Computers, Environment and Urban Systems 86 (2021) 101582

Contents lists available at ScienceDirect

Computers, Environment and Urban Systems

journal homepage: www.elsevier.com/locate/ceus

Burglars blocked by barriers? The impact of physical and social barriers on residential burglars' target location choices in China

Luzi Xiao [a], Stijn Ruiter [b,c], Lin Liu [a,d,*], Guangwen Song [a], Suhong Zhou [e,f]

[a] Center of Geographic Information Analysis for Public Security, School of Geography and Remote Sensing, Guangzhou University, Guangzhou 510006, China
[b] Netherlands Institute for the Study of Crime and Law Enforcement, P.O. Box 71304, 1008 BH Amsterdam, The Netherlands
[c] Department of Sociology, Utrecht University, Utrecht, The Netherlands
[d] Department of Geography and GIS, University of Cincinnati, OH 45221-0131, USA
[e] School of Geography and Planning, Sun Yat-sen University, Guangzhou 510275, China
[f] Guangdong Provincial Engineering Research Center for Public Security and Disaster, Guangzhou 510275, China

A R T I C L E I N F O

Keywords:
Residential burglary
Physical and social barriers
China
Discrete choice

A B S T R A C T

Based on an offender spatial decision-making perspective, this burglary target location choice study aims to understand how physical and social barriers affect why residential burglars commit their crimes at particular locations in a major Chinese city. Using data on 3860 residential burglaries committed by 3772 burglars between January 2012 and June 2016 in ZG city, China, conditional logit (discrete choice) models were estimated to assess residential burglars' target location choice preferences. Three types of physical barriers were distinguished: major roads with access control, major roads without access control, and major rivers. Social barriers were constructed based on the Hukou system to reflect how local and nonlocal residents live segregated lives. Results show that residential burglars are less likely to target areas for which they have to cross a physical barrier and even less likely to do so if they have to cross multiple rivers. Local burglars are more likely to target communities with a majority of local residents than communities with a majority nonlocal population or a mixed community. Such a social barrier was less pronounced for nonlocal burglars. These findings add new insight that physical and social barriers affect, to various degrees, where residential burglars in China commit their crimes.

1. Introduction

Residential burglary is one of the most common property crimes in China and the risk of burglary victimization varies considerably between areas, just as it does in Western societies (Liu & Li, 2017; Ye, Xu, Lee, Zhu, & Ling, 2015). All previous Chinese studies have explained these burglary patterns by looking at differences between areas. They found that areas with lower levels of guardianship (Jiang, Lambert, & Wang, 2007), higher turnover (Lo & Jiang, 2006) and predominantly low-rise buildings (Gu, Zhou, & Yan, 2016) have more burglaries. Although these studies provide insights into where burglaries are more likely to happen in China, most of them implicitly assume that areas with specific environmental characteristics determine where burglaries are committed. However, areas do not decide on being targeted, but burglars decide on where they commit their crimes. In their residential burglary study for the city of The Hague, the Netherlands, Bernasco and Nieuwbeerta (2005) introduced the crime location choice approach, which starts from an offender decision-making perspective. The discrete spatial choice model they used allows for the inclusion of both area-level and offender-level characteristics in order to understand why offenders target particular areas. Ruiter (2017) identified 17 journal articles that used the crime location choice approach to model offender spatial decision-making in the Netherlands, USA, UK, Belgium, and Australia. Only recently was the approach first used to study street robbery (Long, Lin, Feng, Zhou, & Jing, 2018) and theft from the person (Song et al., 2019) in China.

