CrossMark

The determinants of commuting mode choice among school children in Beijing

Li Shengxiao, Zhao Pegnjun *

Department of Urban and Regional Planning, College of Urban and Environmental Sciences, Peking University, Room 3267, Yifu 2 Building, 5 Yiheyuan Road, Haidian District, Beijing 100871, PR China

A B S T R A C T

This study explores the determinants of travel mode choice for journeys to school by students aged 13–15 in Beijing. The descriptive and regression outcomes show that there is a spatial diversity in travel patterns across the city. Students who live in the suburban areas travel longer distances than those who live in the core centre of the city, where most of the good-quality schools are located. In the core area, for students whose school is within 3 km of home, cycling is more popular than other modes. For students who must travel further than 3 km, there is a significant modal split between households with different socioeconomic status and car ownership. Among the most influential factors, policy factors such as the population policy of China and the impact of education policy on different social groups tend to make the determinants of school children's commuting mode choice more complicated.

1. Introduction

Travel mode choice among school children has been widely discussed in recent years. These discussions have mainly occurred in the western context, due to the increasing use of cars to transport children to and from school and a decline in walking and cycling in these countries. The increasing use of cars to get children to school has negative economic, health, social and environmental effects. For example, it is reported that car dependence is a major contribution to a higher rate of childhood obesity in the US (e.g. McDonald, 2008a). In addition, it is argued that traffic congestion in peak hours will worsen should more children be chauffeured by parents (Mackett, 2002; Wen et al., 2008; Black et al., 2001). Travel mode choice is also related to social exclusion (McDonald, 2008c). Generally speaking, while modal choice among children is a transport issue, it is also a health and social issue (McMillan, 2005).

According to previous studies, many factors may affect modal choice among children (see Section 2). These include home–school distance, the personal characteristics of children and their household, the built environment and the specific transport culture of a given space.

In relation to the situation in China, special contextual factors may lead to even more variation in modal choice among children. Firstly, the rapid spatial expansion of cities and the lag in the construction of more educational institutions have led to longer travel distances among children. Secondly, transport resources are unevenly distributed among different socioeconomic groups. As household income, *hukou* status, car ownership and living location all interact with transport resources, this suggests those less well off may be forced to live in less accessible areas, with fewer schooling choices. *Hukou* institution is a special population policy in China. It was introduced in the 1950s in order to control the movement of the rural population to the big cities. It was used to distribute the state's welfare, and residents with an urban *hukou* received a higher level of the state's welfare than a resident with rural *hukou*. This institution continues till now. Residents with and without local urban hukou are treated differently. Residents without local urban *hukou*, such as the migrant low-income workers usually are not qualified to access to local basic services at a normal round, such as education, medical care and other welfares. Finally, various educational policies (e.g. *techangsheng, zhankengsheng*), favouring children in higher socioeconomic groups, gives them the opportunity to travel further for a better education, and relatively more modal choices enable them to do so.

The determinants of children's travel behaviour could be explained with the socio-ecological model (e.g. Green et al., 1996; Stokols et al., 1996). According to the mode, firstly, a child's travel features would be affected not only by theirs socioeconomic

* Corresponding author. Address: Department of Urban and Regional Planning, Peking University, 5 Yiheyuan Road, Haidian District, Beijing, China. Tel./fax: +86 62768005.

E-mail addresses: lishengxiao@pku.edu.cn (S. Li), pengjun.zhao@pku.edu.cn (P. Zhao).

features but also by a set of environmental factors including household characteristics, socio-spatial environment and the policy environment. However, previous studies are short of a thorough discussion on socio-spatial environment and the policy environment. Secondly, social structure is one of important aspects of social process. Social exclusion is one of key indicators of social structure. Transport-related social exclusion is often addressed in the field of transport study (e.g. Lucas and Jones, 2012; Lucas, 2003). Many researchers believe that a child' travel mode could reveal the degree at which the child is socially included (e.g. Talen, 2001; Loo and Lam, 2013).

This paper will explore the determinants of travel mode choice among school children in China, looking at the case of Beijing. This paper will contribute to the present literature in two respects. Firstly, a consideration of the specific institutional factors, such as housing reform, the *hukou* system and the heterogeneous urban education policies will broaden the research framework for studies of travel mode decisions among children. Secondly, providing new evidence from Beijing will compensate for the limited research in this field in developing countries.

2. Linking social exclusion and modal choice among children

Social exclusion refers to a situation where certain members of society are separated from the normal 'sphere' of living and working in society (Johnston et al., 2000). Some social groups are more adversely affected than others, especially children. These unequal outcomes reduce people's ability to fully participate in society and can lead to more significant social exclusion (Lucas and Jones, 2012). Poor educational achievement in particular, is regarded as an essential aspect of social exclusion (Lucas, 2003).

Transportation plays an important role in social exclusion. Poor transport, including lack of transportation infrastructure and personal transportation resources, can deprive people, especially the disadvantaged in society, of equal opportunities to participate in daily activities (Hanson et al., 2004). Social exclusion can, in turn, be exacerbated by poor access to public services and facilities (Pickup and Giuliano, 2005). This relationship echoes Lucas' (2003) views on the interaction between transport and social exclusion. The notion of socially sustainable urban transportation has been proposed as a theoretical attempt to understand the role of transportation in social inclusion (Boschmann and Kwan, 2008) and achieve a more equal and inclusive society. Children are considered to be a special group of transportation research for their role as both benefits and victims of the high-mobility society (Uth Thomsen, 2004). Among children, the transportation resources are unequally distributed, and the equality also contribute to diverse choices when it comes to schooling, attenuating the role of education in decreasing intergenerational poverty.

There are some studies that have paid attention to the relationship between transport and social inclusion among children, most of which aim to determine the relationship between school accessibility and school achievement. It is worth mentioning that Talen's (2001) study was conducted against the background of longer travel distances faced by children as a result of primary school consolidation in Virginia. The effect of a decrease in accessibility on school achievement was evaluated in this study, with the findings revealing 'unpatterned inequity' among children and a reverse relationship between travel distance and school achievement for students in Grade Three. Recently, an empirical study in a rural area of Taiwan found a similar connection between travel distances and school achievement among junior secondary school students (Lin et al., 2013).

