Residential Segregation, Built Environment and Commuting Outcomes: Experience from Contemporary China

Pengyu Zhu*[1], Songnian Zhao[2], Yanpeng Jiang[3]

1. Hong Kong University of Science and Technology
2. Shenzhen University
3. East China Normal University

* Corresponding Author

Email: pengyuzhu@ust.hk

NOT final published version.

Highlights:

1) Apply a Structural Equation Model to estimate multi-directional relationships between residential segregation, built environment and commute outcomes.

2) Both residential segregation and built environment have significant causal impact on migrants' commute distance and duration.

3) Commute outcomes significantly affects migrants' choice of built environment features.

4) However, job accessibility is *not* a major driver for migrant workers' residential segregation in urban villages.

Abstract

This research is one of the few studies to investigate the mutual impact between residential segregation and the commuting outcomes of minority groups in the context of a developing country. Based on previous empirical studies that acknowledged the interactions between the built environment and travel behavior, we develop a Structural Equation Model to illustrate the multi-directional relationships between residential segregation, the built environment and commute outcomes. With survey data collected from migrant workers in 12 Chinese cities, we apply this model to estimate these complex mutual relationships. Our major findings include: 1) Both residential segregation and the built environment have significant causal impact on migrants' commute distance and duration. Distance from home to downtown has the strongest causal effect on commute outcomes, while residential segregation in urban villages ranks the second. 2) Residential sorting is observed. Commuting distance and duration significantly affects migrants' choice of built environment features. 3) However, commuting outcomes are *not* a major (or statistically significant) driver of migrant workers' residential segregation in urban villages. In other words, their choice to reside in urban villages is inelastic to the commuting outcomes of these villages. Other factors such as housing affordability may be more influential. Therefore, demolishing urban villages under "urban renewal" policies will force migrants to relocate to more remote areas with worse job accessibility. These findings have important implications for recently proposed urban renewal policies that are bringing large-scale changes in China. They also offer important insights for other developing countries that are experiencing rapid urbanization. Finally, the framework of this study can be generalized and applied to other countries to examine similar urban issues.

1 Introduction

Residential segregation is observed in many countries across the globe. The reasons for this phenomenon vary by country: in some places, segregation is due to economic factors and institutional constraints in the housing market (e.g., China) (Wang et al., 2009; Wu, 2004, 2006; Zhu 2016), while in others, it may be due to racial discrimination or land regulations (e.g., the U.S.) (Ihlanfeldt, 1997; Ihlanfeldt and Sjoquist, 1998, Logan, Alba, and Zhang, 2002; Andrew et al., 2011). Residential segregation can take the form of formal urban settlements such as ethnic enclaves in developed countries (Zhu et al. 2014), or informal urban settlements such as slums in developing countries. There is another type of informal urban settlement in many Chinese cities called urban villages (Zhu 2016). Urban villages are pre-existing rural settlements enveloped by new urban districts due to rapid urban expansion. They can exist in both inner city and periphery areas. Because of rising land premiums, urban villages in inner city areas have gradually been demolished and replaced with medium-high-rise commercial and residential buildings. These projects are often carried out as part of Urban Renewal Programs led by local governments, and involve collaboration with real estate developers and the villagers (i.e., the owners of the urban village land) (Wang et al. 2017) .

Urban villages are home to many migrants born in rural areas who now live and work in cities. The residential segregation of these migrants in urban villages is a result of both economic and institutional constraints. From an economic perspective, migrant workers, who usually have limited education, tend to take up low-skilled jobs when they come to work in the cities. Most are unable to afford expensive commercial apartments. From an institutional perspective, the current household registration regulations (i.e. *hukou* system) disqualify migrants from buying, or even renting government-subsidized low-income housing. Under national policies to maintain housing market stability and affordability, many cities have adopted strict regulations to prohibit non-locals from purchasing property. Residents without a local *hukou* are not allowed to purchase commercial apartments in many first- or second-tier cities.[1] Due to these constraints, rural migrants have limited choices in the housing market, and thus often reside in informal urban village housing where housing costs are low.

Residential segregation has many outcomes, one of which is its influence on commuting. As early as 1968, John Kain first proposed the Spatial Mismatch Hypothesis (SMH), stating that discrimination and segregation in housing markets, coupled with employment decentralization, reduce job accessibility for racial minority groups residing in inner cities. Since then, the spatial mismatch hypothesis has been extended from African Americans in the United States to other racial/ethnic minorities or immigrant groups in a variety of countries. For example, studies found that

[1] There are two major types of housing in China: 1) commercial apartments built by private developers that are generally freely tradable in the housing market; 2) government-subsidized low-income housing that tends to be restricted to local households only and is non-tradable for fixed number of years.

immigrants in the U.S. living in inner city areas experience residential segregation and limited mobility, and hence are geographically separated from widely dispersed blue-collar job opportunities (e.g., Kasarda and Ting, 1996; Ihlanfeldt, 1997; Raphael, 1998, Zhu et al. 2014).

While the literature has generally concluded that residential segregation impairs job accessibility for racial/ethnic minorities or immigrants in the U.S., and hence increases the costs of commuting for this group, empirical research is scarce in the context of developing countries such as China. In the China-based literature, while there are studies on job accessibility, there are few addressing specifically the residential segregation of marginalized populations and how this affects job accessibility and commuting outcomes. Therefore, the *first* objective of this research is to investigate how residential segregation in urban villages affects the commuting outcomes of rural migrant workers, as measured by commute distance and time. Our hypothesis is similar to the spatial mismatch hypothesis (SMH); that is, that segregation in urban villages may impair job accessibility and therefore lead to longer commutes for their residents.

Spatial mismatch theory asserts that constrained housing choices (i.e., residential segregation) leads to limits accessibility to suitable jobs. Traditionally, job accessibility is often measured by the number of jobs within a radius or travel time from one's home (Matas et al., 2009). While this traditional method can reflect the ease of access to all potential job opportunities, it may not be able to fully account for whether a worker's skillset matches what nearby jobs require (Zhu et al. 2020). For instance, minority groups or migrants are usually low-skilled and less educated; it is possible that the area where they live has a large number of white-collar jobs, but a low number of blue-collar jobs they are qualified for. They may therefore still have to travel a long way to work where low-skill jobs are offered. It is not the overall number of available jobs that matters, but the number of suitable jobs that match with the workers' skillsets. Hence, instead of using potential job accessibility measures, we look directly at how actual commute distance and time are affected by residential segregation.

In examining residential segregation, it should be acknowledged that people often voluntarily choose to live in neighborhoods with features desirable to them; in other words, residential segregation may be to some degree self-selected. There are generally two social and economic reasons for Chinese rural migrants to self-select to live in urban villages. First, they may want to maintain closer ties to their preferred social networks by living in a community with people from the same hometown. Such connections could be advantageous for developing a career or finding a spouse. Another reason migrant workers may voluntarily choose to live in urban villages is to enjoy the cheaper rent while maintaining relatively good access to a variety of destinations. Both reasons represent sources of endogeneity in our analyses, which could potentially bias the results. Empirically, many studies point out that residential segregation of minorities, including immigrants, is correlated with longer commutes (e.g., Holzer, 1991; Holzer et al., 1994; McLafferty and Preston, 1996; Liu 2009; Zhu et al. 2014; Zhu et al. 2017).

However, few have addressed the self-selection bias inherent in their residential location choice, and hence are unable to test the causal impacts of residential segregation on their commute outcomes or commuting behavior.

