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An education-related geodemographic classification of sub-districts in Central Beijing and its implications for access to compulsory education

Abstract

The paper explores the use of geodemographics as a means of assessing potential inequality in access to compulsory education. The article argues that applying an area classification, one of the first in China, allows consideration of multi-dimensional, socio-spatial influences which affect school choice. The ideas are illustrated through a case study of central Beijing. Variables from the 2010 Census have been used to create a sub-district classification to identify whether pupils are living in more or less advantaged locations for access to schools, given China's specific institutional environment. The influence of 'hukou' (the Chinese residential registration system) on the distances that pupils travel to school and the quality of schools that pupils can attend are discussed in detail. Recognition of areas that are most appropriate for additional investment can help improve the efficiency and equity of the allocation of resources to schools. This study also provides new knowledge about the evolution of urban social space, explaining why the implementation of 'nearby enrolment' policy can be both inefficient and inequitable.

Keywords: geodemographic classification, education inequality, hukou, nearby enrolment, China

1. Introduction

Education is not only a fundamental human right but it is also a catalyst to reduce poverty, promote social mobility and encourage economic growth by producing a skilled workforce (UNESCO, 2010; Wilkinson and Pickett, 2010). In 2015, the United Nations Sustainable Development Summit formally adopted the 2030 Agenda for Sustainable Development, the key theme of Goal 4 (SDG4) being to *"ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"* (UNESCO, 2015, p.1). Compared to previous agendas, it places more emphasis on inclusive and equitable quality education for all children. Education inclusion and equality at all levels can improve productivity, promote social cohesion and encourage economic competitiveness (OECD, 2012). For example, South Korea's rapid and remarkable social and economic success is partly related to its decreasing level of education inequality over the past 30 years (Burt and Park, 2009). Education inequality perpetuates existing income differentials (Holsinger and Jacob, 2009) and social disparities (Darling-Hammond, 2007; Breen and Jonsson, 2005). Providing quality and equal education should therefore be a high priority of every national government.

The goal of achieving education equality in China is facing unprecedented challenges as education inequalities between different social classes and income groups are widening. China's continuing urban and socio-economic transformation has led to problems emerging in Chinese cities which are similar to those in mega cities in developed countries in the West (Gu *et al.*, 2005). In terms of education, there is long history of criticism of class stratified school segregation in western cities (Allen, 2007), like Chicago (Christmann, 2005; Lipman, 2005) and London (Hamnett and Butler, 2011a; Harris, 2012; Butler *et al.*, 2013; Harris, 2013), which is largely based on residential segregation and leaves vulnerable children in inferior schools (Butler and Hamnett, 2007; Logan and Burdick-Will, 2015). With the shift from a planned to a market oriented economy in China, the gap between the urban rich and poor is widening, with the Gini coefficient for income inequality increasing from 0.30 in 1980 (Xie and Zhou, 2014) to 0.47 in 2016 (National Bureau of Statistics of the PRC, 2017). There is increasingly marked socio-spatial differentiation caused by income differentiation and increasing levels of residential isolation and social exclusion experienced within cities (Li, 2005; Gu *et al.*, 2006; Fang *et al.*, 2015). In 1993, more than 40% of university students in China came from lower occupation families, e.g. farmers and workers; however, universities today are increasingly dominated by students from wealthy backgrounds (The Economist, 2016).

The uneven allocation of educational resources has received close attention in recent decades (Niu, 1992; Rong and Shi, 2001; Yang *et al.*, 2014a; Li, 2008; Qian and Smyth, 2008), and there is an increasing number of studies of education inequality in China from a geographical perspective. Due to the absence of educational data relating to small areas, most of the research has been focused on inequalities in terms of education provision between different regions or provincial units (Qian and Smyth, 2008; Xie, 2011; Wang, 2014) or between rural and urban areas (Fu and Ren, 2010; Zhang *et al.*, 2015; Rao and Ye, 2016) rather than within urban or rural areas. Although there is some research based on urban areas (Liu and Jacob, 2013), there is a conspicuous lack of detailed studies of education inequality within urban areas and its spatial diversity. In this paper, a geodemographic classification using available data from the most recent Chinese census provides a multi-dimensional analysis framework to identify spatial variations in population types in Beijing and, in combination with survey data, allows us to better understand the inequality in access to compulsory education that exists in the city.

This paper is organised as follows: education inequality within urban areas and the Chinese ‘nearby enrolment’ policy are discussed in section 2; the geodemographic classification approach and the feasibility of its application in educational inequality research are introduced

in section 3; the process of constructing the area classification for sub-districts of central Beijing is elaborated in section 4; the results in terms of inequalities in the demand for and access to education, partly due to the failure of the Governments' nearby enrolment policy are discussed in section 5, together with the corresponding 'action' measures.

2. Hukou system and 'nearby enrolment' policy

In 2011, China's urban population exceeded its rural population for the first time and China's rural population is set to decrease by half by 2050. This rapid urbanisation means there will be increasingly more migrants to the big cities from rural areas whose children require compulsory education (Li and Placier, 2015). Within urban areas in China, there are substantial variations in school enrolment, access to educational facilities and academic or vocational achievement predominantly between the children of local residents and in-migrants. Studies of these disparities have become prominent in the academic literature (Zhang *et al.*, 2015; Fu and Ren, 2010). These in-migrants are often disadvantaged in terms of education because of their non-local hukou registration status (Liu and Jacob, 2013).

The hukou system was established in China as a means to control population movement; everyone is registered with a community which authorises certain rights. The local urban citizens are granted priority access to urban services and facilities, while migrants with a non-local hukou normally have limited access to the same services and facilities, including schools (Zhao and Howden-Chapman, 2010). Consequently, they are discriminated against by policies based on the hukou system, such as the 'nearby enrolment' policy for compulsory education[1]. The Compulsory Education Law of the People's Republic of China (PRC) stipulates that local governments should ensure that school-age children enrol in schools near the places where their residence is registered (Standing Committee of the National People's Congress, 2006) except for boarding schools and private schools (Ministry of Education of PRC, 1992). Local governments have put forward different measures for implementing this so-called 'nearby enrolment' policy.

The school district is one of the most important units associated with this policy and is based on the household registration system. Its boundaries are usually consistent with sub-district administrative boundaries and it is specified as a legal spatial range for enrolment containing several primary schools and middle schools (Bi and Zhang, 2016). In Beijing, primary schools

[1] Compulsory education in China normally includes six years of primary education and three years of junior secondary education (middle school), taking pupils from the age of six to the age of 15.

are supposed to enrol children who live within or whose hukou is within their attendance zones (Zheng *et al.*, 2015). Thus, in China, there is a two-tier system for primary education: school attendance zones are located within each school district (Bi and Zhang, 2016) (Fig. 1). The Local Education Authority (LEA) will specify every primary school attendance zone[2] by naming exact residential buildings or building complexes. The middle school enrolment range is normally within the school district.