Travel mode choice is significantly related to social exclusion. To begin with, children from low-income families are forced to attend schools close to home because of the limited transportation options available, and the quality of schools near low-income neighbourhoods remains low. In contrast, their wealthier counterparts can obtain a better education because they have access to a car, which enlarges their scope for activity. Moreover, parents in higher socioeconomic groups can choose to live near schools of high quality, which may enable children to walk to school, or at least shorten the travel distance and time. In this respect, housing prices might increase, pushing families of lower socioeconomic status out of certain neighbourhoods, making social exclusion even worse. It needs to be recognized that mode choice is one indicator showing social exclusion. For example, for the students who have the same travel mode, they may actually be faced to different level of social exclusion due to their family situation or other factors.

From the ecological perspective, the continuing interactions between people and the environment could shape the social structure through complex processes such as concentration and segregation (e.g. Alihan, 1938, pp. 136–166). Different levels of environmental influences, especially the socio-economic and the policy factors are essential determinants of the school choice of children and their travel mode choice. In this sense, individual children's mode choice could be an indicator of the distribution of educational opportunities and the resources. The features of a child's mode choice could be used to investigate social exclusion caused by the distribution of education sources.

3. Literature review: Key factors in modal choice among children

Researchers have found that there are various factors influencing modal choices among children, especially the choice of active modes such as cycling and walking. The socio-ecological model is often applied to explain the determinants of physical activity (e.g. Green et al., 1996; Stokols et al., 1996). From the ecological perspective, physical activity links to the social and physical environment. Different levels of factors exert disproportional amount of influences on physical activity (Grzywacz and Fuqua, 2000). The influencing factors could be categorized into individual-level influences, household-level influences, surrounding environment influences and policy influences (see Fig. 1). The existing researches believe that the outcome of modal choice among children reflects the complex interactions between children and their surrounding environment. The following texts will review the existing literature on the multi-level determinants of modal choice among children from a socio-ecological perspective.

In this paper, individual characteristics and household features are internal factors. Surrounding environment and policy environment are seen as external factors. The surrounding environment refers to the broad living and studying environment the child is exposed to. It includes the built environment, the perceptive environment to children and their parents' mind. Community environment (e.g. the number of peers living with the child and crime rate of the community) and the school quality can be influential to form the perceptive environment. The local customs and the travel culture can be conductive to the modal choice and these variables also belong to surrounding environment. Following the surrounding environment, policies are another type of factor influencing children's travel mode. The policies usually include education, population, transportation and planning policies and legislation. These policies may constrain or promote school accessibility, affecting the modal choices of children.

3.1. Individual level

Demographic factors, referring to children's characteristics, are of relevance here, the most widely discussed of which are gender
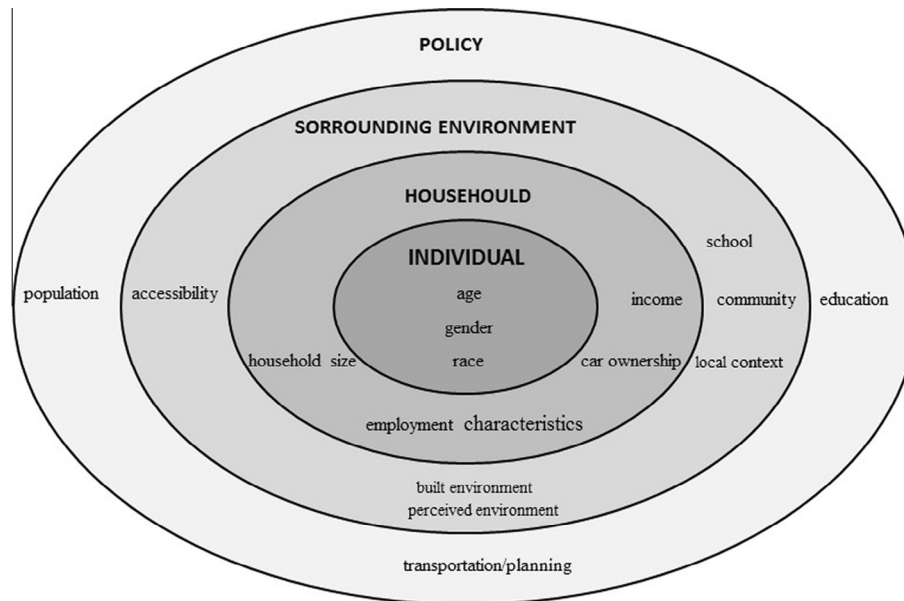
Fig. 1. Socio-ecological model of modal choice among children.

and age. Based on data analysis, most researchers believe that there is a positive relationship between age and the independent behaviour of students (Fyhri and Hjorthol, 2009; Yeung et al., 2008; Loo and Lam, 2013). Gender is another factor, but quite controversial. Some research has found that there is a significant difference in travel behaviour between gender, showing that girls are less likely to commute to school by foot or bicycle by themselves, especially at an early age (McMillan et al., 2006; McDonald, 2012). However, more nuanced conclusions have also been expressed. It has been found that when considering modal choice, parents are more sensitive when the child is a girl and when the child is younger; however, the differences between the sexes weakened as the children grow older (McDonald, 2012). Other individual factors such as race (McDonald, 2008c) and suburban/urban location (Mitra et al., 2010) are also mentioned in the previous studies. The minorities tend to travel more actively and similar conclusions have been reached in research within different regions (Bringolf-Isler et al., 2008; Pont et al., 2009; Wafa and Rachel, 2014).

3.2. Household level

The choice of school itself is a complex question (Van Goeverden and Boer, 2013) and the attributes of households acts a key role in the process of school choice. The choice of travel mode to and from school is in fact the outcome of school selection, accessible transport means and other factors. Moreover, the choice of school may be the result of a number of factors other than distance. Parents' perceptions can also moderate the selective process. Whether parents are willing to choose a school of higher quality for their children will depend on the extent to which parents think this is important. Factors such as the educational experience of the parents and the household income may also contribute to the choice.