Self-selection is not only associated with residential segregation. People might also self-select into certain neighborhoods because of the built environment features. For example, researchers have emphasized that there exists an interaction between built environment features and commuting behavior. Commuting behavior could be affected by built environments, hence when people are choosing where to live, they may look for specific built environment features that are convenient for their preferred commute modes. Ignoring self-selection when analyzing the built environment-travel behavior relationship may lead to biased estimates (Cao, 2015). This notion has been empirically proven, using methods that include structural equation models and quasi-longitudinal analyses (see for example, Handy and Mokhtarian, 2005; Cao, Mokhtarian & Handy, 2007; Van Acker and Witlox, 2011).

Given all these complications, the *second* objective of this research is to apply a Structural Equation Model (SEM) to identify the causal relationships between residential segregation, the built environment, and commuting outcomes. We try to identify the mutual impacts between each pair of these features. The rest of this paper is structured as follows. Section 2 provides a review of empirical studies examining any connections between residential segregation, the built environment, and commuting behavior. Section 3 introduces the methodology and data collected, and Section 4 presents the modeling results, followed by a conclusion and discussion in the final section.

2 Literature Review

2.1 Mutual impacts between residential segregation and commuting behavior

Previous studies have widely discussed the correlation between residential segregation and commuting behavior. The problem of residential segregation is traditionally associated with racial discrimination against minorities in the housing market. Minority groups tend to stay in ethnic neighborhoods even when their socioeconomic statuses have improved (Wilson and Portes, 1980; Alba et al., 1999; Logan, Alba and Zhang, 2002; Allen and Turner, 2009). In fact, living in ethnic communities not only provides minorities with better access to goods and services suited to their tastes and needs, it can also benefit immigrants by facilitating socioeconomic assimilation (into the host society) and providing jobs and housing, especially during economic recessions (Turner et al., 2002; Charles, 2001; Elliott and Sims, 2001; Parks, 2004; Zhu et al., 2014). Like immigrants in America, rural migrants in China are excluded from several segments of the local housing market (Zhao and Lu, 2010). Therefore, they tend to form their own communities and build social networks with people sharing the same backgrounds (Zhu, 2016).

A phenomenon known as "Spatial Mismatch" (SM) emerges when residential segregation is coupled with employment decentralization, impeding job accessibility of inner-city minority groups. Kain (1968) found that African Americans residing close to city centers endured longer commutes as jobs moved to the suburbs. Some researchers consider racial discrimination a barrier to employment opportunities (Ellwood, 1981; McLafferty, 1997; Hellerstein et al., 2008). Many studies have examined the impact of commute modes. Results show that the lack of efficient public transportation from inner cities to employment centers in the suburbs as well as limited car ownership constrain employment potential and reduce employment quality (Sanchez, 1999; Raphael and Rice, 2002; Hanson and Pratt, 1995). This is known as auto mismatch or transport mismatch (Grengs, 2010; Raphael and Stoll, 2001; Taylor and Ong, 1995). This stream of spatial mismatch research has extended to different contexts around the world throughout the years (Ihlanfeldt and Sjoquist, 1998; Houston, 2005).

Traditionally, residential segregation research only focused on communities of African Americans. Recently, more studies have extended their investigations to immigrants and other minority groups, using residence in ethnic enclaves as a measure of residential segregation. It was found that minority groups living in enclaves had longer commutes than their counterpart as their jobs were often far away from their homes (Gottlieb and Lentek, 2001; Shen 2001; Liu 2009; Zhu et al., 2014). They were very dependent on public transportation (Myers, 2001; Purvis, 2003; Bumenberg and Shiki, 2008; Heisz and Schellenberg, 2004; Bumenberg and Shiki, 2007), while carpooling was also a favorable option as they were likely to travel to and from common locations (Kim, 2009; Blumberg and Smart, 2010; Charles and Kline, 2006; Blumberg and Smart, 2014). Nevertheless, some newcomers assimilate American car culture and start driving to overcome geographical barriers in job accessibility (Blumenberg and Shiki, 2007; Blumenberg and Smart, 2010; Raphael and Rice, 2005; Ong and Miller, 2005). However, China seemed to show quite the opposite pattern. Previous work by the author shows that the commute distance and time for urban village residents was shorter than for those in other neighborhoods (citation deleted for review).

On the flip side, it has been demonstrated that commuting patterns or mode preferences may also affect the choice to live in segregated settlements (Clark 1986, 1988; Galster, 1988; Marcuse, 2001; Pascal 1978). Similarly, rural migrant workers in China may prefer residential segregation in urban villages due to their special travel needs and heavy dependency on public transit. So far, there have not been sufficient empirical studies to examine the mutual impacts between residential segregation and commuting behavior in the context of rapid urbanization in a developing country.

2.2 Mutual impacts between built environment and commuting behavior

Previous research has examined how various built environment features impact commuting behavior, among which, density, design, diversity, and accessibility were the most frequently discussed (Cervero and Kockelman, 1997; Boarnet and Sarmiento, 1998; Cao, Mokhtarian and Handy, 2007; Grengs, 2010; Ye and Titheridge, 2017; Hu et al. 2018, 2020; Guerra, et al. 2018; Dissanayake et al. 2018). Some studies have addressed the endogeneity problem associated with people's choices of residential neighborhoods by eliminating biases of self-selection (Schwanen and Mokhtarian, 2005; Cao, et al., 2006; Bhat and Guo, 2007; Cao, et al., 2007; Cao, Mokhtarian and Handy, 2009).

Density measures intensity of land use. Activities and buildings are closer to each other in high-density neighborhoods, and long commutes are associated with low density (Cervero and Kockelman, 1997; Milakis et al., 2005; Cervero and Murakami; 2010; Van Acker and Witlox, 2011). Consequently, people living in low-density neighborhoods tend to have higher incentives to travel by private vehicle to shorten commute time (Cervero, 1996; Camagni et al., 2002; Handy et al., 2002). In contrast, lower car ownership and vehicle miles traveled (VMT) were found in high density areas (Levinson and Kumar, 1997; Litman, 2005; Brownstone and Golob, 2009; Zhu and Mason, 2014).

Diversity of land use is another factor that influences commuting behavior. It was found that a greater mix of land use reduces commute distances as a variety of activities are offered within a short distance (Cervero and Kockelman, 1997; Schwanen and Mokhtarian, 2005). Diversity also affects commute mode. If the mix of land use is more diverse, non-motorized transportation usage increases (Van Acker and Witlox, 2011; Cervero, 1996; Schwanen and Mokhtarian, 2005; Cao, Handy and Mokhtarian, 2009).

Design refers to the built environment conditions in terms of the development or attractiveness of certain commute modes. A neighborhood can be automobile-oriented, transit-oriented or multi-modal oriented. Some studies have compared American cities with different design settings and found that a transit-oriented design tends to be pedestrian-friendly, which affects commute mode choice for a given range of distance (Cervero and Radisch, 1996; Cervero and Kockelman, 1997; Litman, 2005). Neo-traditional design was shown to have lower VMT, compared with more conventional design in the Irvin County, California, as drivers enjoyed higher flexibility in choosing routes (McNally and Ryan, 1992).

