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Changing Spatial and Structural Patterns of Non-agricultural Activities in Outward-moving Beijing Urban Fringe

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Abstract: As responses to metropolitan suburbanization and rural urbanization, the formation and evolution of urban fringes should be understood against the background of overall economic development and spatial reconstruction of entire metropolises. At the same time, however, endogenous interactions between industrial structure and spatial patterns of non-agricultural activities are also worthy of scholarly attention. Since the 1980s, studies on urban fringes in China have been restricted by the lack of micro-level data. This paper investigates the spatial expansion and structural evolution of the urban fringe by taking the case of Beijing and uses systematic firm-level data in 1996 and 2001 from the National Census of Basic Units. The diversity of distribution patterns across industrial sectors brings about two interrelated results. On the one hand, structural adjustment of non-agricultural industries promotes the expansion and spatial evolution of the urban fringe. On the other hand, the stability and dynamics of industrial structure coexist in the moving urban fringe. This study also reveals that the outward-moving urban fringe is the optimal location for manufacturing, especially heavy manufacturing, as well as traditional producer and consumer services. However, industries with spatial stickiness such as tourism and sports have not moved with the fringe. Most advanced services remain concentrated in the city center. The authors argue that it is essential for understanding and managing urban fringes to take into account spatial evolution and industrial structural adjustment together with their interaction with each other.

Keywords: urban fringe; industrial structure; spatial evolution; suburbanization; Beijing; China

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1 Introduction

The study of urban fringes has captured much attention from urban geographers and planners since Conzen and Whitehand′s work in the 1960s (Conzen, 1960; Whitehand, 1967). The definition and identification of urban fringes have been the focus of previous researches (Pryor, 1968; Gu and Xiong, 1989; Lesage and Charles, 2008; Cao *et al*., 2009). Related studies have concentrated on the spatial structure of fringes (Cui and Wu, 1990; Whitehand and Morton, 2004) and their evolution mechanisms (Wu and Ma, 1990). Many studies have also concentrated on their physical features from various perspectives, such as land-use dynamics (Bryant *et al*., 1982; Mori, 1998; Theobald, 2001), landscape patterns (Ichikawa *et al.*, 2006; Malaque and Yokohari, 2007), and farmland protection (Ryan and Walker, 2004). In practical terms, much effort has been spent by scholars, planners, and policy makers in seeking effective approaches to reduce conflicts in land use and disputes among land users, and to solve the problems caused by economic development and population growth in the urban fringes (Reganold and Christensen, 1986; Whitehand and Morton, 2004). Gallent *et al.* (2006) argued that planning could do more to 'manage' the fringe and create new social, economic, and environmental oppor-

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tunities. However, based on a case study, Qvistrom (2007) provided evidence for conflict between the unordered urban fringe and the ambitions within spatial planning to create order, implying the opposition to excessive administrative intervention in these complicated areas. In essence, the development of non-agricultural industries should be the core driving force of urban fringe formation and evolution. Nevertheless, existing literature from this aspect has been limited to agriculture and tourism (Harrison, 1983; Song and Ma, 2002; Su *et al.*, 2004). Partly owing to the lack of systematic micro-level data, scholarly light has been shed only on industrial structure or spatial patterns of manufacturing and services.

Urban sprawl brings about a series of problems in society, environment, land use, and space management on the edge of the city. Urbanization of suburbs is also intensive near urban centers. As the two forces of suburbanization and urbanization coexist in the interconnected belt, the urban fringe of Beijing has been investigated constantly. The first systematic research on the Beijing urban fringe by Cheng and Zhao (1995) identified its boundary and divided it into several kinds of sectors by using remote sensing images. This pioneering work also inspected the expansion history and directional diversity of the fringe belt. The following studies have mainly focused on the spatial identification, land use, and ownership of the Beijing urban fringe, describing the expansion process and summing up the expansion mode in the Beijing metropolitan area (Lin *et al.*, 2007; Wu *et al.*, 2008; Kuang, 2012). Specifically, Lu *et al.* (2005) provided an analysis of the floating population in the urban fringe areas and explored their role in the formation and evolution of local industrial development. In addition, strategies have also been laid down to guide and optimize land use and management (Zong *et al.*, 2002).

The outward movements of the urban fringe are determined to a large extent by the scale and structure of non-agricultural industries which, in turn, have remarkable effects on its internal spatial patterns. The remainder of this paper is organized as follows. The next section of this paper discusses the relationship between outward movement of the urban fringe and evolution of its internal spatial and structure patterns in the context of rapid urbanization in developing countries. Taking Beijing as the case city, we will firstly profile the expansion of the Beijing urban fringe and describe the data sources used in our research. Secondly, a series of indices are introduced to measure the industrial structures and spatial patterns of non-agricultural sectors in the fringe. Thirdly, by using these indices, we conduct an empirical data analysis to explore the spatial patterns of the Beijing urban fringe and their evolution as a consequence of the changing industrial structure. Finally, we investigate the stability and dynamics of the industrial structure in the outward moving Beijing urban fringe and conclude this paper with a summary of major findings and a discussion on driving forces behind the expansion of the Beijing urban fringe.

2 Understanding Spatial and Structural Change in Urban Fringes

With scale and agglomeration economies, metropolitan areas in post-reform China since the 1980s have attracted numerous types of economic resources such as domestic and foreign investment and large numbers of migrants from rural areas. On the one hand, large cities increase faster than smaller ones and play a more important role in the urban system. The inevitable results include rapid expansion of urban land and suburbanization in the metropolitan areas led by industrial enterprises moving from the city center to the periphery. On the other hand, urbanization in China is also promoted by rural industrialization and other forces from below (Ma and Fan, 1994). Urbanization on the city edge is much faster than that in outlying areas of metropolises because of its proximity to the city center. The result of interactions between these two forces, namely suburbanization and urbanization, is the emerging *desakota* or peri-urban areas in metropolitan areas (Webster, 2002). We also prefer to take the view that Chinese urban fringes should be understood in the urbanization context of China.