Socioeconomic status (SES) is a variable that affects the specific choice set of a family, making it another factor to be included. Household income and car ownership are the two main factors to be considered in this respect (Pont et al., 2009; Roya et al., 2012). The higher monthly income and car ownership could lead to a higher dependence on car use among children.

The number of a child's siblings is another factor affecting his or her travel mode. Children with more siblings are found to depend

less on cars and siblings often play the role of these children's companies (McDonald, 2008b). The main reason for this is that the more children are going to school, the more difficult it will be for parents to send their children to distant schools individually (Van Goeverden and Boer, 2013).

In recent years, the spatial and temporal constrains of parents' employment have been increasingly considered (McDonald, 2008b; McDonald and Aalborg, 2009; Pooley et al., 2005; Wen et al., 2008; He, 2013). For dual-worker couples with children, it will be more inflexible to arrange joint trips and the children are more likely to travel by themselves without cars (He, 2013). But another research found that mothers commuting to work in the morning thought it is relatively less time-consuming and more convenient to drive their children to school (McDonald, 2008b). As a result, their children would have a higher level of car use.

3.3. Surrounding environment level

Some studies have provided evidence of school accessibility being a very important factor (Beck and Greenspan, 2007; Bringolf-Isler et al., 2008; Fyhri and Hjorthol, 2009; Pont et al., 2009). A study by Nelson reported that long travel distance is a significant barrier to active commuting for children. The distance of 2.5 miles was found to be a reasonable distance for adolescents to walk or ride a bicycle (Nelson et al., 2008). McDonald found that encouraging schools to be located near residential areas will encourage walking among children in the US (McDonald, 2008a).

An ascending number of researches devoted their attention to both built environment and the perceptive environment. The built environment, such as urban form, is more often discussed (Boarnet et al., 2005; Kerr et al., 2006; McMillan, 2005). Urban form can act on factors such as neighbourhood safety (real and perceived), traffic safety (real and perceived) and household options. These mediating factors may be moderated by other variables, such as social and cultural norms, parental attitudes and demographic elements, before the final decision of parents. There is a consensus that with improved traffic infrastructure projects, such as footpaths, traffic lights, pedestrian crossings and bicycle paths, children are more likely to commute to school on foot or by bicycle, which proves that the Safe Route to School programme in the United States is effective (Boarnet et al., 2005). Moreover, more sprawling cities

(Mitra et al., 2010; Loo and Lam, 2013) might discourage more children from walking or cycling to school. Apart from these factors, the real social environment should also be emphasized. Communities with lower crime rates (McDonald, 2012) and higher social cohesion (McDonald et al., 2010) may encourage more students to commute by walking and cycling.

Further research on the surrounding environment has also been extended to the notion of the perceived environment, and is even considered by some to be more important than the real environment (McMillan, 2007; Kerr et al., 2006; Lang et al., 2011; McDonald, 2010). McMillan, for example, describes how the real surrounding environment is translated into parents' perceptions (McMillan, 2007).

Some researchers have found that the local geographical and cultural contexts also affect children's mode choice for school trips. For example, the bicycle is prevalent in the Netherlands and Flanders in Belgium (Van Goeverden and Boer, 2013). This can be explained by the highly developed facilities for cycling in the two countries, unlike the US and other European countries. In addition, the travel distances for children in the former two countries are relatively short. The relatively undeveloped bus transport system in the two countries may also contribute to mode choice (Boer, 2010). Case studies such as this can help us gain a more comprehensive understanding of travel behaviour in the Western world.

3.4. Policy level

Some studies are focused on how the planning and transportation policies affect children's modal choice for their journey to school. School planning policy is often considered to play an important role in school accessibility, and thus modal choice. For example, McDonald (2008a) argued that school planning policies designed to achieve smart growth goals should also take distance from school to home into account. In particular, providing children with the opportunity to study in their local community school is a very important factor in reducing children's travel distances if the community density is high enough. Another study reveals that school consolidation policy could alter the students' travel mode and affect their school performance (Talen, 2001). As for the transportation policies, Safe Route to School in the US has often been discussed (e.g. Boarnet et al., 2005; McDonald and Aalborg, 2009). Although a consensus on the policy is absent, most researchers believe that policies like this are necessary to improve the active transportation among children. A recent study in UK found that the demand responsive transport service was the most important determinant to explain the travel pattern change among a group of students, and students living outside the service space may be excluded (Kamruzzaman et al., 2011). This is a solution to Lucas' (2003) concern about the deprivation of studying opportunities as a result of poor transport, but the sequent born excluded groups needs more attention.

3.5. Related studies in Asia

As for the research areas, the existing researches focus on the modal choices in the Western world and researches on travel behaviour among children in Asia are relatively rare. Some studies have reported an increasing trend in obesity and car use, for example in Tehran, Iran (Roya et al., 2012). Nevertheless, researches providing new perspectives on travel behaviour are relatively rare. A study in India (Dave et al., 2013) was conducted with the aim of developing more comfortable, safe and equitable transport in India. In Loo's study (Loo and Lam, 2013), accessible school opportunities were evaluated as an indicator of more equal school distribution, taking one of the compact cities in China, Hong Kong, as an example. This study has influenced later studies in mainland China, where an equitable provision of education has been stated to be highly significant, and where the population in large cities is extremely concentrated and unevenly distributed.

Travel behaviour among children has been ignored by researchers in mainland China for a long time. The few studies that have been done were conducted in the medical field, concerning health. Chinese children have been found to be unique among children in developing countries because they do not perform chores at home. Interestingly, compared to developed countries, children in China use bicycles or walking as the most common ways of commuting to school (Tudor-Locke et al., 2003). Another study has shown that active travel is common among children in Jiangsu Province and bicycle riding is the most common mode (Shi et al., 2006), in contrast to the Western world. However, not a single study has been conducted to determine the reasons underlying this relatively active behaviour in mainland China. This study attempts to fill the gap by investigating modal split among children and its determinants in China, using Beijing as a case study.

4. The city background and method

4.1. The city context

Beijing was chosen as an example for this study owing to its perfect reflection of the institutional and cultural dimensions of China. These factors are important in providing new evidence and a greater understanding of modal choices among children in mainland China.