Accessibility is another crucial built environment attribute impacting commuting behavior. Lower VMT and shorter commute time is observed in neighborhoods with higher accessibility (McNally and Ryan, 1992; Cervero and Kockelman, 1997; Handy, Cao and Mokhtarian, 2005; Grengs, 2010; Schwanen et al., 2002). Some studies focused on the impact of accessibility on commute mode choice. It was found that poor accessibility encourages the use of private cars over public transportation (Krizek, 2003; Grengs, 2010). Conversely, neighborhoods with high accessibility often are equipped with a more developed and extensive public transit network, which promotes the use of public transportation (Cervero and Radisch, 1996; Bernick and Cervero, 1997; Schwanen et al. 2002; Tsai, 2009; Van Acker and Witlox, 2011, Liu and Painter, 2012; Clark et al., 2016).

In the meantime, some studies have confirmed that commuting patterns in turn affect residential location choices, in the sense that individuals may self-select to reside in neighborhoods with their preferred built environment features (Ommeren 1999; White, 1977). The availability of various commute modes is a crucial factor in such decisions. Personal preferences can relate to residential sorting too. People who prefer non-motorized commute modes tend to choose residential locations with high diversity in land use, a suitable design, and proximity to jobs (Cervero and Duncan, 2003; Krizek, 2003; Schwanen and Mokhtarian, 2005; Cao, et al., 2006; Cao, et al., 2007; Bhat and Guo, 2007; Tsai, 2009; Cao, et al., 2009). For immigrants, as some cannot afford private vehicles, especially during their early stage of immigration, many prefer to live in ethnic communities where various commute modes are available (e.g., carpooling) (Smart, 2010; Tal and Handy, 2010). Likewise, rural migrant workers in China may also self-select to live in urban villages where public transit networks are usually accessible.

2.3 Impacts of social capital and demographics on commuting behavior and residential segregation

Exogenous variables, such as demographics, educational level, marital status and social networks, may have different effects on migrant workers' commuting behavior and their choice of residential locations. Many studies consider the educational attainment of minority immigrants the reason for residential segregation (Preston et al.,1998; Balakrishnan and Hou, 1999; Zavodny, 1998). Migrant workers with more education tended to be more geographically dispersed (Bartel, 1989; Åslund, 2005). They are likely to have longer distances and time (Oliveira et al., 2015; Zhu et al., 2017). Some Chinese researchers use travel data in China to suggest that income, education, and age are positively related to commute distance (Cao and Yang, 2017; Feng et al., 2017; Yang et al., 2017; Yao and Wang, 2018; Zhu et al., 2017). Interestingly, Feng (2017) found that older men in urban China spent more time commuting longer distances than women of similar age.

With regard to the impact of social capital or social networks, studies have found that kinship networks are important in the immigration process. Migrant workers tend to join their kinfolk when selecting a community of settlement, although some studies find that immigrants who did not join their kinfolks were more likely to find jobs (Choldin, 1973; Boyd, 1989). Long-term residential choices are associated with one's social capital, which may directly impact their commuting behavior (Axhausen, 2008). Moreover, owing to low wages and high job search costs, minority immigrant workers tend to live in ethnic enclaves and spend more time on commutes (Preston et al.,1998). Married workers, and those with high-skilled jobs, such as managerial and science-related positions, tended to commute longer distances (Axisa et al., 2012). Sun et al. (2017) employed the copula-based joint model to analyze travel behavior in China and concluded that income and household size are positively correlated with commuting distance and duration.

3 Research Methodology

3.1 Modeling Approach

To address all the mutual relationships discussed in the literature, we apply a Structural Equation Model (SEM) to simultaneously estimate the endogenous relationships among residential segregation (i.e., the choice to live in an urban village), the built environment, and commuting outcomes (measured by commute distance and duration). SEM is a confirmatory statistical method, which uses existing theories to guide the structures to be modeled. It includes a group of simultaneous equations explained by direct links between variables. The model consists of two major parts: measurement model and structural model. The measurement model captures the relationship between observed and latent variables (Bollen, K. A., & Scott Long, J, 1992; Wu M. L, 2009). There are two sets of measurement models for observed variables: one for the observed endogenous variables and the other for the observed exogenous variables. However, since hypothetically constructed latent variables do not explain travel behavior well, measurement models are often not used in transportation research. Most transportation research uses only the structural model to directly capture the relationships between exogenous and endogenous variables, as well as the relationships among the endogenous variables themselves.

When an SEM has only a structural model, there are four possible elements: the impacts of exogenous variables on endogenous variables, mutual impacts among endogenous variables, and the variances and the covariances of the error terms of endogenous variables. Mathematically, a structural model can be defined as the equation below

$$\eta = B\eta + \Gamma\xi + \mu$$

where exogenous variables and endogenous variables are denoted by the vector ξ and η, respectively. This equation shows that the endogenous variables are a function of each other and all exogenous variables. B indicates the structural coefficient matrix among endogenous variables and Γ indicates the structural coefficient matrix between exogenous variables and endogenous variables. μ is the vector of residuals of the model. We used the maximum likelihood (ML) method to estimate our model, which required the sample data to fit multivariate normality.

In this research, exogenous variables include two built environment variables (i.e., land area ratio between commercial land and residential land, and land area ratio between industrial land and residential land), various demographic/socioeconomic characteristics, social capital indicators, and occupations. Residence in an urban village, commute distance, commute time, commute mode choice, and three other built environment characteristics (i.e., distance to transit station or bus stop, distance to downtown, distance to subcenter) are treated as endogenous variables. (see Table 1).

<Table 1 about here>

Table 1 Exogenous Variables and Endogenous Variables

Exogenous variables	Endogenous variables
Built Environment Variables	***Residential Segregation Measure***

Industrial land/residential land
Commercial land/residential land

Demographic/Socioeconomic Characteristics

Income(log)
Male
Age
Married
Education

Living with family members in current city
The interviewee was cadre before he/she left for the city
The interviewee is Communist Party member

Social Capital Indicators
Length (years) of his/her first non-agricultural job
Number of provinces that he/she had been to
Number of non-agricultural jobs taken so far
Number of years he/she stayed in the current city
Having relatives or friends in the current city
Left hometown with family members

Left hometown with fellows or friends

Occupations
Occupation: Construction, manufacturing, mining worker
Occupation: Self-employed
Occupation: Institutional official
Occupation: Staff (clerical or administrative support)
Occupation: Service worker
Occupation: Manager (used as reference group in model)

Cities (dummy variables)
City-specific fixed effects are included to address common variations across cities. For simplicity, they are not shown in graph or result tables.

Residing in an urban village (yes=1, no=0)

Commuting Outcome Measures
One-way commute distance (kilometer)

One-way commute duration (minute)

Commute Mode Choices
Commute mode is using privately owned vehicles (POV)

Commute mode is taking transit
Commute mode is walking
Commute mode is using the bike (used as a reference group in the model)

Built Environment Variables (endogenous to commuting behavior)
Distance from home to transit station or bus stop (kilometer)
Distance from home to downtown (kilometer)
Distance from home to nearest subcenter (kilometer)

The SEM model can be specified in software like AMOS by indicating arrows in a flow diagram and using matrix notations, symbolic equations, or relational graphs. As shown in Figure 1, socioeconomic characteristics and social capital variables presented on the left are all exogenous variables, as indicated by the one-directional arrows. These exogenous variables directly affect migrant workers' one-way commute distance and time, and whether they live in an urban village. Those from the center to the right side of the graphs are all endogenous variables, except the land area ratio between commercial land and residential land, and the ratio between industrial land and residential land. These two built environment variables are treated by the model as exogenous variables. Note that endogenous variables affect each other through the paths as illustrated by the two-directional arrows.