The forming process, evolution, and possible effects of urban fringes should be interpreted in the macro milieu of development of metropolitan areas as a whole. Since the mid-1980s, tens of millions of ′peasants′ (or more precisely, agricultural *hukou* (household registration) holders) have flowed into coastal metropolitan regions. These new urban residents tend to live in the urban fringe areas with lower rent and less discrimination than city centers, where they rent rooms to do business

or find nearby jobs (Zhang, 2001; Fridemann, 2005; Liu and Cao, 2011). Fringes with this special group of workers have resulted in a proliferation of cheap labor, growth of market demands for living services, and expansion of non-agricultural activities. At the same time, the administrative assignment and free use of urban land have been replaced gradually by conveyance and paid use. Many enterprises with large-scale patrimonial land in the city center gained through administrative transfer began to sell their land use rights at a high price and moved to suburbs with cheap land (Zhou, 1996). Owing to the poor access to transportation and public services, outer suburban districts are not appropriate locations for enterprises either. As a consequence, urban fringes become the optimal location for outward-moving enterprises and the first beneficiaries of urban land marketization. While a large number of manufacturing enterprises have concentrated in urban fringes to maximize their benefits, advanced services with abilities to pay higher rents have got the chance to acquire locations in city centers. The result is a win-win model in which maximization of land utility is achieved simultaneously both in city centers and in urban fringes. A further implication is that the development of the urban fringe, driven mainly by the development of the entire metropolitan area, has in turn promoted the overall industrial structure of the metropolis.

The growth and relocation of non-agricultural activities initiated by manufacturing factors fundamentally bring about the formation and expansion of the urban fringe. Once the market forces are allowed to allocate resources aiming to achieve higher economic efficiency, urban spatial expansion would become an inevitable result for all cities, no matter whether they are in the process of urbanization or suburbanization (Ding, 2005). Therefore, the inner belt of a fringe is certain to become part of the city center, and the urban fringe will gradually expand outward. In this process of suburbanization in metropolitan areas, manufacturing is generally the leading industry (Archer and Smith, 2003). Meanwhile, the initial stage of rural industrialization and urbanization is usually instigated by manufacturing enterprises as well. As a result, manufacturing plays a dominant role in urban fringes and maintains a stable comparative advantage with respect to the city center.

Given the various spatial preferences across various industrial sectors, the industrial structure of non-agricultural activities in the entire metropolis has essential impact on the changing location of urban fringes as well as their internal spatial structures. Some industries tend to agglomerate within finite locations while others disperse. Highways are the most advantageous locations for some industries (Baum-Snow, 2007). Nevertheless, enterprises such as universities, government departments, or public services prefer locations with more residents or more scenic outlooks (Levernier and Cushing, 1994; Aji, 1995; Gong and Wheeler, 2002). The dominant industries, along with the diversity of industrial structure in a metropolitan area will determine the spatial structure of a whole region and further shape its urban fringe in terms of industrial structure and basic spatial patterns. The improvement of the industrial structure of the city will also be reflected, directly or indirectly, in the spatial and industrial characteristics of the fringe belt. The internal spatial structure of urban fringes is also the spatial representation of industries located there. The ebb and flow of industries is the primary cause of spatial evolution of urban fringes.

Although the industrial structure of urban fringes might change with their outward movement, a certain consistency will remain. In the outward moving process of urban fringe, leading industries usually settle at the outer edge of the fringe. When related industries follow them to move out from the city center or rise around them from zero, the outer edge starts to show features of a middle belt. From the perspective of industrial structure, some sectors are mostly located in the middle of the belt, while others prefer inner or outer edges in the process of city expansion. However, some industries are reluctant to move outward with the urban fringe expansion, because they depend greatly on the core resources, or have a high proportion of fixed cost. The inevitable response to these two spatial evolution patterns of various industries is the co-existence of stability and dynamics of industrial structure in the moving urban fringe.

3 Data and Methods

3.1 Study area and data sources

Beijing (39°28'–41°05'N, 115°25'–117°35'E) is located in the northern part of the North China Plain with a total area of 16 807 km^2, 60% of which is hills (Fig. 1). As the political, cultural and economic center of China, the

industrial development in Beijing and its spatial patterns have attracted much scholar attention. However, the lack of micro-level data has long restricted the accurate quantitative investigation into industrial activities in Beijing. Fortunately, National Census of Basic Units (NCBU) in 1996 and 2001 provide an opportunity to systematically inspect the internal characteristics of non-agricultural activities in the urban fringe, including their industrial structure, spatial patterns, and their change and interaction with each other.

The NCBU data reveal various attributes of all enterprises, inclusive of their locations, four-digit industrial classification codes, the number of employees and ownership. This paper focuses only on the manufacturing and service enterprises, excluding all enterprises in mining and quarrying, which fundamentally depend on spatial distribution of natural resources, and electricity, gas, and water production and supply enterprises, which are greatly influenced by government or other non-market forces.

We first set up a database dividing the Beijing Metropolitan area into 161 postal zones (Fig. 1). Then the firm-level data were combined at the postal zone level and connected to the spatial database. The integrated database provided primary data for identifying the urban fringe and inspecting its internal characteristics.

With the most intensive interaction of urban and rural activities, the urban fringe is a quite dynamic area. The layer structure and ′annual ring′ expansion have long been observed (Gu *et al.*, 1993). Nevertheless, limited by the availability of micro-level data and the spatial fuzziness of the fringe, existing studies have been mainly confined to qualitative descriptions. Cao *et al.* (2009) proposed an identification method from a perspective of the density and structure of non-agricultural activities and proved its effectiveness by applying it to the Beijing metropolitan area with the NCBU data. Based on the defined urban fringe of Beijing in 1996 and 2001, they have investigated the layer structure by accurate quantitative analysis. The ratio of service employment to manufacturing (S/M) was employed as the pivotal index in urban fringe identification (Cao *et al*., 2009), and is also the key indicator to describe the layer structure and expansion process in this paper (Fig. 2 and Table 1). This paper takes Cao′s definition of Beijing urban fringe as the study area (Cao *et al*., 2009), covering an annular region from the 3rd to 6th ring road of Beijing (Fig. 2).