The first important factor to consider is housing reform and its implications for the structure of the living environment in Beijing. Housing reform in China generated a new wave of movement from the central part of the city to fringe areas in Beijing (Li, 2004; Wang and Chai, 2009; Zhao et al., 2011) and the lag in infrastructure development has created many single-function living centres (Liu et al., 2009), consistent with the findings of poor accessibility to low-density public facilities as a result of urban sprawl in the US (Ewing, 2008). In the process of rapid urbanization, the uneven distribution of public infrastructure on the urban fringe of Beijing has made spatial inequity more severe (Gu and Shen, 2003; Zhao, 2013b). People living far from their work place will require longer travel times and may depend more on cars (Yang, 2006; Zhao et al., 2011). Generally speaking, housing reform has driven inhabitants outwards. With the best schools concentrated in the inner urban area and the educational centre in Haidian District, the availability of motorized vehicles (e.g. car, public transport) may determine to a large extent the potential schools that children can choose.

The second factor is the special education policies relating to school entrance in Beijing. This paper looks at students entering junior secondary school (year 7 to year 9) as an example. The principle rule applied to determine which junior secondary school a child goes to in Beijing is designed to ensure access to the nearest school (BMCE, 1996). This is done by computer allocation based on a student's residential location. However, various educational policies also offer pupils the opportunity to avoid their assigned school and choose a better school. The imbalanced spatial distribution of junior secondary schools of different quality also makes the policy's initial aim even more unachievable. Many parents are reluctant to accept the result of computer allocation, and their desire to ensure a better education for their children leads them to make use of the present policies rather than purchase expensive houses in the right zones.

For example, students can gain entrance to schools with a high reputation by attending assigned cramming schools and passing exams (*zhankengban*), or through a special talent (e.g. in playing a musical instrument, or playing sport; *techangsheng*). Moreover,

children of parents from certain national corporations and administrative sectors can enter directly into specific secondary schools (*gongjiansheng*). Parents can also pay entrance fees to obtain a place for their child in a key junior secondary school (*jiedusheng*) (21st Century Education Research Institute, 2011). A recent report found that the number of pupils entering junior secondary schools in a district different from the one recorded on his or her *hukou* amounted to 136,000, equivalent to 14.4% of the pupils with Beijing *hukou* (BAES, 2009). Diverse education policies and specific institutional characteristics in the transition period in China has meant that the automatic allocation policy has failed and many pupils enter better quality junior secondary schools through various means, while the others have no choice but to attend the allocated school.

The third and related factor is the *hukou* system itself, which can make social exclusion even worse. In Beijing, children without Beijing *hukou* are treated differently to those who have Beijing *hukou*. These children's parents are usually migrants from rural areas or members of the young middle-income groups working in the private sector, called 'white collars'. It is normal for the children of the former to enter junior secondary schools designated for them because of the difficulty in processing required permits (e.g. living permit, working permit, etc.). For the latter, a large number do not yet have children. By the time their children are ready for junior secondary school, many of them will have moved into a higher socioeconomic group. The only problem might be longer school travel distances.

The unique household culture of China may also be a contributing factor. Many consider that China's one-child policy has led to a spoiled generation, given superior material resources (Settles et al., 2013). In a more competitive era, children are also expected to perform well academically to guarantee their future success (Man, 1993), and today parents devote much of their leisure time and money to their child's education (Chen, 1986; Fong, 2002). School quality is thus given more value due to the competitive social environment and the high expectations of families, while home–school distance and transport to school are considered less important. As a result, many parents adjust their life patterns to provide better education for their children in many ways, such as renting houses near schools and, of course, chauffeuring their children to and from school.

4.2. Data and study area

The original study dataset come from the Third Travel Survey of Beijing Inhabitants (TS 2005), conducted by the Beijing Municipal Committee of Transport and Capital Planning Committee. TS 2005 includes 832,451 one-day travel activities reported by 208,290 inhabitants from 81,698 households, living in the 18 districts of Beijing. The total sample of TS 2005 is 1.5% of the population of Beijing, including those without *hukou*. In the survey, the members of the households selected were asked about their trip patterns on one day. In addition to travel information, such as travel distance, travel time, travel origin and destination, as well as travel modes, interviewees were also asked about related household characteristics, including the characteristics of all of its members, income, car ownership, and characteristics of the housing.

For the present research, the Core District of Capital Function (the city centre and the most urbanized area of Beijing, including Dongcheng District, Xicheng District, Chongwen District and Xuanwu District, for the core area below)[1] and the Urban Function Extended Districts (the peripheral suburb of Beijing,

including Chaoyang District, Fengtai District, Shijingshan District and Haidian District, for the function extended area below) (BMCDR, 2006) were chosen as the areas of study (see Fig. 2). Junior secondary school students aged 13–15 years old (junior secondary group defined by NBS, 2013) living in the study areas were selected, with the sample number of the final dataset 3267.

4.3. Method

Logit and nested-logit models are usually used in studies of modal choices among children. Nested-logit models are applicable when examining modal choices categorized into two types, such as independent and dependent travel behaviour (Lin and Chang, 2010). As mentioned above, the target group is junior secondary school students studying in Beijing, who are able to travel independently (Matthews, 1992). Therefore, the logit model was used in the study to uncover the relationship between school-housing distance and travel modal choices among children (Train, 2003).

The model assumes that the parents in a household n, choose the travel mode j for their children as a comprehensive consideration according to the surrounding environment, the SES of the household and the demographic characteristics of their children to achieve the maximum utility U_{nj}. The probability of choosing the mode j is:

$$P(n = j) = \frac{\exp(V_{nj})}{\sum_{l \in J} \exp(V_{nl})}$$

under the constraint condition, $U_{nj} = V_{nj} + \varepsilon_{nj}$,

where ε_{nj} is the error term distributed iid (independently and identically distribute).

5. Analysis

5.1. School accessibility and modal split

This section provides information about school accessibility and modal split among children living in Beijing. The information may offer some suggestions for deeper analysis in the following section.