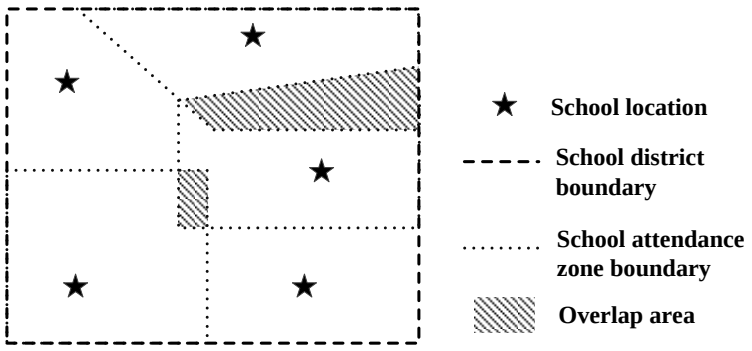

Fig. 1 The relationship between attendance zones and a school district for primary education

It is recognised that enrolment in the UK and the Netherlands, where there is greater freedom of parental choice, tends to lead to longer commuting distances (Hamnett and Butler, 2013). However, the school enrolment system in China, which is strictly constrained by location of hukou or property, is struggling to implement 'nearby enrolment'. For example, the public funding for education in China is from the municipal general fund rather than from local property or council taxes as in the USA (Zheng *et al.*, 2015). Thus, in some highly populated Chinese cities like Beijing, only property owners or people with local hukou are entitled to enrol in the nearby public school (Zheng *et al.*, 2015). The children of families who rent their homes are not guaranteed enrolment under the nearby enrolment policy. Most in-migrants who do not have a local hukou or do not own property are disadvantaged by this 'nearby enrolment' policy and often their children have to commute long distances to school.

Combined with the recent termination of the 'one child' policy (Bi and Zhang, 2016), many cities, especially mega cities such as Beijing, are facing massive challenges in the provision of education services for the children of in-migrants (Zhang, 2011) as well as those of deprived native residents (Bi and Zhang, 2016). Since education resources are inadequate, local governments need to ensure that additional resources are directed to those in greatest need. A geodemographic classification will be constructed in this research to identify the

[2] It may be the case that there is overlap between attendance zones of neighbouring schools. For example, pupils living in the same building but on different floors may be assigned by the LEA to different primary schools.

disadvantaged groups and their distributions, and to detect potential education inequalities in access to compulsory education and its spatial pattern.

3. Geodemographics and Education inequality

Geodemographics is a form of analysis which combines 'geo', implying the places where people live, with 'demographics', indicating the demographic characteristics of households or individuals (Leventhal, 2016). Places usually pre-date their residents, and tend to attract certain population groups because of their characteristics. Geodemographic classification assigns a category to similar neighbourhoods according to the characteristics of their residents. This allows the synthesis of diverse and complex attribute data. The behaviour and characteristics of the residents will further shape the evolution of an area (Harris *et al.*, 2005). Geodemographics therefore provides a framework for understanding the characteristics and behaviour of people who live in these neighbourhoods.

In social research, geodemographics is usually regarded as a multidimensional technique to measure socio-spatial differentiation and deductive models of urban processes (Singleton, 2010). There is an increasing number of applications using geodemographics in sectors such as health (Tickle *et al.*, 2000; Stafford and Marmot, 2003; Abbas *et al.*, 2009), crime (Craglia *et al.*, 2001; Ashby and Longley, 2005) and migration (Dennett and Stillwell, 2011). The methodology has also been applied in the education sector, where inequality is influenced by numerous factors such as demographics (e.g. age, sex, race), socioeconomic status (e.g. poverty level, single parent households, home ownership, income) and housing conditions (e.g. overcrowded households, basic facilities) (Wang, 2012; Williams and Wang, 2014). Within this research, geodemographic classification is applied as a framework to simplify a range of education-related attributes (variables) of the resident population and households into distinct spatial clusters (Gale *et al.*, 2017). Moreover, the level of access to education services can be strongly influenced by who you are (Williams and Wang, 2014) and where you live (Hamnett and Butler, 2011b). Thus geodemographics can be used to investigate potential socio-spatial education in terms of access to education.

Although scholars have employed geodemographic classifications to assist education-related research (Tonks and Farr, 1995; Tonks, 1999; Williamson *et al.*, 2005; Harris *et al.*, 2007; Singleton and Longley, 2009; Singleton, 2010), most of the applications involve access to higher education. Harris (2007) used a general purpose geodemographic system, the Output Area Classification 2001 (OAC 2001), as a framework to analyse whether pupils from varying types of neighbourhood in Birmingham (United Kingdom) were likely to attend their nearest state secondary school. However, using a general purpose classification may not best reflect

education-related problems. Singleton (2010) therefore devised an education-specific OAC in the United Kingdom (UK), but for higher education rather than compulsory school age education. Singleton (2015) has further argued that the OAC, as a national model, can smooth away important characteristics of regional socio-spatial structure and thus for applications in urban and regional research, there may be significant advantages in building discrete urban or region-specific geodemographic classifications (Singleton and Longley, 2015). Furthermore, there is no neighbourhood classification that has been constructed for use in the public sector in China. This paper is the first to apply a geodemographic classification methodology in the context of compulsory education in China and to select central Beijing as a geographical system of interest in order to gain a better understanding of the spatial diversity of potential education inequalities.

4. A geodemographic classification of central Beijing's sub-districts

4.1 The case study area

As China's political, economic and cultural capital, Beijing is a strong magnet for both population and industry. The city has experienced a large influx of in-migrants in the last 20 years and rapid urbanization has taken place with 86.4% of its population classified as urban in 2014 (Beijing Statistical Bureau, 2015). Thus, the study of Beijing has value as a reference for research on other cities which are in the process of rapid urbanization in China. In addition, it is a transitional city that is governed by a socialist regime but influenced by marketisation and globalisation, and therefore provides a unique and contrasting context *vis á vis* western cities.

The city of Beijing is divided into four major zones (Fig. 2): the Capital Core Functional Area; the Urban Function Extension Area; the Urban Development New Area; and the Ecological Conservation Area (as the boundaries between the final two types are not all consistent with the district boundaries, they are combined in Fig. 2a). The Capital Core Functional Area and Urban Function Extension Area are usually referred to as 'the city zones of Beijing', which include the districts of Dongcheng District, Xicheng, Chaoyang, Fengtai, Shijingshan and Haidian (Fig. 2b). The sub-districts of these zones constitute central Beijing and are selected for this research.