3.2 Measures of industrial distribution

Regional competitive industries are generally defined from two perspectives: absolute advantage and comparative advantage. Manufacturing sectors in the urban fringe provide products for the metropolitan, national, and even global markets, but they have little connection with local businesses or residents. In order to evaluate the importance of a manufacturing sector in urban fringes, it is necessary to compare its absolute advantage over others defined by the Employment Contribution Index (ECI):

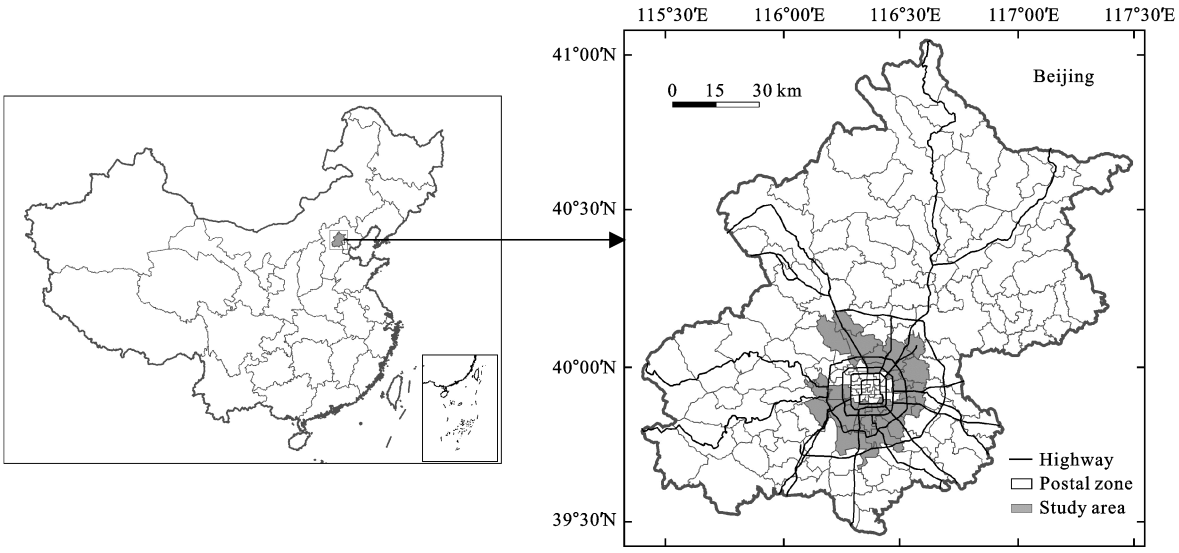
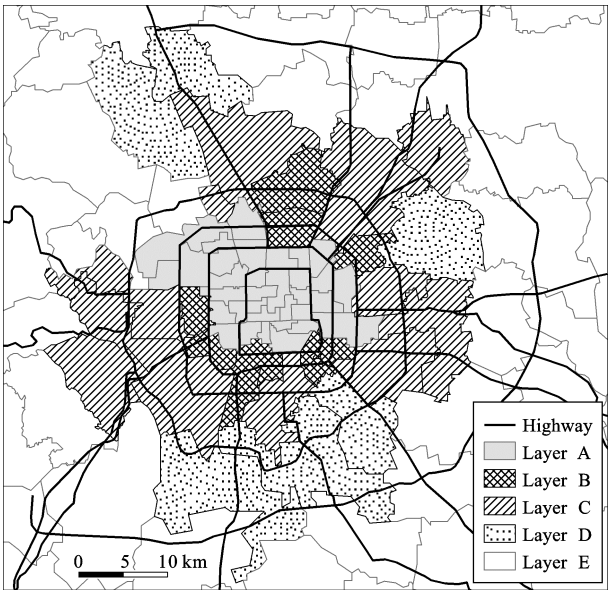


Fig. 1 Location of study area



Source: Cao *et al.* (2009)

Fig. 2 Spatial identification and expansion of Beijing urban fringe in 1996–2001

$$ECI_i = \frac{EMF_i}{EMF} \times 100\% \quad (1)$$

where ECI_i represents the *ECI* of sector *i* to total manufacturing employment in the urban fringe; *EMF* is the total manufacturing employment in the urban fringe; and EMF_i is the employment of sector *i* in the urban fringe.

In contrast with manufacturing, target markets of service sectors are mostly restricted to the urban fringe. Considing the dominant effects of local businesses and residents on service sectors, the Location Quotient (LQ) is employed to indicate the comparative advantage of a service sector, which is quantified as:

$$LQ_i = \frac{ESF_i / ESF}{ES_i / ES} \quad (2)$$

Where LQ_i is the *LQ* of sector *i*; ESF_i and *ESF* are employment of service sector *i* and all service sectors in the urban fringe; and ES_i and *ES* represent the total employment of service sector *i* and all service sectors in the metropolis.

As one of the most popular indices measuring the geographical concentration of industries, the Gini Coefficient (G_i) is defined as follows:

$$G_i = \frac{1}{2n^2\mu}\sum_{j=1}^{n}\sum_{k=1}^{n}\left|s_{ij} - s_{ik}\right| \quad (3)$$

where s_{ij} is share of employment of region *j* in sector *i*; s_{ik} is the share of employment of region *k* in sector *i*; μ is the average share of all regions; *n* is the number of regions.

4 Results and Analyses

4.1 Spatial patterns and their changes

4.1.1 Outward-movement of Beijing urban fringe

With the highest density of non-agricultural activities, the city center (Layer A in Fig. 2, Table 1) has a notable and increasing advantage in service sectors. During the period of 1996–2001, the comparative advantage of services indicated by S/M increased from 3.4 to 9.5. Employment density of non-agricultural industries in the inner belt of the urban fringe doubled in the 5-year period and nearly reached the initial level of the urban center area. Together with the manufacturing decline, the rapid growth of service employment immensely enhanced the S/M value from 2.1 to 5.0, which surpassed the initial city center level. For these reasons, the inner belt of the urban fringe in 1996 could be identified as a new part of the city center by 2001 (Layer B). Non-agricultural employment in other areas of the urban fringe also doubled in the same period. However, owing to its low initial level, non-agricultural employment density in these areas was still only 2249 per km^2 in 2001. Although the S/M experienced a jump from 0.9 to 1.9, what it showed was still the typical characteristic of urban fringes (Layer C). Some outlying areas with rapid development of non-agricultural industries (especially manufacturing) were involved in the 2001 urban fringe (Layer D), because their employment density (400 per km^2) and S/M (1.0) were both quite close to the threshold of urban fringes. However, the non-agricultural industries in most rural areas were still very limited (Layer E).