All of the variables in the model are based on both a theoretical and empirical basis (see Section 2). As for the surrounding environment, the information about the built environment (e.g. population density, land use mix) should be considered at a micro level. However, it is impossible for the survey to include the scope of the entire city. Therefore, the location of the neighbourhood is measured by a dummy variable – whether it is in the core area of capital function or not – used to capture the heterogeneity of the surrounding environment on a crude scale.

Table 1 indicates that more than 50% of the respondents living in a core area go to schools within 2 km of their home. This is more than ten percent higher than their counterparts living in function extended areas. Notably, more than one quarter of students living in a function extended area travel more than 5 km to school. It is conspicuous that the junior secondary school distribution in the function extended area is more scattered than in the core area of capital function.

Table 1 also shows modal distribution for children living in different areas by travel distances. It illustrates that bicycle is the most important travel mode for both the function extended area and the core area. This finding is consistent with the results in the Netherlands (Van Goeverden and Boer, 2013). It also reflects the use of the bicycle by the general population in Beijing (Zhao, 2013b). Respondents tend to walk when the home-to-school distance is less than 1 km and bicycle is preferred when the travel distance is a little longer, especially between 1 and 3 km. If travel

---

[1] In 2010, Xuanwu District was consolidated into Xicheng District, and Chongwen District was consolidated into Dongcheng District.
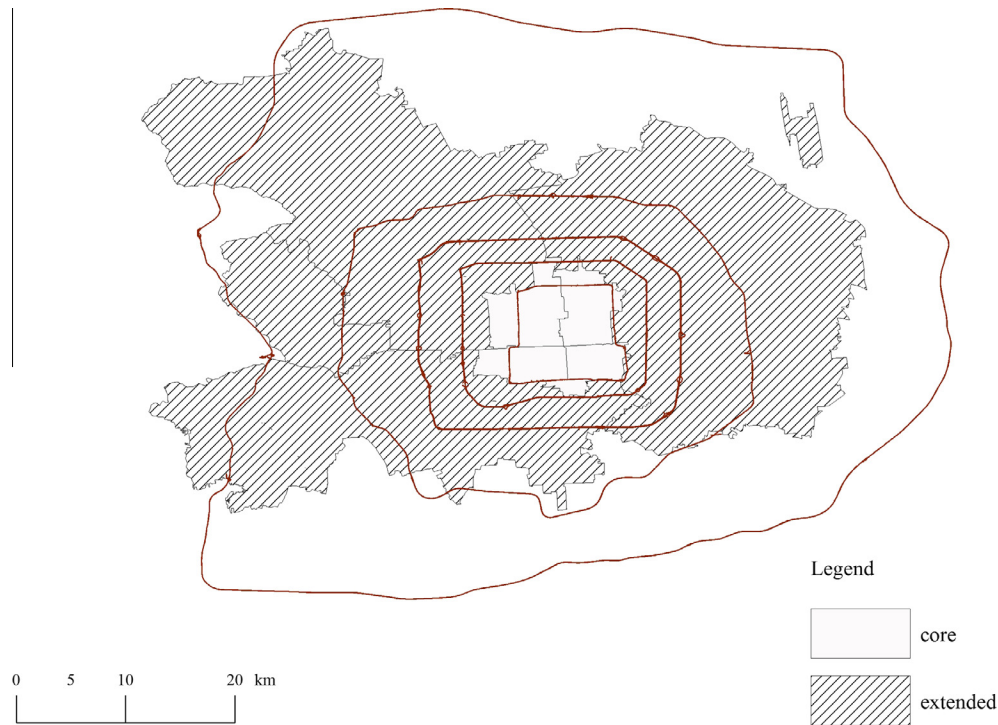
Fig. 2. Study areas.

Table 1
Modal split across distance groups and area (%).

Distance (km)	Core area						Extended area					
	Walk	Bicycle	Public transport	Car	Other	Total	Walk	Bicycle	Public transport	Car	Other	Total
<1	69.31	30.2	0	0	0.5	11.11	76.5	18.89	0.92	2.3	1.38	15.38
1–2	22.72	71.65	2.33	3.3	0	28.86	28.37	60.11	4.43	4.96	2.13	39.22
2–3	3.4	67.48	21.36	7.77	0	14.38	5.34	61.21	22.78	7.12	3.56	15.69
3–5	0.45	59.55	31.36	7.73	0.91	18.32	1.96	48.32	32.68	13.97	3.07	16.76
5–10	0	36.3	50.37	13.33	0	18.32	0.84	25.14	46.37	22.63	5.03	10.28
>10	0	8.57	54.29	31.43	5.71	9.01	0	5.68	49.43	34.09	10.8	2.67
Total	20.18	57.27	16.15	6.02	0.38	100	17.96	42.22	23.59	12.49	3.74	100

distance is longer than 3 km, public transport and car are used more, while bicycle use dramatically declines. In the core area, the bicycle is preferred more when the travel distance is shorter than 3 km, especially for students whose schools are located within 1 km of their homes. When the travel distance is longer than 3 km, public transport is used more than the car. However, it is apparent that trips taken by car by students living in the extended area are more usual compared with the core area. This echoes studies of Beijing that demonstrate that urban sprawl contributes to longer travel distances and a higher rate of car use (Yang, 2006; Zhao et al., 2011). If higher car use is significantly related to car ownership and income, it is possible that students in low-income households might be excluded from better education resources as a consequence of limited transport resources, one determinant of school accessibility. Moreover, even when the travel distance reaches 5 km, there is still a proportion of students who use a bicycle to commute to school. A summary of other variables is provided in Table 2. The data shown in the chart are consistent with findings on the general situation in Beijing.

5.2. Regression results

The data description above shows that modal split among children living within 3 km of school and their counterparts differ. Therefore, respondents are divided into two separate groups. The mode labelled 'others' were excluded from the model. The regression results are shown in Tables 3 and 4.