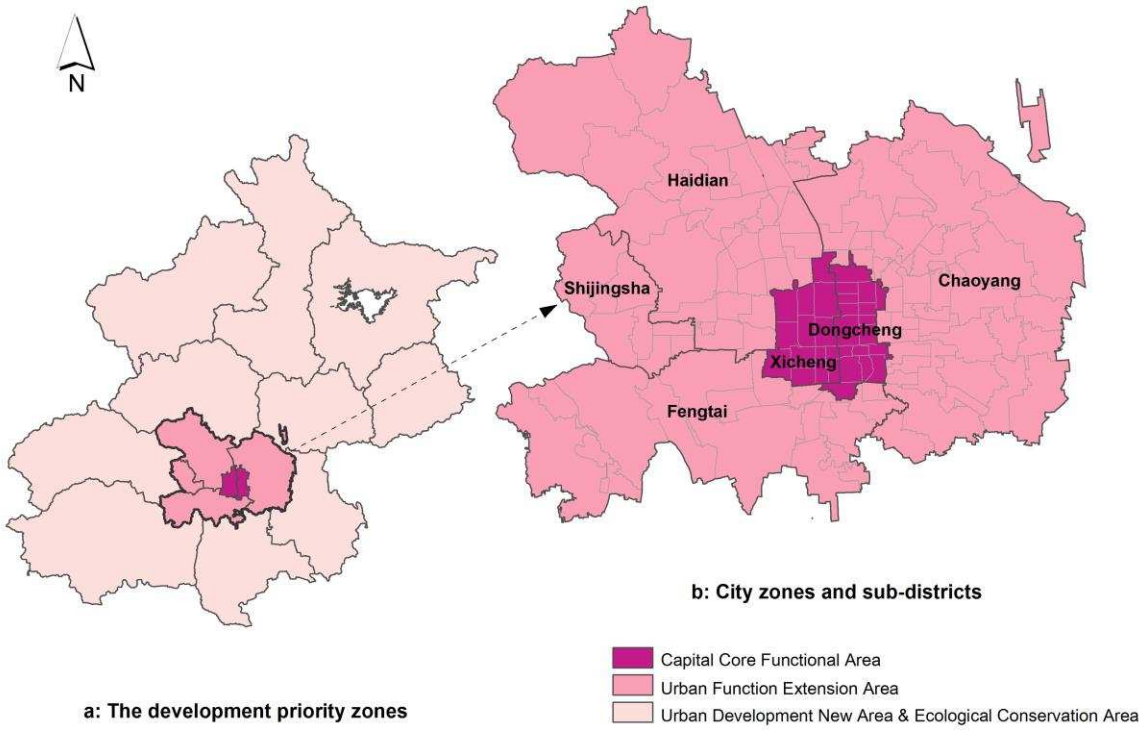

Fig. 2 The development priority zones, city zones and sub-districts of Beijing
Data source：National Administration of Surveying, Mapping and Geo-information

4.2 Input data

The neighbourhood classification has been designed solely using data at the sub-district level from China's latest decennial census in 2010. There are 136 sub-district units in central Beijing. Two sub-districts have been excluded (one because of incomplete information; the other due to it being a mining area and actually outside Beijing) and data for four other sub-districts have been merged into the sub-districts which contained them. Thus, 130 sub-districts have been used in this research.

Based on related literature (Talen, 2001; Harris *et al.*, 2007; Williams and Wang, 2014) and after initial correlation analysis, 33 census variables have been selected to construct the geodemographic classification (Table 1). Although some of the chosen variables are highly correlated, they were retained as their potential correlations can re-enforce important dimensions in the classification (Singleton and Longley, 2009; Singleton, 2010) and add descriptive and predictive power (Gale *et al.*, 2017). All variables were measured in percentages to normalise the data across sub-districts and avoid the influence of unequal populations. Each variable has a direct or indirect influence on education (as indicated in Table

1), and is associated with one of four domains: demographic structure, household composition, housing characteristics and socio-economic traits. As the domains of household composition and socio-economic traits are likely to be familiar to readers, only the demographic structure and housing characteristics, which contain unique variables in China, are explained in subsequent sections.

Table 1 Selected census variables and their influence on education

Variable number	Domain	Variable description	Influence on education
1	Demographic structure	Persons with hukou within this sub-district (%)	Enrolment
2		Persons with hukou outside of this sub-district but within this district (%)	
3		Persons with hukou outside of this district but within this municipality (%)	
4		Persons with hukou outside of this municipality (%)	
5		Non-han nationality*	Culture difference
6	Household composition	Child dependency ratio[3]	Family burden and education requirement
7		Divorce rate	Psychological and economic
8	Housing characteristics	Households in cheap rent housing (%)	Dwelling enrolment and family socio-economic status
9		Households in other rented housing (%)	
10		Households who own self-built housing (%)	
11		Households who own commercial housing (%)	
12		Households who own second hand housing (%)	
13		Households who own economically affordable housing (%)	
14		Households who own purchased public housing (%)	
15		Households whose residence is without tap water (%)	Residence condition of children
16		Per capita housing area is equal or less than 16 square metres (%)	
17		Per capita housing area is from 17 to 39 square metres (%)	
18		Per capita housing area is equal or more than 40 square metres (%)	
19		Households whose rent is less than 200 yuan (%)	Household income
20		Households whose rent is 200 to 500 yuan (%)	
21		Households whose rent is 500 to 1000 yuan (%)	
22		Households whose rent is 1000 to 2000 yuan (%)	
23		Households whose rent is more than 2000 yuan (%)	
24	Socio-economic traits	Persons aged over 6 with lower qualification (%) **	Educational level of parents
25		Persons aged over 6 with middle qualification (%) ***	
26		Persons aged over 6 with higher qualification (%) ****	
27		Employed persons who are managers or directors of government offices, party organizations, enterprises or institutional organizations (%)	Parents' occupation and occupation based social class grading
28		Employed persons with professional occupations (%)	
29		Employed persons with administrative or secretarial occupations (%)	
30		Employed persons with commercial or service occupations (%)	
31		Employed persons with agricultural occupation (%)	
32		Employed persons in manufacturing or transportation (%)	
33		Unemployment rate	

* Han ethnic group is the dominant group in China, which comprises 91.6% of the country's population in 2010 census, correspondingly, non-han nationality refers to minority groups.

** No academic or professional qualifications, primary school qualification, and middle school qualification.

*** High school certificate, which also include vocational high school, secondary specialised school, technician training school; and junior college certificate

**** Bachelor degree and postgraduate degree certificates

4.2.1 Demographic structure

The first set of variables measuring demographic structure includes proportions with ethnic and hukou registration status. The census data are collected at an individual's current usual residence. A different hukou status occurs when the current usual residence of an inhabitant is not consistent with that their registration locations. There are four categories of residential status: hukou within a sub-district; hukou outside of a sub-district but within a district; hukou outside of a district but within a municipality; and hukou outside of a municipality. Fig. 3 explicitly illustrates the influence of different types of hukou on a child's school enrolment based on the current commonly applied enrolment policy in Beijing. As mentioned previously, it is normal that the school district boundaries coincide with sub-district boundaries and each school district consists of one or more sub-districts. In the following illustration, it has been assumed that each sub-district is equal to a school district, so the large round circles in each component of Fig. 3 not only represent a sub-district boundary, but also indicate the range of each school district. The rounded rectangles and the rectangles outside of the circles represent district and municipality boundaries respectively. The small black dot shows a resident's current place of residence. The unshaded hexagons refer to schools performing badly, whereas the shaded hexagons represent schools performing well. The lines connecting the black dots and hexagons represent the preferred school choice of a pupil under each status of hukou, as explained below.

[3] 'Child dependency ratio' is calculated by using the population of children aged 0-14 divided by the population aged 15-65.