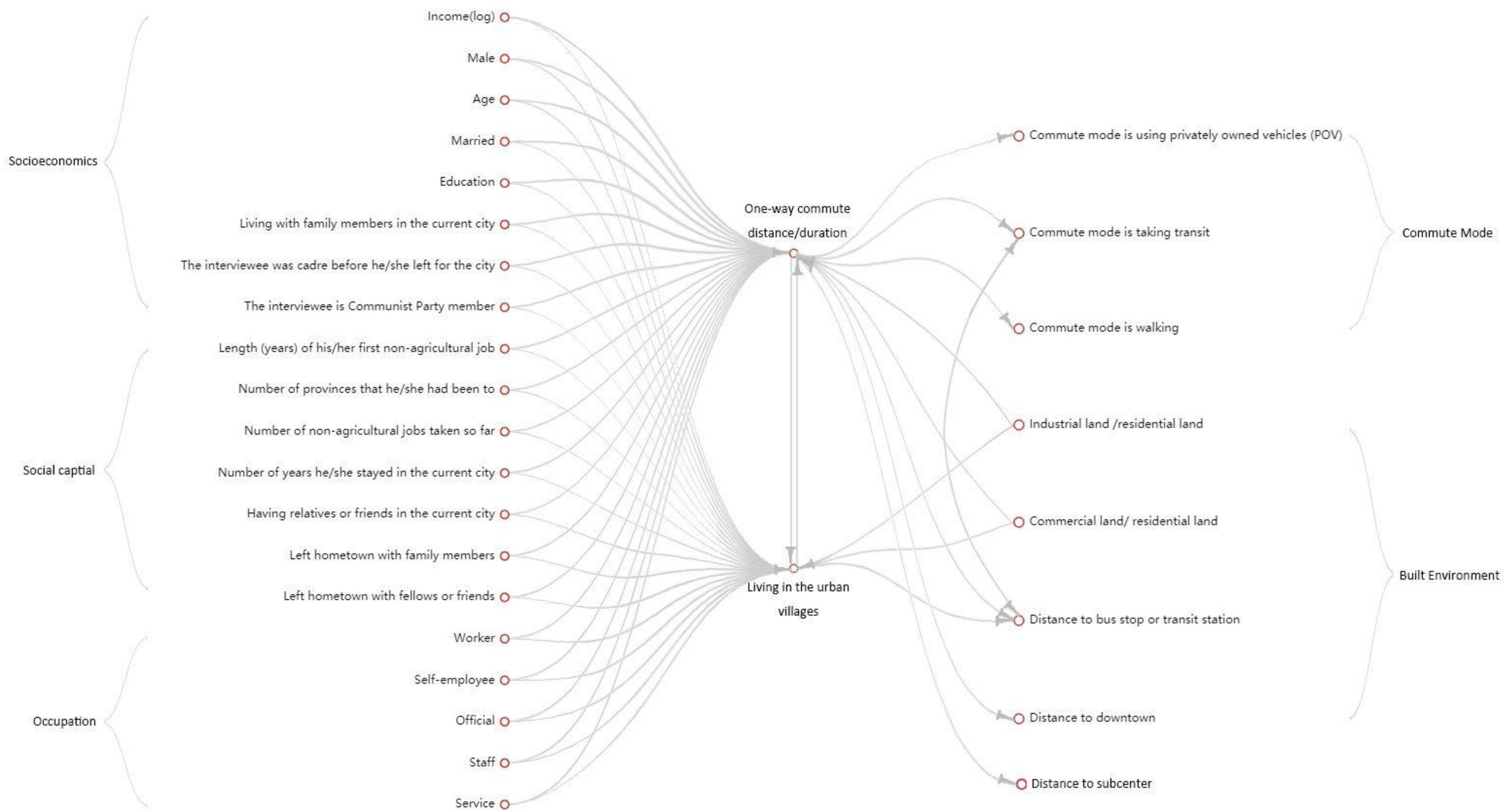

Figure 1 The mutual relationships between endogenous and exogenous variables (Commute distance/duration model)

3.2 Data Source

Data used in this research were extracted from a national survey conducted between 2009 and 2010. Our survey targeted twelve cities in four major economic regions of China that are undergoing rapid urbanization, including the Bohai Bay Area, the Yangtze River Delta Region, the Pearl River Delta Region, and the Chengdu-Chongqing Region. Three types of cities were chosen in each respective region by population size, which includes one medium-sized city with no more than 500,000 people, one large city with 500,000 to 2 million people, and one megacity with a population over 2 million. The selected cities included Weifang, Jinan and Langfang in the Bohai Bay Area; Ningbo, Jiangyin and Yueqing in the Yangtze River Delta Region; Chongqing, Chengdu and Nanchong in the Chengdu-Chongqing Region; Guangzhou, Zhongshan and Dongguan in the Pearl River Delta Region. In each city, we obtained a sample of 200 migrant workers who were randomly selected from the city migration registration list provided by local government agencies such as the migration administrative agency. If the selected individual had already moved away at the time we reached out, the systematic random sampling continued until we reached the designed sample size of 200 migrants. Migrant workers were defined as those working in cities but their permanent residences were registered as 'rural' in their *hukou* record. These individuals had left their hometowns (i.e. registered *hukou* locations) and moved to cities for work. The sampled group of workers were asked to report information including whether they were living in urban villages, their commuting patterns, occupations, socioeconomic status, and their employment and migration histories. Built environment features were measured based on the residence locations the migrant workers reported, combined with GIS maps collected from the city's Urban Planning Bureau.

As shown in Table 2, 57.0% of the respondents were residing in urban villages when the survey took place. The average one-way commute distance and time were 1.49 kilometers and 9.56 minutes. 66.5% of respondents chose to commute on foot and 24.2% by bike. Only 3.8% commuted by public transportation and 0.9% by privately owned vehicles (POV). While these numbers are good reflections of the commuting patterns of rural migrant workers in China, they are quite different from those observed in the U.S. or Europe. Note that the demographic and socioeconomic characteristics of our sample were similar to those reported in the 2014 Monitoring and Surveying Report of Migrant Workers (MSRMW), released by the National Bureau of Statistics of China (NBSC).

Table 2 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
One-way commute distance	2052	1.49	2.89	0	40
One-way commute duration	2070	9.56	10.06	0	92
Residing in an urban village (yes=1, no=0)	2183	0.57	0.50	0	1
Walk mode	2145	0.67	0.47	0	1