For respondents living within 3 km of school, distance is a significant reason for a declining rate of walking, consistent with a study in the US (McDonald, 2008a). When the travel distance reaches 2 km, there is a significant transfer to public transport. After controlling for other variables, the influence of age (or school level) and gender are significant. Respondents at higher levels of school and boys in the survey are more inclined to use the bicycle than other travel modes. The significant effects of income confirm that low-income households are more likely to walk rather than use the bicycle, and children from households with private cars are more likely to travel to school by car. Moreover, children from households of four and more people, perhaps households with more than one child, or with a grandparent, are more likely to walk than three-people households, when other variables are controlled. If four-people households in the survey are primarily those with more than one child, our findings are consistent with a study in the US that found a higher rate of walking to and from school for households with more siblings (McDonald and Aalborg, 2009). However, due to the higher numbers of elderly living with nuclear families in China, further research is needed to determine the precise relationship between household structure and travel mode choice.

Table 2
Descriptive summary of other variables.

Variable	Classification	Core district (1313 cases)	Percent	Extended area (1954 cases)	Percent	Total (3267 cases)	Percent
Gender	Male	697	53.08	972	49.74	1669	51.09
	Female	616	46.92	982	50.26	1598	48.91
Hukou status	Hukou	1236	94.14	1878	96.11	3114	95.32
	Without hukou	77	5.86	76	3.89	153	4.68
Monthly income (Unit: RMB)	<2500	577	43.95	852	43.69	1429	43.79
	2500–5500	576	43.79	875	44.87	1450	44.44
	>5500	161	12.26	223	11.44	384	11.77
Car ownership	Without car	920	70.07	1265	64.74	2185	66.88
	With car	393	29.93	689	35.26	1082	33.12
Household size	2	148	11.27	221	11.31	369	11.26
	3	895	68.16	1403	71.8	2298	70.34
	⩾4	270	20.56	330	16.89	600	18.36

Table 3
Regression results for home-to-school distances within 3 km (reference group: bicycle).

Mode	Walk			Public transport			Car		
	Coef.	Std. err.	$P > z$	Coef.	Std. err.	$P > z$	Coef.	Std. err.	$P > z$
Demographics									
14 years old	−0.362[**]	0.15	0.013	−0.309	0.234	0.185	0.001	0.293	0.997
15 years old	−0.449[***]	0.14	0.001	−0.452[***]	0.223	0.043	−0.56[*]	0.296	0.057
Male	−0.295[**]	0.118	0.012	−0.513[***]	0.190	0.007	−0.793[***]	0.25	0.002
Household characteristics									
Income <2500 RMB	0.412[***]	0.132	0.002	−0.152	0.21	0.462	−0.099	0.32	0.757
Income >5500 RMB	0.299	0.201	0.136	−0.151	0.36	0.671	0.374	0.295	0.206
Car	−0.050	0.14	0.971	−0.680[***]	0.25	0.005	4.102[***]	0.603	0
Household size = 2	0.169	0.183	0.356	0.195	0.286	0.496	0.506	0.372	0.173
Household size ⩾ 4	0.293[*]	0.151	0.052	0.218	0.241	0.37	−0.040	0.332	0.905
Distance (km)									
1–2	−2.104[***]	0.139	0	0.919	0.74	0.21	0.301	0.5	0.545
2–3	−3.849[***]	0.253	0	2.832[***]	0.73	0	0.810	0.512	0.113
Surrounding environment									
Extended area	−0.425[***]	0.118	0	−0.466[**]	0.19	0.02	−0.477[*]	0.250	0.057
Policy									
Hukou	−0.142	0.262	0.587	−0.293	0.460	0.528	−0.118	0.649	0.856
_cons	1.600[***]	0.320	0	−2.72[***]	0.862	0.002	−5.196[***]	1.010	0
n	1959								
Chi^2	928.44								
P	0								
Log likelihood	−1521.905								
Pseudo R^2	0.2337								

[*] Significance at 1% level.
[**] Significance at 5% level.
[***] Significance at 10% level.

The surrounding environment, presented by the dummy variable 'function', is significant among the groups who walk or take public transport, but not the bicycle. Children living in a core area have a tendency towards bicycle use for travel to school rather than other modes. This implies that in the extended area, the environment is not so conducive to cycling, which has been proven in previous research, which found that less diversity of land use and worse jobs-housing balance account for less likelihood of cycling in Beijing (Zhao, 2013a). *Hukou* is not significant after controlling for other variables. The regression results for children who need to travel longer than 3 km are shown in Table 4.

For distance variables, there is a significant modal split across the different groups. A longer distance contributes to a higher rate of use of motorized vehicles. Age is insignificant as a determinant of modal split. Boys are more likely to cycle to school than girls. *Hukou*, monthly income, car ownership and household structure all act significantly on the modal split between public transport and car. Children from high-income households or households with private cars are more likely to travel by car than public transport. Interestingly, children from households with two people, in most cases defined as 'single-parent

households', are more likely to travel to school by car. As for *hukou* status, students without hukou are more likely to go to school by public transport.

The regression results in Table 4 concerning household characteristics are more significant compared to those in Table 3. This suggests that the effect of household characteristics on modal split grows as the distance from home-to-school increases. For children travelling more than 3 km from home to school and living in the function extended area, the car is more likely to be used (compared to public transport) than it is by those living in the core area, similar to the finding in Table 4. It is clear that the presentation of modal split for different distance groups is distinctly diverse. For the group within 3 km, 2 km is an important turning point, before which we find a split between bicycle and walking, and after which a significant increase in use of motorized vehicles is observable. By contrast, the other group tells us a different story, where the focus is a split between car and public transport use, which is related more to socioeconomic and institutional (e.g. *hukou*) variables. For both distance groups, it is worth discussing how we might achieve a more inclusive society for children, from the perspective of modal split.

Table 4
Regression results for home-to-school distances greater than 3 km (reference group: public transport).