4.1.2 Spatial change of manufacturing

While the urban fringe has been identified with a common standard, non-agricultural activities were far from evenly distributed in 1996. At the macro level, employment density of manufacturing was higher in the south, west, and inner belts than those in the north, east, and outer belts in 1996 (Fig. 3). At the micro level, a large proportion of manufacturing employment concentrated in several specific locations, which could be defined as manufacturing centers and sub-centers. In detail, 26.2%

Table 1 Changes of layer structure of Beijing urban fringe in 1996–2001

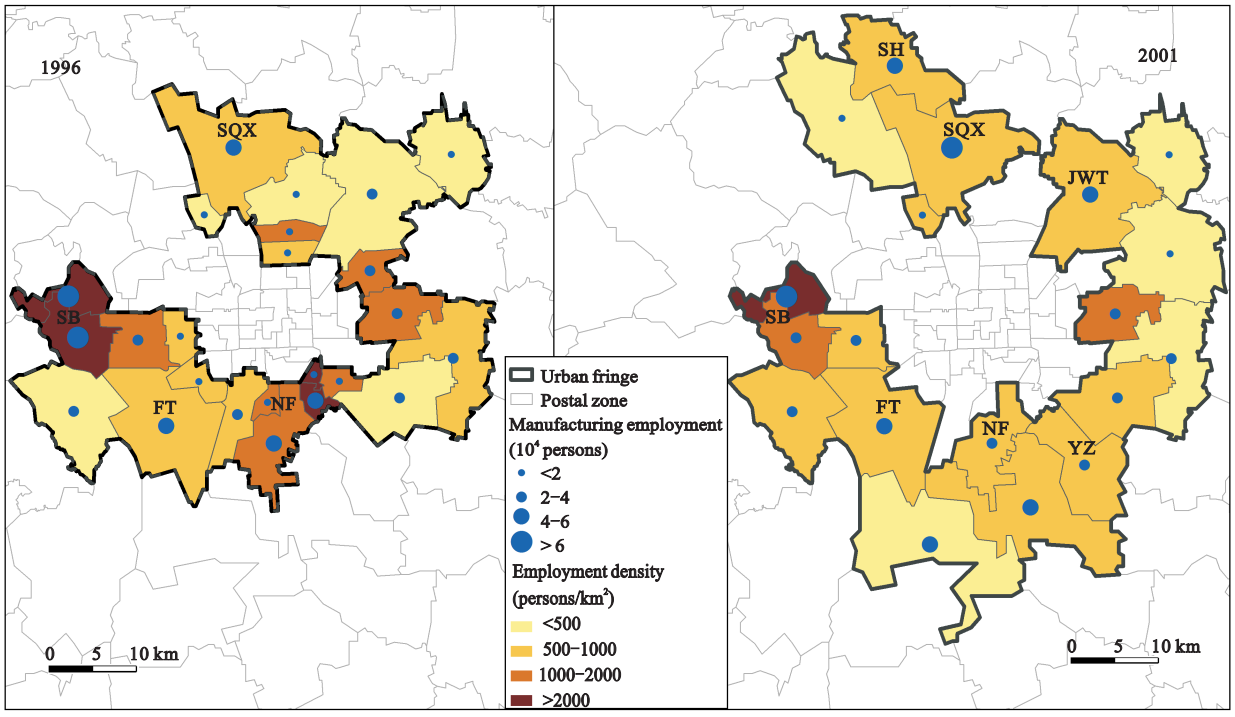
Layer	Identification		Non-agricultural employment density (persons/km^2)		S/M index	
	1996	2001	1996	2001	1996	2001
A	City center	City center	9641	17459	3.4	9.5
B	Urban fringe	City center	3809	7152	2.1	5.0
C	Urban fringe	Urban fringe	1504	2249	0.9	1.9
D	Outlying area	Urban fringe	393	733	0.7	1.0
E	Outlying area	Outlying area	84	123	0.8	1.3

Note: S/M index is ratio of service employment to manufacturing

of the total manufacturing employment in the fringe was concentrated in the major center with Shoudu Iron & Steel Co. and Badachu High-Tech Park (SB) in the western suburb, where the highest manufacturing employment density was also located. With a total share of 25% of the manufacturing employment, the Shangdi-Qinghe-Xisanqi Region (SQX), Nanyuan-Fangzhuang Region (NF), and Fengtai Economic-Technological Development Zone (FT) were defined as sub-centers (Fig. 3).

The spatial evolution of Beijing urban fringe happened in two ways in the 5-year period. The first model showed that the SQX region enhanced its advantage and extended its territory to the adjacent outer Shahe Region (SH). Another form of outward expansion was the simultaneous decrease of employment in the traditional centers and growth in their outer neighbors, indicating the outward movement of manufacturing centers and the urban fringe. Typical examples were the SB and NF. Most of these former centers experienced a serious decline from 10% to 40%, especially in the southern NF region.

In general, the spatial unevenness of manufacturing in the Beijing urban fringe had weakened greatly in 2001. The rapid growth of manufacturing in the SH region. Jiuxianqiao-Wangjing-Tianzhu Region (JWT), Beijing



1) The tinted areas are urban fringes in 1996 and 2001, which are analyzed and compared in the main text. The blank areas are other postal zones in Beijing, of which the economic activities will not be analyzed in this study. 2) SB: Shoudu Iron & Steel Co. and Badachu High-Tech Park; SQX: Shangdi-Qinghe-Xisanqi Region; NF: Nanyuan-Fangzhuang Region; FT: Fengtai Economic-Technological Development Zone; SH: Shahe Region; JWT: Jiuxianqiao-Wangjing-Tianzhu Region; YZ: Beijing Economic-Technological Development Area in Yizhuang