Bike mode	2145	0.24	0.43	0	1
Transit mode	2145	0.04	0.19	0	1
Privately owned vehicles (POV) mode	2145	0.01	0.10	0	1
Industrial land /residential land	1969	1.55	6.97	0	120
Commercial land/ residential land	1969	0.93	2.03	0	43.80
Distance to transit station or bus stop (kilometers)	2023	0.63	0.92	0	8.80
Distance from home to downtown (kilometers)	2019	12.55	8.93	0	71.2
Distance from home to subcenter (kilometers)	2191	14.27	9.55	0	37.85
Income (monthly)	2139	1761	2487	500	60000
Male	2193	0.57	0.50	0	1
Age	2187	32	10	16	65
Married	2193	0.65	0.48	0	1
Education	2193	8.86	3.46	0	18
Living with family members in current city	2193	0.60	0.49	0	1
Interviewee was cadre before he/she left for city	2193	0.03	0.17	0	1
Interviewee is a Communist Party member	2193	0.06	0.23	0	1
Length (years) of his/her first non-agricultural job	2187	8.37	6.17	0	39
Number of provinces that he/she had been to	2191	1.20	1.40	0	20
Number of non-agricultural jobs taken so far	2182	2.00	1.73	0	30
Number of years he/she stayed in current city	2190	5.99	5.00	1	34
Having relatives or friends in current city	2168	0.53	0.50	0	1
Left hometown with family members	2193	0.34	0.48	0	1
Left hometown with fellows or friends	2193	0.18	0.38	0	1
Construction, manufacturing, mining worker	2140	0.33	0.47	0	1
Self-employed	2140	0.18	0.38	0	1
Institutional official	2140	0.01	0.07	0	1
Staff (clerical or administrative support)	2140	0.11	0.32	0	1
Manager (used as reference group in model)	2140	0.08	0.26	0	1
Service worker	2140	0.30	0.46	0	1

4 Model Results

Table 3 presents the goodness-of-fit statistics for the commute distance model and the commute duration model. Overall, our models fit the sample data well. The GFI (Goodness-of-fit Index) and AGFI (Adjusted Goodness-of-fit Index) are both greater than 0.90, and the RMSEA values (Root Mean Square Error of Approximation) are low (0.050 for commute distance model and 0.048 for commute duration model). Considering the sample size and degrees of freedom, even though the models have relatively high χ^2 statistics, they still indicate a good fit. Moreover, the probability levels for commute distance and duration models are both 0.000, indicating that the model results are statistically significant.

Table 3 Goodness-of-fit statistics of the models

Goodness-of-fit measures	Commute distance model	Commute duration model
Sample size	1728	1728
Chi-Square (χ^2)	1722.935	1535.470
Degrees of freedom	319	311
Probability level	0.000	0.000
GFI	0.941	0.945
AGFI	0.915	0.918
RMSEA	0.050	0.048

4.1 Mutual Effects between Residential Segregation, Built Environment and Commuting Outcomes

As reported in Table 4, residential segregation in urban villages had a significant impact on migrant workers' one-way commute distance and time. Migrant workers commuted shorter distances and spent less time on daily commutes if they lived in urban villages. These results suggest that residential segregation actually improves migrant workers' commuting outcomes. This finding is reasonable because the rapid urbanization of Chinese cities has resulted in many urban villages formed within or near industrial districts and employment sub-centers where blue-collar jobs are abundant; hence migrant workers residing in these urban villages have good access to suitable jobs. In the meantime, our model did not show any significant causal impact of commute distance and time on migrant workers' choice of living in urban villages. In other words, commute outcomes were not a major driver for migrant workers' residential segregation in urban villages. Affordability and institutional barriers appear to be the more fundamental reasons. Commute outcomes might be something migrant workers consider when deciding where to live, but certainly not (statistically) significant enough for them to choose expensive locations over affordable urban villages. Fortunately, these urban villages improve commute outcomes. It appears that for migrant workers, the causal relationships between residential segregation and commute outcomes only work unidirectionally-- residential segregation affects commute outcomes, but not vice versa.

Among various built environment factors, distance from home to downtown and distance from home to nearest subcenter significantly impacts migrant workers' commuting outcomes. Commute distance and time increase if one lives further away from downtown or subcenter. We also find that distance from home to downtown has a greater impact on commute outcomes than distance from home to subcenter. That may be because more job opportunities are concentrated in downtown than in subcenters. Mixed land use reduces commute distance and time. Living near a transit station increases commute distance and time because public transit users typically commute a much longer distance than those who walk or bike to work. Their commute time is also generally longer than car users since public transit users usually do not take the most direct route from one area to another. These findings are all consistent with what the literature suggests. In the meantime, commute distance and time significantly affect migrants' built environment feature preferences. For example, migrant workers with longer commute time tend to self-select into neighborhoods closer to transit stations to shorten their commutes. This finding supports the hypothesis of self-selection as discussed in other empirical studies (e.g., Schwanen and Mokhtarian, 2005; Cao, et al., 2006; Bhat and Guo, 2007; Cao, et al., 2007, 2009).

When we rank the effects of all significant variables by their magnitude (regardless of the sign of the effects), we find that living in an urban village is the second largest factor impacting commute distance and time, while distance to downtown has the greatest impact. All other (statistically) significant variables, including socioeconomic characteristics, have relatively weak effects.

The inter-relationships between residential segregation and the built environment are shown in Table 4. Residing in urban villages increases both the distance from home to downtown and from home to transit stations. This suggests that urban villages, relatively speaking, are far from downtown and are not well connected to public transit networks. From the perspective of transportation equity, it might be important to locate transit stops near these urban villages.

<Table 4 about here>

Table 4 Total interrelation effects among exogenous and endogenous variables

From	To Living in an urban village	One-way commute distance	One-way commute duration	Distance to bus stop or transit station	Distance to downtown	Distance from home to nearest subcenter	Commute mode: privately owned vehicles	Commute mode: transit	Commute mode: walking
Residing in an urban village	/	-0.05***	-0.12***	0.51***	0.14***	-	-0.01***	-0.04***	0.03***
One-way commute distance	-	/	/	-0.01***	-0.36**	-0.01**	-0.01***	0.06***	-0.07***
One-way commute duration	-	/	/	-0.02***	-0.37***	-0.02***	-	0.07***	-0.08***
Distance to transit station or bus stop	-0.50***	-0.04***	-0.01***	/	-	-	-	-0.01*	-
Distance from home to downtown	-	0.31***	0.41***	-	/	-	0.04***	0.16***	-0.02***
Distance from home to nearest subcenter	-	0.03***	0.04***	-	-	-	-	-	-
Commute mode is using privately owned vehicles	-	-	-	-	-	-	/	-	-
Commute mode is taking transit	-	-	-	-	-	-	-	/	-
Commute mode is walking	-	-	0.01***	-	-	-	-	-	/
Industrial land /residential land	0.14***	-0.04***	-0.12***	-	-	-	-	-0.01**	-
Commercial land/ residential land	-	-	-	-	-	-	-	-	-
Income(log)	-	-	-	-	-	-	-	-	-
Male	-	-	-	-	-	-	-	-	-
Age	-	0.02*	0.03**	-	-	-	-	-	-
Married	0.05*	-	-	-	-	-	-	-	-
Education	-0.05**	0.03**	0.03**	-	-	-	-	-	-
Living with family members in current city	0.06***	0.03***	0.04***	-	-	-	-	-	-
Interviewee was cadre before he/she left for city	-	-	-	-	-	-	-	-	-
Interviewee is a Communist Party member	-	-	-	-	-	-	-	-	-
Length (years) of his/her first non-agricultural job	-0.07**	-	-	-	-	-	-	-	-
Number of provinces that he/she had been to	0.06***	0.01*	0.02*	-	-	-	-	-	-

Number of non-agricultural jobs taken so far	-	-	-	-	-	-	-	-	-
Number of years he/she stayed in current city	-	-	-	-	-	-	-	-	-
Having relatives or friends in current city	-	-	-	-	-	-	-	-	-
Left hometown with family members		-	-	-	-	-	-	-	-
Left hometown with fellows or friends	0.04*	-	-	-	-	-	-	-	-
Construction, manufacturing, mining worker	0.24***	-0.02***	-0.03***	-	-	-	-	-	-
Self-employed	-	-	-	-	-	-	-	-	-
Staff (clerical or administrative support)	-	-	-	-	-	-	-	-	-
Institutional official	-	-	-	-	-	-	-	-	-
Service worker	-	0.07***	0.102***	-	-	-	-	-	-

Notes:

* Significant $\alpha = 0.10 (\rho < 0.10)$

** Significant $\alpha = 0.05 (\rho < 0.05)$

*** Significant $\alpha = 0.01 (\rho < 0.01)$

- indicate the effect is not significant.