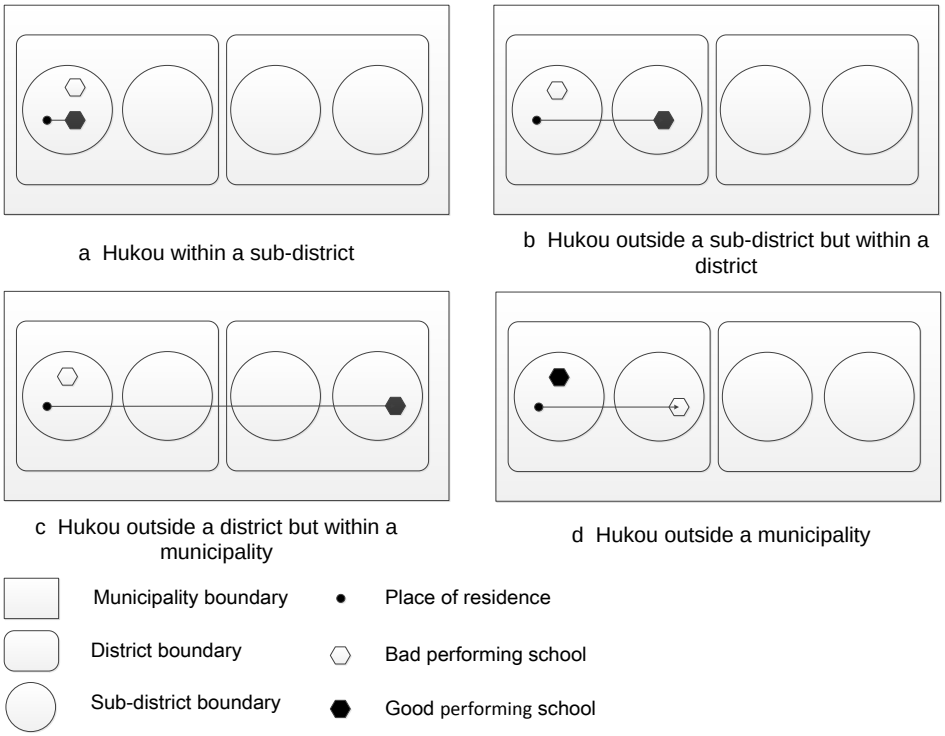

Fig. 3 Schematic diagram of school enrolment with different hukou status

Hukou within a sub-district (Fig. 3a): In this instance, the pupil's current residence is consistent with the registration sub-district. According to the general admission policy within central Beijing, children in this category are given priority to enrol in a nearby school and thus the commuting distance for this group may not be very far.

Hukou outside a sub-district but within a district (Fig. 3b): In this case, a pupil lives in one sub-district but has registration in another sub-district, but within the same district of residence. Usually, the housing ownership certificate and the household registration record are both used as proof for nearby enrolment (Wu, 2013). Thus, if the parents are home owners of the current residence, they will have the right to enrol in a school either near their current residence or their place of registration. However, if there is a better school near their place of registration (Fig. 3b), the child is likely to choose this school and commute a longer distance. This is one of the important reasons that explain the long commuting distances made by children with a particular status.

Hukou outside a district but within a municipality (Fig. 3c): In this situation, a pupil's place of registration is in another district but within Beijing. Similar to the above description, if there is a school near the pupil's place of registration which is better (Fig. 3c), the result will probably be an even longer commute to school compared to the pupil shown in Fig. 3b, as in this case, the commute to school will cross a district boundary.

Hukou outside a municipality (Fig. 3d): If a pupil who does not have hukou within Beijing wants to enrol in a public school, the family needs to provide many documents, such as parents' job contracts and temporary residence permits to meet the requirements of each district. Many migrant children have been deprived of formal education because of these rigorous requirements. Even if they can provide the correct documents, schools will meet the demand from local people first, so children with the non-local hukou status are not guaranteed a school place through the 'nearby enrolment' policy; they can only enrol in schools where there are places left. They do not have the chance to compete with local residents for places in oversubscribed 'key' schools; the schools where they will be able to enrol are not nearby and are most likely to be of lower education quality.

Thus, a pupil's hukou status is a crucial influence on his or her accessibility to schools and, consequently, on the education quality he or she receives.

4.2.2 Housing characteristics

There are four aspects used in this research to measure housing characteristics: housing type, per capita living space, facilities and rent. The living conditions and family socio-economic status of children will be reflected by these variables; they will significantly affect a child's achievements as shown by previous research (Logan *et al.*, 2012; Williams and Wang, 2014). Seven housing types were included in the set of selected variables (Table 1). In addition to common residence categories, such as commercial housing, there are also some unique housing categories in China, such as purchased public housing and economically affordable housing. Purchased public housing is also called privatised public housing (Yang *et al.*, 2014b) and includes houses previously owned by state-owned enterprises (SoEs) that have been sold to their employees at considerably reduced prices. Economic Affordable Housing (EAH) (*jingjishiyongfang* in Chinese) is aimed at low- and medium-income households, while Cheap Rent Housing (CRH) targets the bottom low-income households with a local hukou. In addition, there is a small amount of 'self-built' housing which refers to housing units financed by households and usually located in the collectively owned land in rural areas on the peripheries of cities (Yang *et al.*, 2014b; Fang *et al.*, 2015; Fu *et al.*, 2015). Moreover, the Chinese census requires residents to specify the size of their accommodation (square metres) (Harris *et al.*, 2005). The per capita housing area reflects the degree of residential overcrowding.

4.3 Pre-processing the data

Before clustering can be undertaken, the data have to be pre-processed. The skewed variables such as 'Non-han nationality (%)', were transformed to a log scale (1 was added to each value before the log transformation) to reduce the influence of outliers at the high end of

the value scale (Vickers and Rees, 2007). In addition, range standardisation has been conducted for all the variables to ensure each has the same importance and their variation can be captured equally (Vickers and Rees, 2007). Compared to other standardisation methods, such as using z-scores, range standardisation is helpful for coping with extreme outliers (Vickers and Rees, 2007). The formula for range standardisation (0-1 normalisation) is defined as follows:

$$R_i = \frac{x_i - x_{min}}{x_{max} - x_{min}} \quad (1)$$

where R_i is the standardised value of variable *x* for zone *i,* x_i is the initial value of variable *x* in zone *i,* x_{min} is the minimum value of variable *x*, while x_{max} is the maximum value. The value of each variable will range from a minimum value 0 to a maximum value of 1 after this standardisation, ensuring that the similarity or dissimilarity is measured on the same numeric scale.

4.4 Clustering the data

After being pre-processed, the data were clustered by applying the k-means clustering algorithm.

4.4.1 Clustering method

Clustering using k-means is a commonly used approach in geodemographics (Harris *et al.*, 2005). It is a non-hierarchical and highly efficient way of clustering a large volume of data. The iterative allocation-reallocation method (k-means where k is the number of clusters) first creates clusters by imperfectly arranging zones into the final number of predefined groups and reallocating the assignments iteratively to obtain a better fit. This approach tries to minimise variability within clusters and maximise variability between clusters (Vickers and Rees, 2007). The clustering criterion, E_c, is minimising the objects' Euclidean sum of squared deviations to the cluster mean, which is also called the total Within-cluster Sum of Squares (WSS). This clustering criterion can be defined as:

$$E_c = \sum_{i=1}^{\mathrm{k}} \sum_{x=1}^{m} (Z_{ix} - Z_{mx})^2 \quad (2)$$

where Z_{ix} is the value of observation i of variable x and Z_{mx} is the average of values of variable x. It can be applied for continuous data variables, so long as an appropriate distance measurement can be defined (Leventhal, 2016). Thus, it is an ideal approach to be used in this research.

In terms of software implementation, when using SPSS, the final cluster solution may be highly influenced by the starting values (the original cluster centre or initial seeds). The clustering method adopted in the 2001 OAC in the UK (Vickers and Rees, 2007) was challenged by Dennett and Stillwell (2011) since this algorithm generates different solutions depending on the order in which the data are sorted. The rigid initial seeds assignment is not helpful to get an optimal global solution. The parameter, 'nstart', in R was used as a solution to this problem running the clustering algorithm multiple times (50 in this instance) with a different set of initial cluster centres each time. Although, the optimum global solution is impossible to determine, the cluster scheme created by comparing the results using different initial seeds can get very close to an optimum global solution compared with the use of rigid initial cluster centres.