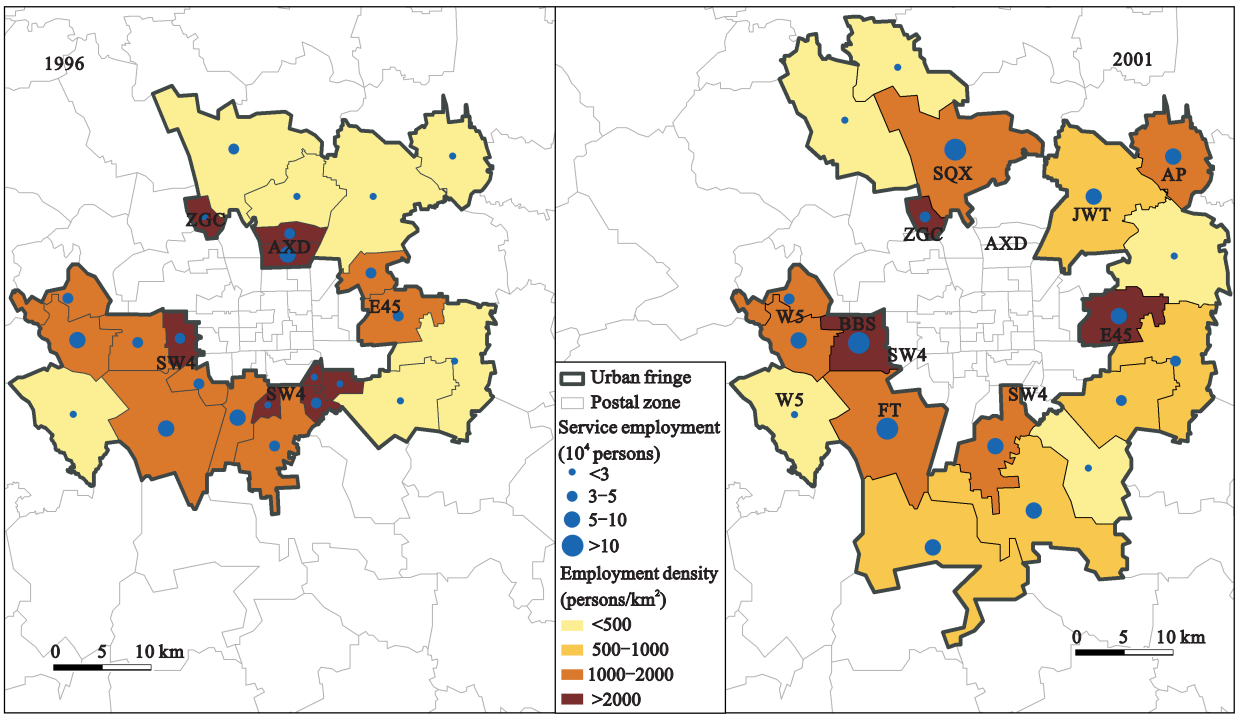
Fig. 3 Changing spatial patterns of manufacturing from 1996 to 2001

Economic-Technological Development Area in Yizhuang (YZ), and brought about dramatic industrial growth in the northwestern, northeastern, and southeastern suburbs, where there had been few manufacturing enterprises in 1996. This resulted in an equalizing trend of manufacturing spatial distribution. The geographical concentration of manufacturing indicated by the Gini Coefficient fell from 0.40 to 0.32. As illustrated in Fig. 2, the spatial imbalance of the urban fringe′s manufacturing was weakened between the inner and outer belt and almost disappeared in many locations.

4.1.3 Spatial change of services

Differences in the nature of services and manufacturing have led to distinct characteristics of their spatial distribution in the urban fringe. In 1996, services in the Beijing urban fringe showed significant patterns of layer distinction and polarization among postal zones. A large amount of service employment was located in the Asian Games Village-Xiaoguan-Datun Road Region (AXD) and Zhongguancun (ZGC) between the North 3rd and the North 5th Ring Roads. That region, together with the area between the East 4th and 5th Ring Roads (E45), and the southern and western regions within the 4th Ring Road (SW4), formed the service-intensive inner layer of the fringe. The density of service employment was higher than 2500 employees/km^2 in the inner layer, while it was lower than 500 employees/km^2 in almost all postal zones in the outer layer (Fig. 4).

In contrast to the equalization process of manufacturing, the spatial distribution of services was very concentrated in this period. The first reason was the varying trends of service development in different parts of the former outer layer. In some areas, following the rapid growth in manufacturing and population, service industries increased more than threefold, and thus new service centers appeared in Babaoshan (BBS), FT, the airport region (AP), part of E45, and the north belt from SQX to JWT. In contrast, services stagnated in the wide area beyond the West 5th Ring Road inclusive of Xiangshan in Haidian District, Shijingshan District, and west of the Yongding River in Fengtai District (W5). The other reason for the concentration of services was



1) The tinted areas are urban fringes in 1996 and 2001, which are analyzed and compared in the main text. The blank areas are other postal zones in Beijing, of which the economic activities will not be analyzed in this study. 2) AXD: Asian Games Village-Xiaoguan-Datun Road Region; E45: Area between the East 4th and 5th Ring Roads; ZGC: Zhongguancun; SW4: southern and western regions within the 4th Ring Road; BBS: Babaoshan; SQX: Shangdi-Qinghe-Xisanqi Region; FT: Fengtai Economic-Technological Development Zone; JWT: Jiuxianqiao-Wangjing-Tianzhu Region; AP: the Airport Region; WO5: the wide area beyond the West 5th Ring Road inclusive of Xiangshan in Haidian District, Shijingshan District, and west of the Yongding River in Fengtai District.

Fig. 4 Changing spatial patterns of services from 1996 to 2001

the very limited scales of services in new entrants of the fringe with comparative advantage in manufacturing. The concentration trend led to an increase in Gini coefficient of service sectors from 0.27 to 0.37, which surpassed that of manufacturing. Furthermore, with the industrial structural adjustment and relocation of the urban fringe, the inner layer with well-developed service industries such as the AXD, SW4, and part of the E45 region evolved into part of the city center in 2001.

4.2 Structural change of non-agricultural activities

The urban sprawl of the Beijing metropolitan area has been evidenced by both the declining density of non-agricultural activities in the urban fringe and the rising contribution of outlying areas to the metropolitan development. Although the Beijing urban fringe moved outward in the study period of 1996–2001, the number of employees in the fringe increased from 1 536 000–1 857 000 or by 20.9% (Table 2). However, the area of the urban fringe expanded even faster. As a result, the employment density declined by 22.9% from 1945 employees/km^2 to 1499 employees/km^2. The density of employment in the urban center and outlying areas increased in the same period (Table 2). The ratio of non-agricultural employment density in the urban fringe to that in the urban center declined from 20.3%–11.6%, and its comparative advantage over the outlying areas dropped from 19.3–11.6 at the same time. The high-quality, low-price supply of suburban cultivated land has led to an extensive expansion of industrial plants and an increasing role of outlying areas in metropolitan development.

While employment in the manufacturing industries was outstripped by service sectors in the Beijing urban fringe, the manufacturing advantage of urban fringe comparing with the entire metropolitan area was strengthened. In 1996, there were 694 132 employees in the manufacturing sector in Beijing urban fringe, accounting for 45.2% of the total non-agricultural employment in this region. At that time, the proportion was only 39.0% in the entire metropolis and 22.8% in the urban center. Five years later, the manufacturing employment in the urban fringe had increased to 715 811, but its share in non-agricultural employment had decreased to 38.6%. In contrast, the employment in service sectors increased rapidly. Despite the more intensive industrial structural adjustment in the entire metropolis and a faster decline of manufacturing as well as more rapid growth in services, the comparative advantage of manufacturing was still maintained in the urban fringe (Table 3).

4.2.1 Manufacturing structure

Technology- and capital-intensive industries were the mainstays of non-agricultural activities in the urban

Table 2 Spatial changes of non-agricultural employment in Beijing metropolitan area

	Employment (10^6 persons)				Employment density (10^3 persons/km^2)			
	1996	2001	1996–2001	%	1996	2001	1996–2001	%
Urban center	2.14	4.84	2.70	126.2	9.64	12.98	3.33	34.6
Urban fringe	1.54	1.86	0.32	20.9	1.95	1.50	–0.45	–22.9
Outlying area	1.48	1.76	0.27	18.4	0.10	0.12	0.02	24.0
Metropolis total	5.16	8.45	3.30	63.9	0.31	0.52	0.20	64.0

Table 3 Composition of non-agricultural employment and its change between 1996 and 2001

		Mamufacturing		Service	
		Employment (10^3 persons)	Percent (%)	Employment (10^3 persons)	Percent (%)
1996	Urban center	489	22.8	1653	77.2
	Urban fringe	694	45.2	841	54.8
	Outlying area	831	56.1	651	43.9
	Total	2013	39.0	3145	61.0
2001	Urban center	548	11.3	4294	88.7
	Urban fringe	716	38.6	1141	61.4
	Outlying area	802	41.1	1150	58.9
	Total	2066	23.9	6585	76.1

fringe. Mechanical and electronic industries such as general machinery, special purpose machinery, transport equipment, electronic and telecommunications, and electrical machinery and equipment were among the top 10 industries in terms of employment. Their total employment was more than 35% of all manufacturing sectors. Ferrous metal smelting and rolling maintained the first place with an employment contribution of 14.6% in 1996 and 13.1% in 2001. In addition, the non-metal mineral products and metal products provided 6.5% and 5.8% of the total manufacturing employment (Table 4).

There are two reasons for this feature of industrial structure in the Beijing urban fringe. First, with high consumption of energy, water, and land resource, along with severe environmental pollution, heavy manufacturing tends to locate or relocate in the urban fringe with easy availability of such resources and lower environmental standards. The other reason for the heavy-industry-dominated structure of manufacturing is the synchronism of heavy industrialization and suburbanization in the entire metropolis. In a general sense, most cities start their industrialization process from light industries. When heavy industrial enterprises search for locations, the urban center has usually been filled up. Therefore, the city edge or suburb becomes the best choice, if not the only one, for them.

By listing and comparing the top 10 sectors in manufacturing in terms of their employment scale, Table 4 suggests that the manufacturing structure was relatively stable in the urban fringe of Beijing in the period 1996–2001. Although the fringe-belt experienced an outward movement of approximately 2.5 km during this period, only one of the manufacturing industries fell outside the top 10 and was replaced by another sector. The former was chemical materials and chemical products, which was the 10th largest manufacturing sector in 1996 with employment contribution index (ECI) of 3.6%, and the latter was clothing and other fiber products, which ranked the ninth in 2001 with an ECI of 4.3%.

Within the top 10 sectors, some relatively advanced industries grew faster while others slower in the period when relevant sectors with less value-added declined. The electronic and telecommunications and transport equipment showed an increase of 3.0 and 2.4 percentage points in ECI and were the fastest expanding industries, while the special purpose machinery and general machinery sectors became the two most declining indus-

Table 4 Top 10 manufacturing industries and their employment contribution indices (ECI)

	Rank	Manufacturing sector	Employment (10^3 persons)	Employment contribution index (%)
1996	1	Ferrous metal smelting and rolling	101.3	14.6
	2	Special purpose machinery	70.1	10.1
	3	Transport equipment	57.3	8.3
	4	General machinery	52.0	7.5
	5	Electronic and telecommunications	50.3	7.2
	6	Non-metal mineral products	45.0	6.5
	7	Metal products	40.3	5.8
	8	Textile industry	38.4	5.5
	9	Electrical machinery and equipment	37.8	5.4
	10	Chemical materials and chemical products	24.7	3.6
2001	1	Ferrous metal smelting and pressing	93.6	13.1
	2	Transport equipment	76.3	10.7
	3	Electronic and telecommunications	73.3	10.2
	4	Non- metal mineral products	49.6	6.9
	5	Metal products	45.8	6.4
	6	General machinery	36.8	5.1
	7	Special purpose machinery	33.9	4.7
	8	Electrical machinery and equipment	33.4	4.7
	9	Clothing and other fiber products	31.0	4.3
	10	Textile industry	29.0	4.0

tries with shrinkage in ECI of 5.4 and 2.3 percentage points respectively. The ECI of ferrous metal smelting and rolling decreased by 1.5 percentage points, whereas that of metal products increased by 0.6 percentage points. The ECI of the textile industry declined from 5.5% to 4.0%, while that of the clothing and other fiber products rose by 1.8 percentage points to exceed the former. These facts indicate the updating of the manufacturing structure notwithstanding the outward movement of the urban fringe.

4.2.2 Service structure

Owing to the rapid development of manufacturing in the urban fringe, service industries closely associated with manufacturing became the dominant sectors there. Transport and storage were leading services with the highest comparative advantage measured by Location Quotient (LQ), and leasing services, which were mainly composed of machinery and equipment leasing, grew rapidly as well (Table 5). The LQs of these low-end producer services increased by 0.4–3.1. Additionally, the wholesale trade at the city edge gradually benefited from the advanced transportation system and its proximity to the city.

With low entry barriers and ubiquitous distribution, personal services such as retailing, hotels, catering, and recreational services usually play leading roles in the process of suburbanization of services and the outward movement of urban fringes. Since these industries essentially depend on the volume of employment and residents, their LQs remained stable at around 1.0 during the 5 years.

In contrast with low-end producer and individual services, advanced producer services such as finance, insurance, consulting, and business broking were still highly concentrated in the urban center and inner belt of urban fringe. As the urban fringe moved outward, the LQs of advanced services and real estate development decreased by 0.3–1.0, indicating that decentralization of advanced producer services did not happen in Beijing. Hence the inner fringe belt with rapid development of such services soon evolved to be part of the urban center. This result is in accord with what was proposed in a special study by Zhao (2007).

The spatial stickiness of some industries as a consequence of immobility of core resources or facilities was the root cause for structure evolution of services. There were numerous tourist attractions consisting of both

Table 5 Top 10 service sectors in Beijing urban fringe

	Rank	Service sector	Employment (person)	Location quotient
1996	1	Storage	8157	1.97
	2	Sports	4737	1.91
	3	Air transport	560	1.79
	4	Real estate development and operation	17268	1.70
	5	Highway transport	25231	1.68
	6	Transport supporting and auxiliary services	15299	1.63
	7	Leasing services	4622	1.60
	8	Waterway transport	58	1.46
	9	Tourism	6192	1.31
	10	Wholesale trade of energy, materials and electronic equipment	56100	1.28
2001	1	Air transport	49073	4.87
	2	Storage	11460	3.22
	3	Highway transport	20791	2.08
	4	Leasing services	13084	2.02
	5	Transport supporting and auxiliary services	11273	1.73
	6	Other transport	487	1.50
	7	Geological prospecting	2286	1.45
	8	Social welfare	3273	1.38
	9	Other wholesale trade	14001	1.22
	10	Education	93756	1.22

historical and cultural landscapes and natural scenery in the inner suburbs of Beijing. This service structure was an obvious advantage for tourism in 1996. Because of the spatial stickiness of these resources, however, the superiority of tourism disappeared when the urban fringe moved outward in 2001. The LQ of tourism fell from 1.31 to 0.23. Similarly, immobility of sports facilities brought about a remarkable decline of sports services in the outward-moving urban fringe. In addition, education and scientific research lost some of their outstanding advantage because of both the immobile facilities and cultural milieu in the city center and the inner edge. The construction of college towns in the outer suburbs such as Changping and Fangshan has also weakened the fringe′s comparative advantages in these industries.

5 Discussion and Conclusions

Taking Beijing metropolitan area as a case study, this paper has shed light on the spatial and structural evolution of the urban fringe and revealed some interesting features that might also be applicable to other large Chinese cities. The Beijing urban fringe has moved outward, characterizing a layer pattern and a layer structure. During the study period between 1996 and 2001, the spatial imbalance of manufacturing was weakened between the inner and outer belts, and even disappeared in some parts through the ebb and flow of manufacturing centers. In contrast, the spatial patterns of services changed from regional unevenness in general and homogeneity in sub-regions to a high agglomeration within finite locations. The changing internal spatial structure of the fringe is greatly influenced by the dynamic industrial structure created by various growth speeds across sectors with different location preferences.

As the leading industry of both suburbanization and urbanization, manufacturing (especially heavy manufacturing), with high consumption of energy, water, and land resources as well as heavy pollution, maintained its stable comparative advantage in the outward-moving urban fringe. Its internal structure was relatively stable but gradually adjusted in the Beijing urban fringe. At the same time, manufacturing-related services and living services also developed rapidly and maintained their advantages in the outward-moving fringe. However, industries such as tourism and sports had no motivation to move outward. Most advanced services still remained concentrated in the city center. The diversity of distinct spatial patterns across industrial sectors has resulted in the co-existence of stability and dynamic in the industrial structure in the outward-moving urban fringe.

Two perspectives in understanding urban fringe development have been proposed and demonstrated to be effective in our case study. First, urban fringes, in which industrialization and urbanization of rural areas and suburbanization of central cities co-exist and interact intensively and generate all sorts of conflicts, are formed in the context of overall economic development and spatial reconstruction of entire metropolises. In turn, industrial development in urban fringes has significant effects on the economic expansion and spatial reconstruction of metropolitan areas. Therefore, the formation and evolution of fringes in China should be understood in the wider background of metropolitan development. Second, the authors argue the significance of the interaction between spatial evolution and structural change of non-agricultural activities in this process. Thus we appeal for a combined action of spatial optimization and industrial structure adjustment in solving economic, spatial, and social problems in urban fringes.

References

Aji M A, 1995. Intra-metropolitan productivity variations of selected manufacturing and business service sectors: What can we learn from Los-Angeles? *Urban Studies*, 32(7): 1081–1096. doi: 10.1080/00420989550012582

Archer W R, Smith M T, 2003. Explaining location patterns of suburban offices. *Real Estate Economics*, 31(2): 139–164. doi: 10.1111/1540-6229.00061

Baum-Snow N, 2007. Did highways cause suburbanization? *The Quarterly Journal of Economics*, 122(2): 775–805. doi: 10.1162/qjec.122.2.775

Bryant C R, Russwurm L H, Mclellan A G, 1982. *The City's Countryside, Land and Its Management in the Rural-Urban Fringe*. Addison-Wesley: Longman Group Limited.

Cao Guangzhong, Miao Yangbing, Liu Tao, 2009. Seeking a method for identifying the urban fringe spatially based on industrial activities: A case study of Beijing. *Geographical Research*, 28(3): 771–780. (in Chinese)

Cheng Liansheng, Zhao Hongying, 1995. Discussion on the city border area of Beijing. *Journal of Beijing Normal University*, 31(1): 127–133. (in Chinese)

Conzen M R G, 1960. Alnwick, Northumberland: A study in town-plan analysis. *Transactions and Papers* (*Institute of British Geographers*), (27): 1–22

Cui Gonghao, Wu Jin, 1990. The spatial structure and development of Chinese urban fringe. *Acta Geographica Sinica*, 45(4): 399–411. (in Chinese),

Ding Chengri, 2005. Economic mechanism for urban spatial expansion. *City Planning Review*, 29(4): 56–60. (in Chinese)

Friedmann J, 2005. *China's Urban Transition*. Minneapolis: University of Minnesota Press.

Gallent N, Bianconi M, Andersson J, 2006. Planning on the edge: England's rural-urban fringe and the spatial-planning agenda. *Environment and Planning B-Planning & Design*, 33(3): 457–476. doi: 10.1068/b31171

Gong H M, Wheeler J O, 2002. The location and suburbanization of business and professional services in the Atlanta metropolitan area. *Growth and Change*, 33(3): 341–369. doi: 10.1111/1468-2257.00194

Gu Chaolin, Chen Tian, Ding Jinhong *et al*., 1993. The study of the urban fringes in Chinese megalopolises. *Acta Geographica Sinica*, 48(4): 317–328. (in Chinese)

Gu Chaolin, Xiong Jiangbo, 1989. On urban fringe studies. *Geographical Research*, 8(3): 95–101. (in Chinese)

Harrison C, 1983. Countryside recreation and London′s urban fringe. *Transactions of the Institute of British Geographers*, 8(3): 295–313

Ichikawa K, Okubo N, Okubo S *et al.*, 2006. Transition of the Satoyama landscape in the urban fringe of the Tokyo metropolitan area from 1880 to 2001. *Landscape and Urban Planning*, 78(4): 398–410. doi: 10.1016/j.landurbplan.2005.12.001

Kuang, Wenhui, 2012. Spatio-temporal patterns of intra-urban land use change in Beijing, China between 1984 and 2008. *Chinese Geographical Science*, 22(2): 210–220. doi: 10.1007/s11769-012-0529-x

Lesage J P, Charles J S, 2008. Using home buyers' revealed preferences to define the urban-rural fringe. *Journal of Geographical Systems*, 10(1): 1–21. doi: 10.1007/s10109-007-0055-z

Levernier W, Cushing B, 1994. A new look at the determinants of the intra-metropolitan distribution of population and employment. *Urban Studies*, 31(8): 1391–1405. doi: 10.1080/00420989420081221

Lin Jian, Tang Xiaoxu, Huang Feimei *et al.*, 2007. Spatial identification and land use of urban-rural linkage area: A case study on Beijing′s center city. *City Planning Review*, 31(8): 36–44. (in Chinese)

Liu Tao, Cao Guangzhong, 2011. Determinants of city size of China: Development, government and location. *Resources Science*, 33(8): 1570–1577. (in Chinese)

Lu Qi, Wu Peilin, Lu Lixin *et al.*, 2005. The relation between the characteristics of the migrants and the economic development in Beijing and the regional differentiation of their distribution. *Acta Geographica Sinica*, 60(5): 851–862. (in Chinese)

Ma L, Fan M, 1994. Urbanization from below-the growth of towns in Jiangsu, China. *Urban Studies*, 31(10): 1625–1645. doi: 10.1080/00420989420081551

Malaque I R, Yokohari M, 2007. Urbanization process and the changing agricultural landscape pattern in the urban fringe of Metro Manila, Philippines. *Environment and Urbanization*, 19(1): 191–206. doi: 10.1177/0956247807076782

Mori H, 1998. Land conversion at the urban fringe: A comparative study of Japan, Britain and the Netherlands. *Urban Studies*, 35(9): 1541–1558. doi: 10.1080/0042098984277

Pryor R J, 1968. Defining the rural-urban fringe. *Social Forces*, 47(2): 202–215. doi: 10.1093/sf/47.2.202

Qvistrom M, 2007. Landscapes out of order: Studying the inner urban fringe beyond the rural-urban divide. *Geografiska Annaler Series B-Human Geography*, 89(3): 269–282. doi: 10.1111/j.1468-0467.2007.00253.x

Reganold J P, Christensen G R, 1986. Boundary review boards—A legislative approach to manage growth conflicts in the urban fringe in Washington State. *Landscape and Urban Planning*, 13(3): 183–197. doi: 10.1016/0169-2046(86)90033-2

Ryan R L, Walker J, 2004. Protecting and managing private farmland and public greenways in the urban fringe. *Landscape and Urban Planning*, 68(2–3): 183–198. doi: 10.1016/S0169-2046(03)00165-8

Song Hong, Ma Yong, 2002. Study on development of landscape agriculture in metropolitan fringe. *Economic Geography*, 22(3): 376–378. (in Chinese)

Su Ping, Dang Ning, Wu Bihu, 2004. Attraction categories and spatial characteristics in recreation belt around metropolis: Beijing case study. *Geographical Research*, 23(3): 403–410. (in Chinese)

Theobald D M, 2001. Land-use dynamics beyond the American urban fringes. *Geographical Review*, 91(3): 544–564. doi: 10.1111/j.1931-0846.2001.tb00240.x

Webster D, 2002. *On the Edge*: *Shaping the Future of Peri-urban East Asia*. Stanford: Shorenstein APARC.

Whitehand J W, 1967. Fringe belts: A neglected aspect of urban geography. *Transactions of the Institute of British Geographers*, (41): 223–233

Whitehand J, Morton N J, 2004. Urban morphology and planning: The case of fringe belts. *Cities*, 21(4): 275–289. doi: 10.1016/j.cities.2004.04.001

Wu Jin, Ma Qingliang, 1990. Mechanism analysis of spatial structure evolution in the urban fringe. *City Planning Review*, 14(2): 38–42. (in Chinese)

Wu Zhengzheng, Song Jinping, Wang Xiaoxia *et al.*, 2008. On urbanization process and spatial expansion in the urban fringe of Beijing: A case study of Daxing district. *Geographical Research*, 27(2): 285–293. (in Chinese)

Zhang L, 2001. *Strangers in the City*: *Reconfigurations of Space, Power and Social Networks within China's Floating Population*. Stanford: Stanford University Press.

Zhao Qunyi, 2007. Study on spatial change of producer services in Beijing: Based on economic unit census. *Urban Studies*, 14(4): 70–77. (in Chinese)

Zhou Yixing, 1996. On the suburbanization of Beijing. *Scientia Gelgraphica Sinica*, 16(3): 198–206. (in Chinese)

Zong Yueguang, Zhou Shangyi, Zhang Zhenshi *et al.*, 2002. Spatial characteristics of suburbanization and its developing strategies in Beijing. *Acta Geographica Sinica*, 57(2): 135–142. (in Chinese)