For occupations, reference group is “Manager”.

For commute mode choice, reference group is “commute mode is biking”.

4.2 Mutual Effects between Residential Segregation, Built Environment and Commute Mode Choice

Living in urban villages reduces the probability of commuting by car or public transit, and increases commutes on foot, all with respect to commutes by bike, the reference group in the SEM. As discussed in previous sections, most urban villages in our sample cities are located near industrial areas or employment subcenters where there is an abundance of blue-collar jobs. Our earlier studies have also found that there are many job opportunities within the urban villages, such as grocery stores and restaurants (Zhu, 2016). These jobs are often within walking distance from migrants' homes. Results show that living in urban villages reduces the likelihood of commuting by public transit, which suggests the current public transit system may have overlooked the needs of these residents. They may have no choice but to walk or bike their way to work. However, the model did not show any significant causal impact of commute mode choice on residential segregation. Compared to housing expenses, transportation only accounts for a fraction of migrant workers' monthly expenditure. Therefore, it is not surprising that migrant workers' decisions to reside in urban villages are not influenced by their choices of commute mode.

In terms of built environments, distance to downtown significantly affects commute mode choice. The further workers live from downtown, the more likely they are to choose commute by public transit, and the less likely to commute on foot or by bike. Everything else being equal, locations further from downtown typically have lower job density, which makes walking or biking less appealing or impractical. Meanwhile, living closer to a transit stop significantly increases the likelihood of commuting by transit. We also find that the likelihood of commuting by public transit is negatively influenced by the ratio of industrial to residential land area, suggesting that public transit networks are underdeveloped in industrial districts.

4.3 Effects of social capital and demographics on commuting outcomes, residential segregation and built environment preferences

As shown in Table 4, migrant workers who are older or with higher levels of educational attainment (as measured by years of schooling) tend to have longer commute distance and time. In terms of the social capital variables, migrant workers living with family members in current city have longer commutes. A possible explanation is that they may have family support to allow them to work for jobs that need long commutes. Additionally, migrant workers who have worked in more provinces may be more competitive in job markets and have more social capital. They might be more likely to get better paying jobs further away from their homes and therefore spend more time commuting.

As expected, being married or living with family members increases the probability of residing in an urban village, while the opposite is observed for those with better education or more experience with non-agricultural jobs. Migrant workers who have been to more provinces are more likely to live in urban villages. This is because living in urban village is usually more flexible and less constrained by a lease, which makes their next relocation easier. Meanwhile, migrant workers who left their hometowns with companions are more likely to live in urban villages as they are probably more interdependent and prefer the close social connections with other residents in those neighborhoods. Compared with other occupations, those who worked in construction, manufacturing, or mining were more likely to live in urban villages due to budget constraints. This finding is in line with the conclusions of Bhat and Guo (2007).

5 Conclusions

In Chinese society, rural migrant workers' residential segregation is more than an outcome of affordability and commuting cost. It is further complicated by China's exclusionary housing regulations, where the current *hukou* system constrains migrants from purchasing or even renting government-subsided affordable housing units. As a result, urban villages have become home to many migrant workers. This paper provides important insight into how migrants' residential segregation (in urban villages) and their commute outcomes affect each other. Results show that residential segregation reduces commute distance and time, but shorter commutes are *not* a major (or statistically significant) driver for migrant workers to reside in urban villages. The causal relationships between residential segregation and commute outcomes therefore only work unidirectionally -- residential segregation improves commute outcomes, but not *vice versa*. Other factors such as affordability, the *hukou* system, (exclusionary) housing regulations and social networks are more influential in affecting migrants' residential location choices. Fortunately, urban villages happen to have relatively good job accessibility, as shown in the impact of residential segregation on commute distance and time. This is due to the rapid urbanization in Chinese cities which results in urban villages being well integrated into new urban districts with abundant low-skilled employment opportunities. This is one of the main reasons that the outcome of residential segregation in China is different from what is observed in the United States.

In the past few years, policymakers have been promoting urban village demolition projects as part of "urban renewal" policies. Migrant workers are forced to relocate to more remote areas with worse job accessibility. As our models suggest, their decisions to reside in urban villages are inelastic to the commute outcomes of those places. When the decision of where to live depends largely on affordability and exclusionary housing regulations, accessibility is simply too much of a luxury to be considered. If no supporting measures that accommodate migrant workers at locations with reasonable accessibility are properly implemented along with these large-scale demolition projects, cities will face serious job-housing imbalances and social inequity in the foreseeable future.

In addition, residential sorting is observed among migrant workers in China. Commute distance and time are found to significantly affect migrants' choice of built environment features of their neighborhoods. In other words, they self-select into neighborhoods with their preferred built environment. Our empirical analyses conclude that built environment features also have a significant causal impact on commuting outcomes. We find that a shorter distance to downtown, a shorter distance to subcenter, and more diversified land use all reduce commute distance and time for migrant workers. If urban renewal policies are justified, policymakers need to plan proactively to place these migrant workers in locations closer to employment (sub)centers, such as new industrial centers with a good mix of industrial, commercial and residential land.

Finally, while there are many studies examining the relationship between residential segregation and commuting outcomes, there are as yet few studies addressing this relationship for the specific minority group our study targets, namely, China's rural migrant workers. The literature on the relationship between minority groups, residential segregation, and commuting outcomes in the United States and Europe is well-developed, but this topic has yet to be thoroughly investigated in a developing country with rapid urbanization, where internal migrants also experience residential segregation, but in very different urban environments. Our contribution is therefore to extend the existing literature to a new context where rapid population migration and urban expansion are happening simultaneously. Our research thus has important international implications for many developing countries.

References

Andrew L. Spivak, Loretta E. Bass & Craig St. John (2011). Reconsidering Race, Class, and Residential Segregation in American Cities, Urban Geography, 32(4), 531-567.

Athens, I. (2008). Relationships between urban form and travel behaviour in Athens, Greece. A comparison with Western European and North American results. Ejtir, 3(8).

Bernick, M., Cervero, R., (1997). Transit Villages for 21st Century. McGraw-Hill, New York, 17–63.

Bhat, C. R., & Guo, J. Y. (2007). A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. Transportation Research Part B Methodological, 41(5), 506-526.

Blumenberg, E. A., & Shiki, K. (2003). How welfare recipients travel on public transit, and their accessibility to employment outside large urban centers. University of California Transportation Center.

Boarnet, M.G., Sarmiento, S. (1998). Can land use policy really affect travel behaviour? A study of the link between non-work travel and land use characteristics. Urban Stud, 35: 1155–1169

Bollen, K. A., & Scott Long, J. (1992). Tests for Structural Equation Models: Introduction. Sociological Methods & Research, 21(2), 123–131.

Bray, D. (2005). Social space and governance in urban China: The danwei system from origins to reform. Stanford: Stanford University Press.

Camagni, R., Gibelli, M. C., & Rigamonti, P. (2002). Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion. Ecological economics, 40(2), 199-216.