4.4.2 Number of clusters

One limitation of this method is that the selected number of clusters must be specified before running a k-means algorithm rather than being derived automatically. As the number of clusters needs to be suitable for the research purpose and useful for further analysis, it should be as close to the perceived ideal as possible (Vickers and Rees, 2007). As there are 130 sub-districts within central Beijing, six may be a target number of clusters for this research to enable ease of visualisation and labelling. Thus, solutions in the range of four to eight clusters were investigated. The R package 'NbClust' from Charrad *et al.* (2014) was used to determine the optimum cluster scheme. This package provides an exhaustive list of 30 indices to determine the number of clusters for a given dataset. For each index, NbClust proposes the best cluster scheme, so that the results of all indices can be compared to get the best solution. Using NbClust, 14 out of 30 indices suggested five as the best number of clusters. In addition, two of the top performance indices suggested by Milligan and Cooper (1985), the Duda index and the Beale index, also proposed five clusters as the best solution and the one that was subsequently adopted.

4.5 Naming and describing the clusters

After running the k-means clustering and obtaining the results, the clusters were labelled and given descriptions, as shown in Fig. 4, based on the principal and distinctive variables. The locations of primary and secondary schools are also shown on the map in Fig. 4 to indicate the school distribution in each cluster. The geodemographic clusters display a pattern of concentric rings, although some parts of these rings are discrete. The cluster labelled 'Long settled Beijing society' (cluster 3) is concentrated in the central areas of Beijing, including the Dongcheng and Xicheng districts and areas within the second ring road. Areas in cluster 2, labelled 'Employees of state-owned enterprises and white collar workers', are located in the middle of inner Beijing, mainly located between the second and fifth ring roads, although some

are located further out. The distribution of sub-districts classified and labelled as ‘High income internal migrants’ (cluster 1) is more widely spread, but these areas are mainly located in the outer area of inner Beijing. Areas in the cluster labelled ‘In-migrants living in deprived suburbs’ (cluster 4) are found outside and around the above three clusters. Cluster 5, whose areas are farthest from the city centre, is called the ‘Urban-rural transition belt’. In addition, the typical neighbourhood of each cluster has been presented in Fig. 5.

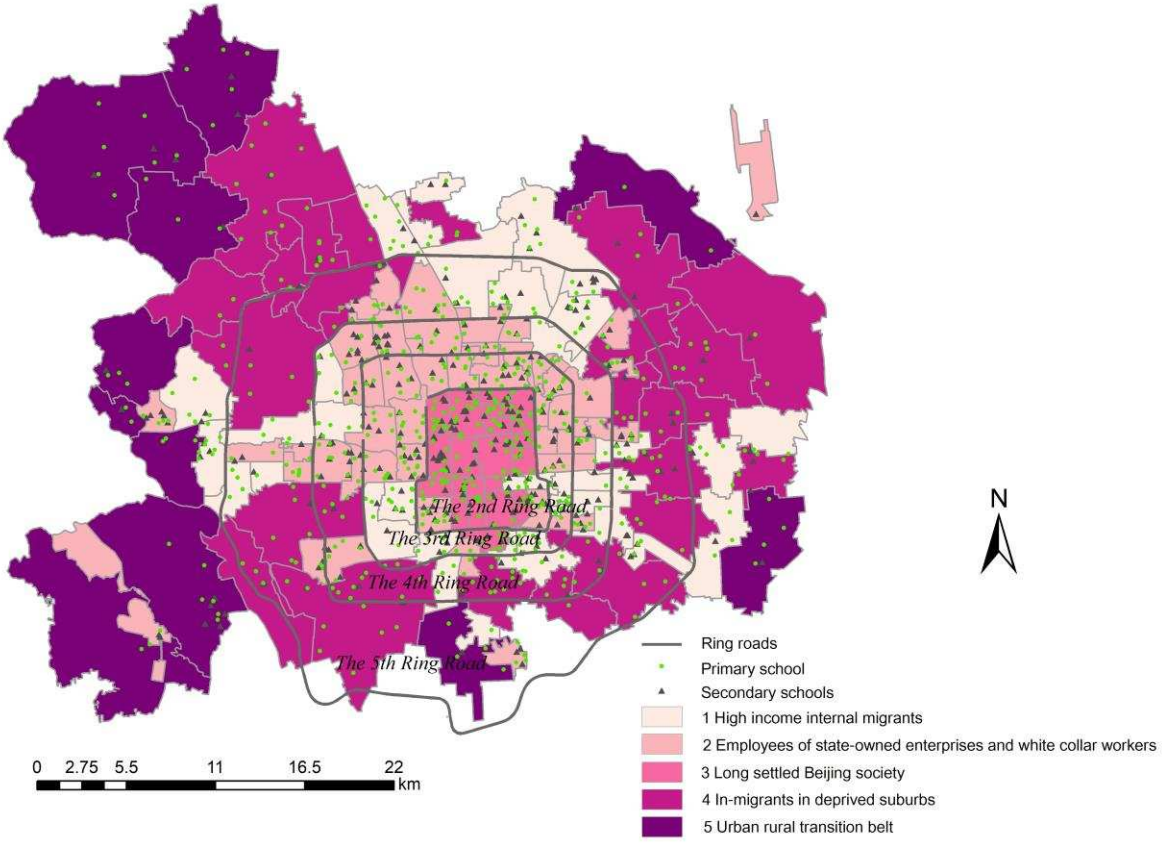

Fig. 4 Education related geodemographic classification of central Beijing by sub-district and the distribution of primary schools and secondary schools

Data source：Geographical Information Monitoring Cloud Platform

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b

c

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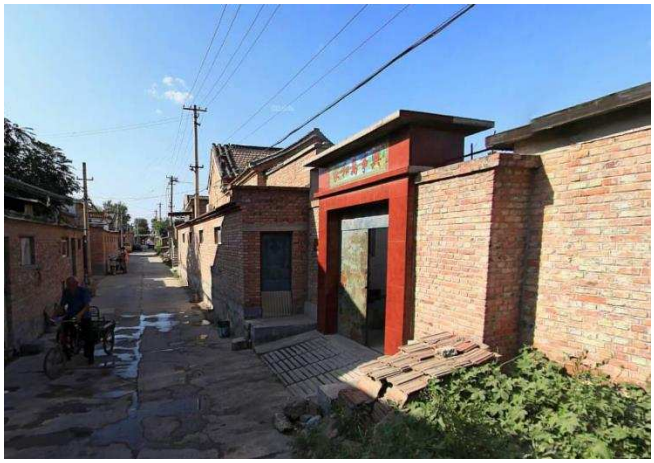


e

a Cluster 1 – Luxury villas outside of fifth ring road and next to Olympic Sports Center

b Cluster 2 – Work-unit compound in petroleum sector within the third-ring road

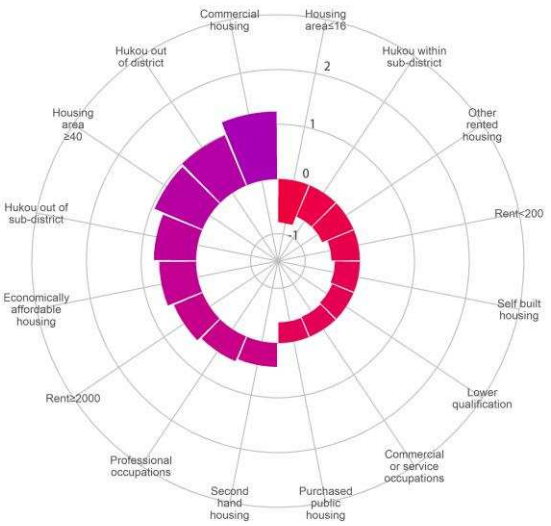
c Cluster 3 – Hutong-courtyard neighbourhood in the inner city