Mode	Walk			Bicycle			Car		
	Coef.	Std. err.	$P > z$	Coef.	Std. err	$P > z$	Coef.	Std. err	$P > z$
Demographics									
14 years old	−0.751	0.875	0.391	0.259	0.190	0.172	−0.220	0.252	0.383
15 years old	−0.716	0.709	0.312	0.257	0.165	0.121	−0.256	0.213	0.228
Male	−1.317	0.8	0.1	0.572[***]	0.138	0	0.009	0.186	0.960
Household characteristics									
Income <2500 RMB	−1.035	0.678	0.127	−0.156	0.152	0.302	−0.614[***]	0.232	0.01
Income >5500 RMB	−14.669	1154.862	0.99	0.274	0.246	0.911	0.454[*]	0.253	0.07
Car	−0.005	0.737	0.995	0.077	0.168	0.650	2.637[***]	0.221	0
Household size = 2	1.055	0.727	0.147	−0.078	0.232	0.737	0.536[*]	0.308	0.083
Household size ⩾4	−14.666	1045.725	0.989	−0.075	0.18	0.675	−0.282	0.259	0.275
Distance (km)									
3–5	16.127	1308.487	0.99	2.547[***]	0.311	0	−0.539[**]	0.256	0.04
5–10	14.747	1308.488	0.991	1.552[***]	0.315	0	−0.335	0.240	0.162
Surrounding environment									
Extended area	−1.713	1.068	0.109	0.260[*]	0.145	0.072	0.461[*]	0.221	0.037
Policy									
Hukou	14.195	1941.971	0.994	0.386	0.342	0.260	1.142[**]	0.482	0.018
_cons	−31.617	2341.664	0.989	−2.942[***]	0.480	0	−2.698	1.595	0.5
N		1226							
Chi²		544.94							
P		0							
Log likelihood		−1063.039							
Pseudo R^2		0.204							

[*] Significance at 10% level.
[**] Significance at 5% level.
[***] Significance at 1% level.

6. Discussion and policy implications

By taking various aspects of the variables into account, the study shed light on modal split among junior secondary school students in Beijing with a mixed institutional and cultural context. With respect to children living within 3 km of school, we found that children from low-income families are more likely to walk, indicating a disadvantageous environment for bicycling to some extent. As for their counterparts, children from households with higher socioeconomic status, with private cars and Beijing *hukou* are more likely to travel by car, a reflection of a different level of school accessibility. Both groups demonstrate social exclusion.

Various educational policies allow junior secondary school students some degree of choice of school. However, these opportunities are limited, which may contribute to fierce competition among children. The uneven distribution of key junior secondary schools means children living in the function extended area suffer from higher travel costs. For children coming from low-income households, transport accessibility can be a major barrier to better education. This is partly supported by an empirical study of a voucher policy in the city of Milwaukee in the US aimed at encouraging children from low-income households to enter private schools. The study found that 8% of the households refused the opportunity because of problems related to the accessibility of the schools (Peterson et al., 2002).

Above findings suggest there be at least two ways of improving children's school accessibility. One could be to increase the number of schools across different function areas in Beijing, taking school quality into account. In addition, the policy of allowing students to enter junior secondary school by special means may in fact be a way of excluding those who cannot afford the expensive fees and transport costs. One possible outcome is that students from lower socioeconomic backgrounds are constrained to attend schools close to their home, while those from high-income households have more freedom to attend schools with better resources,

regardless of the high costs of travel, in terms of time and money. In other words, only those from households with a higher socioeconomic status have the opportunity to enter key schools. This has been called the 'cream-skimming effect' of private schools in the US (Fuller and Elmore, 1996). This effect, partly related to the unequal distribution of transport resources, should be considered more closely, both by policymakers and researchers, to better understand how it generates a potential sorting effect according to the socioeconomic status of students.

The other may be to enhance transport services for children. This study shows that transportation planning should take children's special needs into consideration if possible. In particularly, it is essential to note that public transport should be improved. As analyzed previously, the underdevelopment of public transport services can partly account for the increasing use of cars by children in the function extended area. Unlike the US, and some European countries such as the Netherlands, whose public transport systems are undeveloped for various reasons, Beijing should depend more on public transportation to handle traffic congestion and traffic pollution in the long term as a compact city. Therefore, it is of vital importance to provide various public transportation facilities in the function extended area, which can greatly contribute to real school distribution equity across different groups of students, expanding their school options, especially for those from low-income households.

Car ownership is another issue. Although it is important to encourage public transit-oriented development in Beijing as a preferable transport mode in the future, there is no doubt that access to a private car can increase the travel scope of children and expand their school choices, especially in the present situation, where public transport is relatively poor in the function extended area. Without a car, especially in areas where transport accessibility is poor, children face big obstacles to a better education. In this respect, it is important that residents without Beijing *hukou* should have the right to have a car licence. Future urban planning and

school planning should avoid the concurrent existence of spatial segregation and socioeconomic segregation, which has been found in other research (Zhao, 2013b).

Finally, it is worth noting that even for shorter travel distances the bicycle is used less in the function extended area. The findings in this study show that the surrounding environment – a crude compound of many variables such as population density, road flatness and jobs-housing imbalance – in the function extended area discourages children from cycling, echoing the findings of Zhao (Zhao, 2013a). Notably, it is very important to advocate cycling as one of the effective means to sustain an environmentally friendly transport system in Beijing.

7. Conclusions

This study found that the specific institutional and cultural context in Beijing is an important determinant of school accessibility and modal split for junior secondary school students. Students are travelling longer distances as a result of housing reform and the uneven distribution of key schools, especially students living in the function extended area. For the group with travel distances of less than 3 km, 2 km is a transitional point and the bicycle is the most used mode. In circumstances where travel distances are longer than 3 km, public transport use increases. Relatively active travel behaviour is found among junior secondary school students in China. Notably, car use in Beijing for the trip to school is significantly related to household characteristics, which is a reflection of modal split. Moreover, the variation in bicycle use across different function areas is also significant.

For the group travelling further than 3 km, discussion should focus on the determinants of public transport and car use. There is a conspicuous split between these two modes dependent on the socioeconomic status of a household. Children with Beijing *hukou*, from high-income households and with private cars are more likely to travel to school by car. Moreover, although the rate of car use among children for longer travel distances is higher in the function extended area, children living there depend more on public transport. The results of two logit regression models show that modal split across different social groups is more evident in this group with a greater school–home distance.

Further research is needed to fill the following gaps. Firstly, travel behaviour should be considered in relation to more educational factors, such as school choice, school quality and the spatial distribution of educational opportunities, to determine the level of mismatch between home and schooling. Secondly, the internal links between travel distance, travel time, transport accessibility, school accessibility and school achievement should be further explored through the development of a specific model that can assist us to better understand the modal split and distance sorting to improve social inclusion.