Cao, X. (2015). Examining the impacts of neighborhood design and residential self-selection on active travel: a methodological assessment, Urban Geography, 36(2), 236-255.

Cao, X., Handy, S. L., & Mokhtarian, P. L. (2006). The influences of the built environment and residential self-selection on pedestrian behavior: evidence from Austin, TX. Transportation, 33(1), 1-20.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2007). Do changes in neighborhood characteristics lead to changes in travel behavior? A structural equations modeling approach. Transportation, 34(5), 535-556.

Cao, X. J., Mokhtarian, P. L., & Handy, S. L. (2009). The relationship between the built environment and nonwork travel: A case study of Northern California. Transportation Research Part A: Policy and Practice, 43(5), 548-559.

Cao, X., Yang, W. (2017). Examining the effects of the built environment and residential self-selection on commuting trips and the related CO2 emissions: an empirical study in Guangzhou, China. Transport. Res. Part D: Transport Environ. 52, 480–494.

Cervero, R. (1996). Mixed land-uses and commuting: evidence from the American Housing Survey. Transportation Research Part A: Policy and Practice, 30(5), 361-377.

Cervero, R., & Duncan, M. (2003). Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area. American journal of public health, 93(9), 1478-1483.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: density, diversity,

and design. Transportation Research Part D: Transport and Environment, 2(3), 199-219.
Cervero, R., & Murakami, J. (2010). Effects of built environments on vehicle miles traveled: evidence from 370 US urbanized areas. Environment and planning A, 42(2), 400-418.
Cervero, R., & Radisch, C. (1996). Travel choices in pedestrian versus automobile oriented neighborhoods. Transport Policy, 3(3), 127-141.
Charles, C. Z. (2003). The dynamics of racial residential segregation. Annual Review of Sociology, 29(1), 167-207. doi:10.1146/annurev.soc.29.010202.100002
Clark, W. A. V. (1986). Residential segregation in American cities: a review and interpretation. Population Research & Policy Review, 5(2), 95-127.
Clark, W. A. V. (1988). Understanding residential segregation in American cities: interpreting the evidence: a reply to Galster. Population Research & Policy Review, 7(2), 113-121.
Clark, W. A. V., & Burt, J. E. (1980). The impact of workplace on residential relocation. Annals of the Association of American Geographers, 70(1), 59-67.
Clark, B., Chatterjee, K., & Melia, S. (2016). Changes to commute mode: The role of life events, spatial context and environmental attitude. Transportation Research Part A: Policy and Practice, 89, 89-105.
Cutler, D. M., Glaeser, E. L., & Vigdor, J. L. (2008). Is the melting pot still hot? explaining the resurgence of immigrant segregation. The Review of Economics and Statistics, 90(3), 478-497. doi:10.1162/rest.90.3.478
Dissanayake, D., Kurauchi, S., Ohashi, S. (2012). Inter-regional and inter-temporal analysis of travel behaviour for Asian metropolitan cities: Case studies of Bangkok, Kuala Lumpur, Manila, and Nagoya. Transport Policy, 19(1):36-46.
Ellwood, D.T. (1981). The Spatial Mismatch Hypothesis: are there Teen-Age Jobs Missing in the Ghetto?. Harvard University.
Feng, J. (2017). The influence of built environment on travel behavior of the elderly in urban China. Transp. Res. Part D Transp. Environ,52, 619–633.
Feng, J., Dijst, M., Prillwitz, J. (2017). Changing travel behaviour in urban China: Evidence from Nanjing 2008–2011. Transport Policy. 53:1-10.
Guerra, E., Caudillo, C., Monkkonen, P., Montejano, J. (2018) Urban form, transit supply, and travel behavior in Latin America: Evidence from Mexico's 100 largest urban areas. Transport Policy. 69: 98-105.
Galster, G. (1988). Residential segregation in American cities: a contrary review. Population Research & Policy Review, 7(2), 93-112.
Gottlieb, P. D., & Lentnek, B. (2001). Spatial mismatch is not always a central-city problem: an analysis of commuting behaviour in Cleveland, Ohio, and its suburbs. Urban Studies, 38(7), 1161-1186.
Grengs, J. (2010). Job accessibility and the modal mismatch in Detroit. Journal of Transport Geography, 18(1), 42-54.
Han, H., Yang, C., Wang, E., Song, J., & Zhang, M. (2015). Evolution of jobs-housing spatial relationship in Beijing Metropolitan Area: a job accessibility perspective. Chinese Geographical Science, 25(3), 375-388.
Handy, S. L., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built

environment affects physical activity: views from urban planning. American journal of preventive medicine, 23(2), 64-73.
Handy, S., Blumenberg, E., Donahue, M., Lovejoy, K., Shaheen, S. A., Rodier, C. J., ... & Tal, G. (2009). Travel Behavior of Immigrant Groups in California. California PATH Program, Institute of Transportation Studies, University of California at Berkeley.
Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? Evidence from Northern California. Transportation Research Part D: Transport and Environment, 10(6), 427-444.
Hansen, W. G. (1959). How Accessibility Shapes Land Use. Journal of the American Institute of Planners, 25(2), 73–76. doi:10.1080/01944365908978307
Hellerstein, J. K., Neumark, D., & McInerney, M. (2008). Spatial mismatch or racial mismatch? Journal of Urban Economics, 64(2), 464-479.
Holzer, H., 1991. The spatial mismatch hypothesis: what has the evidence shown?. Urban Stud. 28, 105–122.
Holzer, H. J. (1994), Black employment problems: New evidence, old questions. J. Pol. Anal. Manage., 13: 699–722.
Houston DS (2005) Methods to test the spatial mismatch hypothesis. Economic Geography 81: 407–434.
Hu, L., Sun, T., & Wang, L. (2018). Evolving urban spatial structure and commuting patterns: A case study of Beijing, China. *Transportation Research Part D*, 59, 11-22.
Hu, L., Yang, J., Yang, T., Tu, Y., & Zhu, J. (2020). Urban Spatial Structure and Travel in China. *Journal of Planning Literature*, 35(1), 6–24.
Ihlanfeldt, K. R. (1997). Information on the spatial distribution of job opportunities within metropolitan areas. Journal of Urban Economics, 41(2), 218-242.
Ihlanfeldt KR and Sjoquist DL (1998) The spatial mismatch hypothesis: A review of recent studies and their implications for welfare reform. Housing Policy Debate 9: 849–892.
Immergluck, D. (1998). Neighborhood economic development and local working: The effect of nearby jobs on where residents work. Economic Geography, 74(2), 170-187.
Kain, J.F., (1968). Housing segregation, negro employment, and metropolitan decentralization. Q. J. Econ. 82 (2), 175–197.
Krizek, K. J. (2003). Residential relocation and changes in urban travel: Does neighborhood-scale urban form matter?. Journal of the American Planning Association, 69(3), 265-281.
Lee C.and Moudon A. V.2006. The 3Ds+ R: Quantifying land use and urban form correlates of walking. Transportation Research Part D: Transport and Environment 11(3): 204-215.
Li, S. M. (2010). Evolving residential and employment locations and patterns of commuting under hyper growth: the case of Guangzhou, China. Urban Studies, 47(8), 1643-1661.
Litman, T. (2005). Land use impacts on transport. Victoria Transport Policy Institute (www. vtpi. org).
Liu, C. Y. (2009). Ethnic enclave residence, employment, and commuting of Latino workers. Journal of Policy Analysis and Management, 28(4), 600-625.