d Cluster 4 – Migrants' neighbour in Xibeiwang and beyond the third ring road

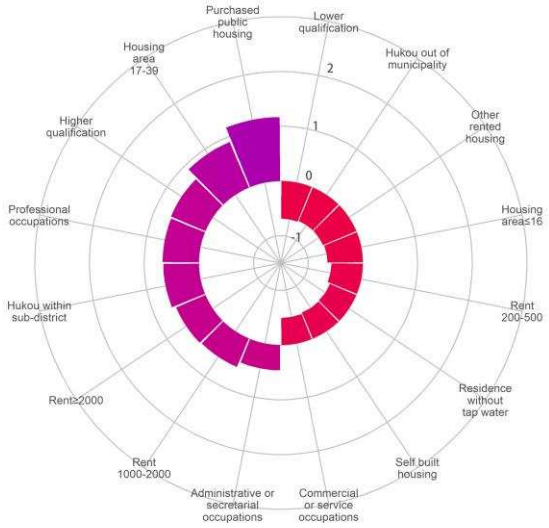
e Cluster 5 – Rural residential area in northwest of Haidian district

Fig. 5 Typical neighbourhood of each cluster
Source: Baidu streetscape

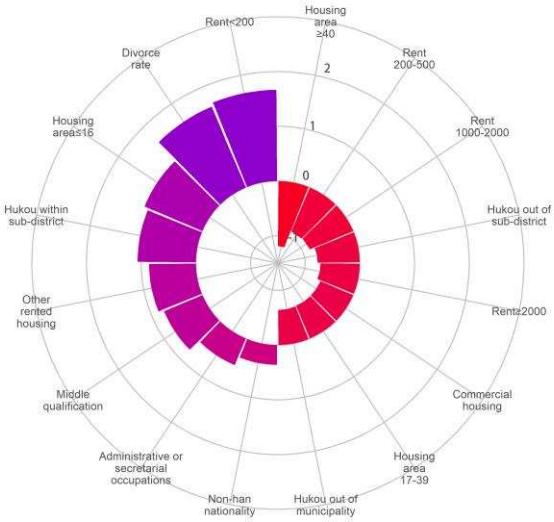
The principle features of each cluster were summarized and displayed by the radial plots below Fig. 6. Z-scores were used in this research to assess the distinctive variables, because identification of variable effects is facilitated if the value sits above or below the study area mean, 0. The 8 highest and 8 lowest variables in each cluster were sorted by z-score and displayed anticlockwise (highest to lowest). The difference in the value of each variable from the mean (0) is represented by the length, direction and colour of each bar and the range of the y axis is from -1.5 (the centre of the circle) to 3. The highest and lowest values of variables are immediately distinguishable and reflect the principal features of the cluster in terms of its demographic structure, household composition, housing and socio-economic features.



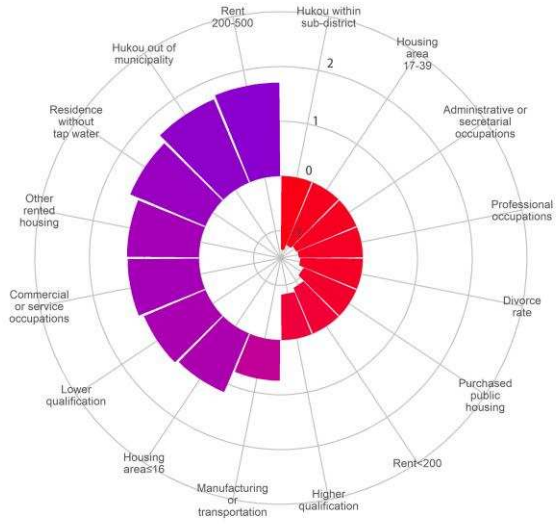
a



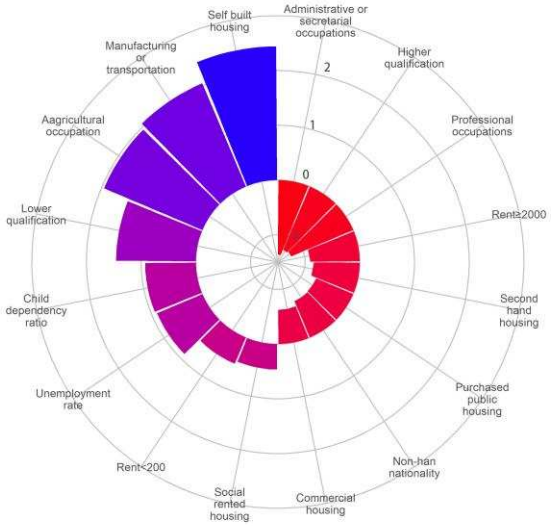
b



c



d



a cluster 1 High income internal migrants	b cluster 2 Employees of state-owned enterprises and white collar worker
c cluster 3 Long settled Beijing Society	d cluster 4 In-migrants in deprived suburbs
e cluster 5 Urban-rural transition belt	

e

Fig. 6 Radial plot of each cluster

The distinct characteristics and education related descriptions of each cluster have been described in detail by the following pen portraits. In reality, due to the drawbacks of geodemographics, such as the ecological fallacy (Burrows *et al.,* 2005; Graham, 2005; Leventhal, 2016) and the Modifiable Areal Unit Problem (MAUP) (Openshaw, 1994), within each sub-district, these characteristics will show a degree of variability and applicability.

4.5.1 Cluster 1: High income internal migrants

The areas in this cluster have a high percentage of spacious and owner occupied commercial housing (Fig. 6a), which include the most luxury villas (Fig. 5a). This means their economic status is comparatively high. There is a high proportion of residents with their hukou outside a district but within the municipality, or with their hukou outside the sub-district but within the district. The population in these areas is likely to contain many residents who have migrated within Beijing. In view of Beijing's development process and housing reform policy, it is likely that the hukou of these residents is within inner Beijing, where they previously lived. To avoid the crowded living environment in central areas, and with the encouragement of the commercial housing development in the outer zone of central Beijing, this sub-group contains people who changed their residence and moved to an outer zone with spacious housing and a more pleasant living environment. However, the schools with a good reputation historically are mainly located in the inner areas of central Beijing; there are only a few high quality schools located in the newly developed outer areas. As the place of hukou registration of these inhabitants tends to be in inner Beijing, their children still have the opportunity to enrol in a better school in an inner area as discussed in section 4.2.1 (Fig. 3b and Fig. 3c). Chinese parents prefer to choose a school with higher teaching quality and commuting distance seems to be less important if their economic status permits (Bi and Zhang, 2016). As their economic status is high, it can be speculated that some of the children living in these areas would commute quite a long distance to enrol in a better school rather than enrol in a nearby school, resulting an increase in the traffic burden and more congestion.

4.5.2 Cluster 2: Employees of state-owned enterprises and white collar workers

More people in this group own purchased public housing and have their hukou in the same sub-district as where they live (Fig. 6b). Their living conditions are moderate (neither crowded nor very spacious) (Fig. 5b). The high proportion who own purchased public housing indicates that quite a lot of people in these areas are working in state-owned enterprises that are the

legacy of the danwei (work unit) system which is now defunct. Prior to the housing reform, employees of state owned companies were provided with welfare housing and comprehensive services including medical supplies and education facilities by the danwei unit, which is a unique organizational form of the socialist system. Since the 1990s, a market based housing reform was implemented to transform housing from a welfare item of the socialist system to a commodity in the post-socialist market (Yang *et al.*, 2014b). In 1998, residents were encouraged by the Government to buy commodity housing from the market or buy public housing which was owned by the state, the so-called state-owned enterprises (SoEs), at considerably reduced prices (Yang *et al.*, 2014b).