Acknowledgements

References

21st Century Education Research Institute, 2011. The Way to Management on the School Selection Entering Junior High School in Beijing (in Chinese).

Alihan, M., 1938. Social Ecology: A Critical Analysis. Columbia University Press, New York.

Beijing Academy of Educational Science (BAES), 2009. Research Report on Educational Development in Beijing, 2008. Beijing Press.

Beck, L.F., Greenspan, A.I., 2007. Why don't more children walk to school? J. Saf. Res. 39 (5), 449–452.

Beijing Municipal Bureau of Statistics, 2013. NBS Survey Office in Beijing. Beijing Statistical Yearbook 2013. China Statistics Press.

Black, C., Collins, A., Snell, M., 2001. Encouraging walking: the case of journey-to-school trips in compact urban areas. Urban Stud. 38 (7), 1121–1141.

Beijing Municipal Commission of Development and Reform (BMCDR), 2006. Functional Region Development Planning in the Period of the 11th Five Years Plan (in Chinese).

Beijing Municipal Commission of Education (BMCE), 1996. Advice on the Reform of Entrance to Junior High School in Beijing 1996 (in Chinese).

Boarnet, M.G., Anderson, C.L., Day, K., et al., 2005. Evaluation of the California Safe Routes to School legislation: urban form changes and children's active transportation to school. Am. J. Prev. Med. 28 (2), 134–140.

Boer, E. de, 2010. School 2010. Concentration and School Travel. TRAIL Research School, Delft.

Boschmann, E.E., Kwan, M.P., 2008. Toward socially sustainable urban transportation: progress and potentials. Int. J. Sustain. Transport. 2 (3), 138–157.

Bringolf-Isler, B., Grize, L., Mäder, U., et al., 2008. Personal and environmental factors associated with active commuting to school in Switzerland. Prev. Med. 46 (1), 67–73.

Chen, K., 1986. A Study of Current Only-Child Families in PRC: A Survey of 1180 Families in the Urban and Suburban Areas of Beijing. ASP Association Paper.

Dave, S.M., Raykundaliya, D.P., Shah, S.N., 2013. Modeling trip attributes and feasibility study of co-ordinated bus for school trips of children. Procedia – Soc. Behav. Sci. 104, 650–659.

Ewing, R.H., 2008. Characteristics, causes, and effects of sprawl: a literature review. In: Urban Ecology. Springer, US, pp. 519–535.

Fong, V.L., 2002. China's one-child policy and the empowerment of urban daughters. Am. Anthropol. 104, 1098–1109.

Fuller, B.F., Elmore, R., 1996. Who Chooses? Who Loses? Culture, Institutions and the Unequal Effects of School Choice. Teachers College Press, 1234 Amsterdam Ave., New York, NY 10027.

Fyhri, A., Hjorthol, R., 2009. Children's independent mobility to school, friends and leisure activities. J. Transp. Geogr. 17 (5), 377–384.

Green, L.W., Richard, L., Potvin, L., 1996. Ecological foundations of health promotion. Am. J. Health Promot. 10 (4), 270–281.

Grzywacz, J.G., Fuqua, J., 2000. The social ecology of health: leverage points and linkages. Behav. Med. 26 (3), 101–115.

Gu, C., Shen, J., 2003. Transformation of urban socio-spatial structure in socialist market economies: the case of Beijing. Habitat Int. 27 (1), 107–122.

Hanson, Susan, Giuliano, Genevieve (Eds.), 2004. The Geography of Urban Transportation. Guilford Press.

He, S.Y., 2013. Will you escort your child to school? The effect of spatial and temporal constraints of parental employment. Appl. Geogr. 42, 116–123.

Johnston, R.J., Gregory, D., Pratt, G., Watts, M. (Eds.), 2000. The Dictionary of Human Geography, fourth ed. Blackwell, Oxford.

Kamruzzaman, M., Hine, J., Gunay, B., et al., 2011. Using GIS to visualise and evaluate student travel behaviour. J. Transp. Geogr. 19 (1), 13–32.

Kerr, J., Rosenberg, D., Sallis, J.F., et al., 2006. Active commuting to school: associations with environment and parental concerns. Med. Sci. Sports Exerc. 38 (4), 787.

Lang, D., Collins, D., Kearns, R., 2011. Understanding modal choice for the trip to school. J. Transp. Geogr. 19 (4), 509–514.

Li, S., 2004. Residential Mobility and Urban Change in China: What have we learnt so far? Centre for China Urban and Regional Studies, Hong Kong Baptist University.

Lin, J.J., Chang, H.T., 2010. Built environment effects on children's school travel in Taipei: independence and travel mode. Urban Stud. 47 (4), 867–889.

Lin, J.J., Huang, Y.C., Ho, C.L., 2013. School accessibility and academic achievement in a rural area of Taiwan. Child. Geogr., 1–17.

Liu, Z.L., Zhang, Y., Chai, Y.W., 2009. Home-work separation in the context of institutional and spatial transformation in urban China: evidence from Beijing household survey data. Urban Stud. 16 (9), 110–117 (in Chinese).

Loo, B.P.Y., Lam, W.W.Y., 2013. Does neighbourhood count in affecting children's journeys to schools? Child. Geogr., 1–25.

Lucas, K., 2003. Making the connections: final report on transport and social exclusion.

Lucas, K., Jones, P., 2012. Social impacts and equity issues in transport: an introduction. J. Transp. Geogr. 21, 1–3.

Mackett, R.L., 2002. Increasing car dependency of children: should we be worried? Proc. ICE-Munic. Eng. 151 (1), 29–38.

Man, G., 1993, April 21. 80% of Pupils go to Sunday School. Beijing Daily, p. 3.

Matthews, M.H., 1992. Making Sense of Place: Children's Understanding of Large-scale Environments. Barnes & Noble Books.

McDonald, N.C., 2008a. Children's mode choice for the school trip: the role of distance and school location in walking to school. Transportation 35 (1), 23–35.

McDonald, N.C., 2008b. Household interactions and children's school travel: the effect of parental work patterns on walking and biking to school. J. Transp. Geogr. 16 (5), 324–331.