Liu, C. Y., & Painter, G. (2012). Travel behavior among Latino immigrants: the role of ethnic concentration and ethnic employment. Journal of Planning Education and Research, 32(1), 62-80.
Logan, J., Zhang, W., & Alba, R. (2002). Immigrant Enclaves and Ethnic Communities in New York and Los Angeles. American Sociological Review, 67(2), 299-322.
Matas, Anna, Raymond, José-Luis and Roig, José-Luis, (2009), Car ownership and access to jobs in Spain, Transportation Research Part A: Policy and Practice, 43, issue 6, p. 607-617
Marcuse, P. (2001). Enclaves yes, ghettoes, no: segregation and the state. Conference paper presented at the international seminar on segregation in the city. Lincoln Institute, July, 26–28.
McLafferty, S. (1997). Gender, race, and the determinants of commuting: New York in 1990. Urban Geography, 18(3), 192-212.
McLafferty, S., & Preston, V. (1992). Spatial mismatch and labor market segmentation for African-American and Latina women. Economic Geography, 68(4), 406-431.
McLafferty, S. and Preston, V. (1996), Spatial Mismatch and Employment in a Decade of Restructuring*. The Professional Geographer, 48: 420–431.
McNally, M. G., & Ryan, S. (1992). A comparative assessment of travel characteristics for neo-traditional developments. University of California Transportation Center.
Meurs, H., & Haaijer, R. (2001). Spatial structure and mobility. Transportation Research Part D: Transport and Environment, 6(6), 429-446.
Mokhtarian P, Cao X. (2008). Examining the impacts of residential self-selection on travel behavior: a focus on methodologies. Transport Res B-Meth, 42: 204-228.
Ta, N., Chai, Y., Zhang, Y., Sun, D. (2017). Understanding job-housing relationship and commuting pattern in chinese cities: Past, present and future. Transp. Res. Part D Transp. Environ, 52, 562–573.
Pascal, A. (1978). Armour v. Nix, U.S. District Court, Northern district of Georgia, Atlanta Division, Civil Action 16708, Transcript of Proceedings, Defendants' Exhibit #18.
Preston, V., McLafferty, S., & Liu, X. F. (1998). Geographical barriers to employment for American-born and immigrant workers. Urban Studies, 35(3), 529-545.
Raphael, S., Stoll, M. A., Small, K. A., & Winston, C. (2001). Can boosting minority car-ownership rates narrow inter-racial employment gaps? [with comments]. Brookings-Wharton Papers on Urban Affairs, 2001(1), 99-145.
Schwanen, T., Dijst, M., & Dieleman, F. M. (2002). A microlevel analysis of residential context and travel time. Environment and Planning A, 34(8), 1487-1507.
Schwanen, T., & Mokhtarian, P. L. (2005). What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled. Transportation Research Part D: Transport and Environment, 10(2), 127-151.
Shen, Q. (2001). A spatial analysis of job openings and access in a US metropolitan area. Journal of the American Planning Association, 67(1), 53-68.
Sun, B., Ermagun, A., Dan, B. (2017). Built environmental impacts on commuting mode choice and distance: Evidence from Shanghai. Res. Part D Transp. Environ,52,

441–453.
Tal, G., Handy, S. (2010). Travel behavior of immigrants: An analysis of the 2001 National Household Transportation Survey. Transport Policy. 17(2): 85-93.
Taylor, B. D., & Ong, P. M. (1995). Spatial mismatch or automobile mismatch? An examination of race, residence and commuting in US metropolitan areas. Urban studies, 32(9), 1453-1473.
Tsai, Y. H. (2009). Impacts of self-selection and transit proximity on commute mode choice: evidence from Taipei rapid transit system. The Annals of Regional Science, 43(4), 1073.
Turner, M. A., Ross, S. L., Galster, G. C., & Yinger, J. (2002). Discrimination in metropolitan housing markets: National results from Phase I HDS 2000. Washington, DC: US Department of Housing and Urban Development.
Van, V. Acker. and Witlox F. 2011. Commuting trips within tours: how is commuting related to land use? Transportation, 38(3): p. 465-486.
Van, V. Acker, Witlox, F., van Wee, B. 2007. The effects of the land use system on travel behaviour: a structural equation modelling approach. Transport Planning and Technology, 30: 331–354.
Wang, E., Song, J., & Xu, T. (2011). From "spatial bond" to "spatial mismatch": An assessment of changing jobs–housing relationship in Beijing. Habitat International, 35(2), 398-409.
Wang, H., Zhu, P. Xiao Chen, Sarah Swider. (2017). Land Expropriation in Urbanization China: an Examination of Negotiations and Compensation. *Urban Geography*. 38(3), 401-419.
Wang YP, Wang Y and Wu J (2009) Urbanization and informal development in China: Urban village in Shenzhen. *International Journal of Urban and Regional Research*. 33(4): 957–973.
Wheaton, W.C. 2004. Commuting, congestion, and employment dispersal in cities with mixed land use. Journal of Urban Economics, 55(3): 417-438.
Wu M. L. (2009). Structural Equation Model. Chongqing: Chongqin University Press.
Wu W (2004) Sources of migrant housing disadvantage in urban China. *Environment and Planning A* 36: 1285–1304.
Wu W (2006) Migrant intra-urban residential mobility in urban China. *Housing Studies* 21(5): 745–765.
Wu, W., Hong, J. (2017). Does public transit improvement affect commuting behavior in Beijing, China? A spatial multilevel approach. Transport. Res Part D. 52,471-479.
Van Acker, V., & Witlox, F. (2011). Commuting trips within tours: how is commuting related to land use?. Transportation, 38(3), 465-486.
Yang, S., Fan, Y., Deng, W., Cheng, L. (2017). Do built environment effects on travel behavior differ between household members? A case study of Nanjing, China. Transport Policy. 81:360-370.
Yao, M., Wang, D. (2018) Mobility and travel behavior in urban China: The role of institutional factors. Transport Policy. 69: 122-131.
Zenou, Y. (2013). Spatial versus social mismatch. Journal of Urban Economics, 74, 113-132.

Zhao, P. (2010). Sustainable urban expansion and transportation in a growing megacity: Consequences of urban sprawl for mobility on the urban fringe of Beijing. Habitat International, 34(2), 236-243.
Zhao, P., & Lu, B. (2010). Exploring job accessibility in the transformation context: an institutionalist approach and its application in Beijing. Journal of Transport Geography, 18(3), 393-401.
Zhu, P., Liu, C. Y., & Painter, G. (2014). Does residence in an ethnic community help immigrants in a recession? Regional Science and Urban Economics, 47, 112-127.
Zhu, P., Zhao, S., Wang, L., Yammahi, S.A. (2017). Residential segregation and commuting patterns of migrant workers in China. Transport. Res Part D. 52,586-599.
Zhu, P. (2016). Residential segregation and employment outcomes of rural migrant workers in China. Urban Studies, 53(8), 1635-1656.
Zhu, P., & Mason, S. G. (2014). The impact of telecommuting on personal vehicle usage and environmental sustainability. International Journal of Environmental Science and Technology, 11(8), 2185-2200.
Zhu, P., Ho, S., Jiang,Y. and Tan, X. (2020). Built environment, commuting behaviour and job accessibility in a rail-based dense urban context. *Transportation Research Part D: Transport and Environment*, Volume 87, October 2020, 102438.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: