.*, 2012; Wang *et al.*, 2013). The second direction is to choose commuting time as a threshold to measure job accessibility. It is known, however, that job-accessibility is highly sensitive to different commuting-time thresholds (Kawabata and Shen, 2007).

There is great potential for further research on these topics, with a goal toward proposing public policies that can resolve the jobs-housing imbalance. A distribution strategy that moves the companies and factories to the suburbs from the central city may be effective. At present, the government has discussed the building of the Capital Vice Center in Tongzhou District and has proposed transferring the primary and secondary schools and municipal hospitals to Tongzhou to address the problem of excessive jobs and population density in the inner city.

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