As each danwei usually had its own schools for employees' children, the education provision in these residential areas was normally sufficient (Chen *et al.*, 2015). In addition, in the danwei system, the matched schools were normally located close to or even within employees' residential areas, which is also indicated by the school densities shown in Fig. 4. Although the danwei system has disappeared, the schools have remained, so education resources for employees of SoEs are relatively adequate, there are several schools with high quality (key schools), and children's commuting distances are not very long.

Other distinctive characteristics of this cluster are its high percentage of population with higher qualifications and with professional white collar occupations. The best universities, scientific research institutions and high-tech firms in China are concentrated in these areas, including Tsinghua University, Peking University and the technology hub, Zhongguancun (known as 'China's Silicon Valley'). Existing research has demonstrated that parents' education is important for predicting children's achievement (Davis-Kean, 2005). Parents with high qualifications will not only have an influence on what their children achieve, but find it easier to get the limited local hukou quota, so they have more chance to enrol their children in a nearby quality school. Thus, children in this cluster are likely to have a significant advantage in receiving education not only because of the shorter commute distance and better education quality, but also because their parents' qualifications and occupations are superior.

4.5.3 Cluster 3: Long settled Beijing society

Most people living in cluster 3 have their hukou in the same sub-district (Fig. 6c), although more people are living in crowded and less desirable environments. Few residents in these areas are living in spacious accommodation. Areas in this cluster are found inside the second ring road (Fig. 4), where there is a concentration of Beijing's hutong and quadrangle courtyard areas that has existed for hundreds of years (Fig. 5c). Beijing's quadrangle dwellings were

designed for large single families, but they have been subdivided into smaller quarters and shared by a lot of different families since 1950; thus the living environment of residents in this cluster is densely populated. Most buildings are comparatively low-rise constructions (no more than six storeys) and some of them are falling into disrepair. However, these inner areas are not only occupied by the poor; there are also residents of the affluent class still residing in these areas because of redevelopment that has occurred (Fang *et al.*, 2015). High quality education resources are historically located in these areas (Bi and Zhang, 2016), so some rich people stay there to give their children a better education.

As the proportion of pupils with their hukou within the sub-district in this cluster is high, the commute distance of children is likely to be relatively short. In terms of education quality and distance to school (school density is high) (Fig. 4), children in this cluster should not be considered as being very deprived; however, the unpleasant living environment and high divorce rate may affect pupils' success.

4.5.4 Cluster 4: In-migrants in deprived suburbs

Compared to other clusters, there is a large group of in-migrants who do not have a Beijing hukou, living in low rent accommodation, without the necessary facilities and with low qualifications (Fig. 6d). As only people with a Beijing hukou are eligible to apply for social rented housing, there is a high percentage of residents living in other rented housing paying 200 to 500 yuan (around £20-50) per month, which is a low price for private rental accommodation. Their residential environment is unpleasant, crowded and lacking basic facilities. Due to the strict household registration system, migrants only have access to commodity housing which is expensive (Fig. 5d). Moreover, they are disadvantaged in the urban housing market by requiring various types of certificates for purchasing housing. According to a survey by Logan (2009), most migrants are living in market rented rather than owner occupied housing, as shown by the census data.

A high proportion of people in this cluster type are employed in commercial and service occupations and have primary or middle school education. As shown in Fig. 5d, for those who can provide the required documents, the children of migrant families usually cannot enrol in nearby schools because they lack a Beijing hukou and do not own property in Beijing. They will be allocated to less popular schools within the range of the district of residence. As the areas of these outer districts are very large, pupils normally have to commute a longer distance to low-performance schools. Therefore, these areas will potentially be the most educationally disadvantaged areas in the city.

4.5.5 Cluster 5: Urban-rural transition belt

Areas in this cluster tend to have a large amount of spacious and self-built housing (Fig. 6e and Fig. 5e), which is usually located in rural and suburban conjoint areas (Fig. 4). There are high proportions of residents with agricultural occupations and very low qualifications. Scholars have demonstrated a significant gap in the average years of schooling, enrolment and graduation rate between the urban and rural population in China (Zhang *et al.*, 2015). The unbalanced education provision between rural and urban areas potentially leads to education disadvantage for residents in these areas. If they have local hukou, they can enrol in a nearby school but this normally has lower education quality compared to inner areas of Beijing. The education support from parents is comparatively weak because of their poor qualifications. In addition, the children dependency ratio is also very high in this cluster, which is likely to be due to large number of 'left behind' children, whose parents went to urban areas to find jobs.

4.6 Application and validation

To evaluate how well this classification performs and validate the above descriptions of potential education inequality, data from 2014 Pupil Travel Survey have been used. This survey was conducted by the Beijing Municipal Commission of Transport for the first time in 2014 and was one of 16 specific surveys that constituted the Fifth Comprehensive Travel Survey of Beijing, a survey which was undertaken in schools within six districts of central Beijing. Most primary schools (96.9%) and secondary schools (96.1%) have taken part in this survey, and the valid observations account for 62.5% of all primary pupils and 53.5% of all secondary pupils. Information such as the sub-district name of pupils' home and school, and travel time and distance from home to school are included in this survey and can thereby be linked to the clusters described above. The average travel distances of pupils living in each cluster are shown in Fig. 7. Although differentiation by the educational quality of schools is not possible, the results of the 2014 Travel Survey validate the assumptions about pupils' commuting distance in section 4.

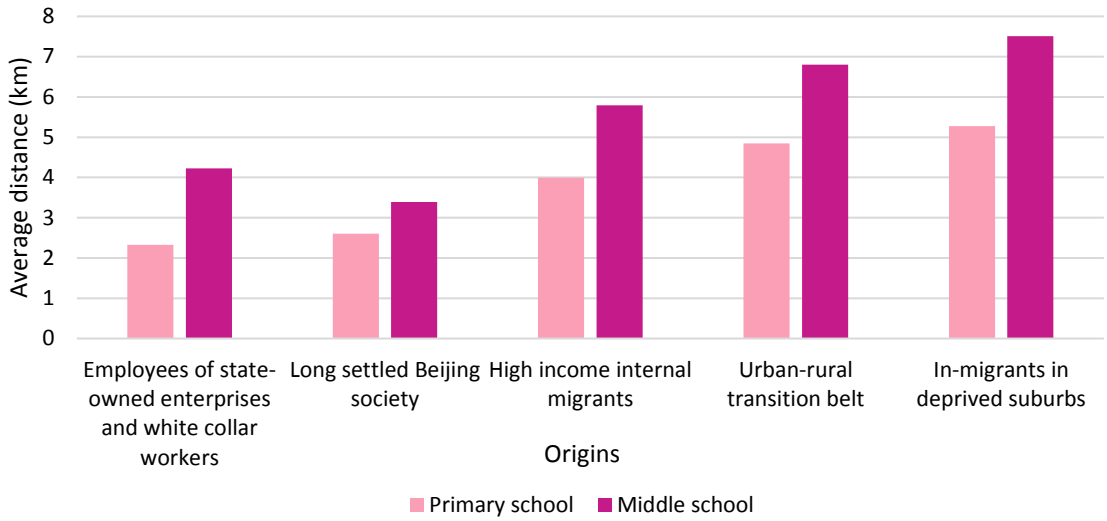


Fig. 7 Average travel distance to school within each cluster by education stage

The cluster with the shortest average commute distance to primary school is 'Employees of state-owned enterprises and white collar workers', especially at primary level. The mean commute distances to primary and middle schools in 'Long settled Beijing society' are very short compared to other clusters, especially middle schools. In addition, 'Urban-rural transition belt' and 'In-migrants in deprived suburbs' are shown to be disadvantaged groups from the perspective of accessibility to education services. According to a specification issued by the former state education commission, the distance between a pupil's residence and school should be within 3km (Ministry of Education of PRC, 2006). However, apart from the first two clusters, the average commute distances for primary schools of the other clusters are all over 3km, indicating that nearby enrolment policy is not working in some places. In addition, the primary school commute distance of 'In-migrants in deprived suburbs' exceeds 5km, which is regarded as too far to commute for primary school pupils (McDonald, 2010).

5. Conclusions

This research provides the first geodemographic classification relating to a public sector service in China. It is also the first time that a compulsory education-specific area classification has been used to assess potential inequalities in access to schools. This study offers a valuable data exploration approach that yields new ideas and insights about potential inequalities in education, providing a useful point of reference for areas where educational research is limited by the availability of data for small areas. In terms of substantive findings, potential inequalities in access to schools due to the nearby enrolment policy for different types of area are revealed in central Beijing. This is associated with housing type, parental

occupation, qualifications and, in particular, registration status which has mediated the influence of market sorting and maintained the advantage of local households over migrants with similar or even higher incomes (Fang *et al.*, 2015). This area classification provides some crucial education-related implications and is constructive in clarifying the main issues of education development within each type of area revealed by the cluster analysis and in formulating the corresponding 'action' measures proposed below.

Areas with 'In-migrants living in deprived suburbs' are likely to be the most educationally disadvantaged places in the city. Compared to local low-income households in the clusters labelled 'Long settled Beijing society' and 'Urban rural transition belt', those migrants living in areas labelled 'In-migrants living in deprived suburbs' may be far more disadvantaged in terms of education because of their non-local hukou status. The clustering and decentralization of migrants occurs because they do not have access to social rented housing in inner areas and the only cheaper rented accommodation available for them is in the outer areas, some of which is provided by local rural villagers (Wu and Treiman, 2004; Song *et al.*, 2008). Their children normally have to commute long distances to enrol in relatively unpopular schools, and the long-distance commutes have been validated by the analysis of data from the 2014 Pupil Travel Survey. Moreover, it is the case that for most migrants, due to not having the required documents such as parents' job contracts, temporary residence permits and social insurance, their children do not have the right to enrol in schools in Beijing at all. They have to leave their children with their parents in rural areas. The so-called 'left-behind' children, accounting for 58.9% of primary school age and 68.7% of middle school age children of migrants in 2014 in China (calculated from data of China Statistical Yearbook in 2015), experience developmental issues (e.g. juvenile delinquency, suicide caused by mental problems). Education inequality for these migrant children will not only have an influence on their social mobility, but will also be harmful to the city's human capital accumulation and hinder its long-term economic development (Zhang *et al.*, 2015).

According to the above disadvantages identified by the area classification, local authorities in the problematic sub-districts should undertake specific measures to address these apparent educational disparities for in-migrant children. First, the education of migrant children should be properly integrated into the system of planning for education needs and the education provision for migrant children should be included in the performance evaluation of local government in these areas. Second, the residents with rented properties in these areas should enjoy equal nearby enrolment rights as those with local hukou or property ownership. Moreover, better quality schools, which are normally over-subscribed and therefore unavailable for migrant children, should provide some places for these pupils. Third, the

Government should develop schools in those areas labelled as ‘In-migrants living in deprived suburbs’ for these migrant children to meet the demand of the increasingly concentrated migrant population in these areas. The private schools which are providing education specifically for migrant children should get more support, in terms of funding, qualified teachers and facilities. As these areas are mostly in outer parts of the city, these measures can solve not only the problems of difficulties in access to schools for in-migrant children and reduce travel distances, but can also facilitate the population dispersal from congested inner Beijing and the formation of in-migrant concentration areas where the environmental conditions are more healthy.

People living in areas labelled ‘Urban rural transition belt’ are also likely to be deprived in terms of education due to few high performance schools being located in rural areas. Moreover, the lower density development of rural areas means that the commute distance in rural areas tends to be longer than in urban areas. Increasing financial and human capital resources should be allocated to these areas to promote the education quality of schools and increase accessibility by providing more school buses or adding more teaching points. With the population dispersal from inner Beijing, more in-migrants will tend to move further away from the inner city and reside in the rural-urban transition areas. The long-term education provision in these areas should be proactively prepared in the light of this trend. Furthermore, the education and mental health of the ‘left behind’ children indicated by the high child dependency ratio in these areas should also be given attention.

This research demonstrates that the ‘nearby enrolment’ policy can be inefficient. This is due to the strict hukou restrictions and the requirement of property ownership during the enrolment process. From this analysis we recognise that migrant children are excluded from consideration by the ‘nearby enrolment’ policy because of their non-local hukou, but even for local residents, the implementation of the ‘nearby enrolment’ policy is still distorted because of their hukou status. Children in ‘High income internal migrants’ areas also tend to commute long distances to schools of high quality because their current places of residence and those of their hukou registration (where high quality schools are located) are different, except for some areas where the policy is even more rigorously applied. In the Dongcheng district in Beijing, only children who can provide both property ownership certificates and have local hukou are eligible to enrol in nearby schools (Xinhuanet, 2015). Moreover, some of the high income groups are capable of ‘buying their way’ into prestigious school catchment areas in the inner city, while living in ‘High income internal migrants’ areas where there are more spacious properties (Wu *et al.*, 2015). This not only exacerbates the traffic congestion, but also has negative implications for the nearby enrolment rights of the more disadvantaged

residents. This phenomenon is not unique to China; in the western world, research has shown that wealthy middle-class parents can 'work' the system effectively no matter whether there is total freedom of parental choice, limited parental choice or strict nearby enrolment policy (Hamnett and Butler, 2013). However, unlike the actual residence-based nearby enrolment in western countries, such as London (Hamnett and Butler, 2011a), the hukou and the property-based enrolment policy strengthens the advantages of high income groups further in receiving high quality education under China's specific institutional background. Thus, decreasing the privilege of Beijing hukou and providing similar quality education services citywide are keys to reducing the long commute distances in 'High income internal migrants' and easing traffic pressure in Beijing.

All in all, this research identifies for the first time the potential socio-spatial education inequality in Beijing using geodemographic classification. Within a wider education inequality context, this work also provides new theoretical perspectives for research on school enrolment policy and will be a reference for the development of education equality in other countries. It is acknowledged there are some limitations to this research, such as the ecological fallacy issue of using geodemographic classification, and that the accuracy of this classification will gradually degrade over time due to its reliance on the decennial census data (Leventhal, 2016). Thus, more in-depth and comprehensive qualitative research should be conducted in some sub-districts to investigate the detailed variations and disparities within each cluster and inform on the influences of areas on a disadvantaged group's education. When new census data are available, an education related classification can be reconstructed to thereby monitor changes in the effects of education related policy on education inequalities.

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