All crime location choice studies so far have shown that offenders are more likely to commit crimes in areas that are closer to their homes than in areas further away (Ruiter, 2017). However, those studies that only included distance from home as a measure for how offenders are related to potential target areas implicitly assumed that all areas at the same distance are equally likely targeted. This assumption clearly

* Corresponding author at: Center of Geographic Information Analysis for Public Security, School of Geography and Remote Sensing, Guangzhou University, Guangzhou 510006, China.
E-mail address: lin.liu@uc.edu (L. Liu).

https://doi.org/10.1016/j.compenvurbsys.2020.101582
Received 7 May 2020; Received in revised form 30 November 2020; Accepted 1 December 2020
Available online 17 December 2020

oversimplifies how people can actually use urban space. In a recent study of Frith, Johnson, and Fry (2017), they used time distance by considering the configuration and properties of the road networks to better measure the cost of travel. Travel is often easier in some directions than in others as it might be obstructed by physical barriers like major roads and rivers. Several crime location choice studies indeed found that offenders are less likely to target areas on the other side of such physical barriers (Baudains, Braithwaite, & Johnson, 2013; Clare, Fernandez, & Morgan, 2009; Summers, 2012). Next to these physical barriers, offenders' target location choices were also found to be affected by social barriers, which are related to how people live segregated lives. Offenders of a specific racial/ethnic background were less likely to target areas with a majority population of a different racial/ethnic group (Bernasco & Block, 2009; Bernasco, Block, & Ruiter, 2013; Bernasco, Ruiter, & Block, 2017; Chamberlain & Boggess, 2016). However, these studies rarely tested the effects of physical and social barriers simultaneously.

Several scholars have examined the possible relationship between physical and social barriers, albeit in a non-crime related context. Noonan (2005) showed for the city of Chicago that physical and social barriers often coincide, as people who live on different sides of a physical barrier often belong to different racial/ethnic groups. Roberto and Hwang (2016) showed that the link between physical and social barriers is not limited to the highly-segregated city of Chicago, but actually quite common across large US cities. The coexistence of the physical barriers and social barriers underscores the need of simultaneous treatment of both types of barriers.

The same should hold for Chinese cities, as the rapid urbanization has led to the construction of many highways and urban expressways, which cut across cities and divide them into distinct functional regions (Yuan, Yu, & Xie, 2012). At the same time, Chinese cities have increasingly become socially segregated since the 1980s (Lin & Gaubatz, 2017), with many migrants from the rural areas moving into the cities to earn a living. These domestic migrants often live segregated from the local residents (Lin & Gaubatz, 2017; Zhu, 2015), they are generally poorer and less educated and they also have distinct lifestyles and activity spaces (Liu, Huang, & Zhang, 2017; Zhou, Deng, Kwan, & Yan, 2015).

This study conceptualizes social barriers for the Chinese context, without a link to racial/ethnic differences, but specific to how local residents and domestic migrants from other parts of China live segregated lives. It improves upon previous research by testing the impact of such social barriers on burglars' crime location choices while simultaneously accounting for the effects of physical barriers. Furthermore, previous studies on physical barriers only tested whether offenders are less likely to target areas on the other side of one physical barrier (Baudains et al., 2013; Clare et al., 2009; Summers, 2012), whereas the study area used here allows for testing whether offenders are even less likely to target areas for which they have to cross multiple physical barriers. This study combines both physical and social barriers in a single model and test their effects on burglary location choices simultaneously.

2. Theory and hypotheses

Crime pattern theory provides a framework for understanding why target choices of residential burglars would be affected by physical and social barriers. According to its geometry of crime, offenders commit crimes in areas where their awareness space overlaps with the spatial distribution of attractive targets (Brantingham & Brantingham, 1993; Brantingham & Brantingham, 2008). People's awareness spaces get shaped during their routine activities, as these make them spend most of their time in only a few areas. The activity nodes routinely visited and the paths used to travel between them as well as the areas within visual range of these nodes and paths make up people's awareness spaces (Brantingham & Brantingham, 1993). Although most crime location choice studies lack extensive information on the awareness spaces beyond the home locations of offenders, a few studies showed that other activity nodes also affect where offenders commit crimes. All studies found that offenders generally commit crimes close to home (Ruiter, 2017) and several studies showed that next to this strong distance decay effect, offenders are also more likely to offend in areas where they used to live (Bernasco, 2010), where their close family members live (Menting, Lammers, Ruiter, & Bernasco, 2016), where they had already committed offenses (Bernasco, Johnson, & Ruiter, 2015; Lammers, Menting, Ruiter, & Bernasco, 2015), close to areas they frequently visit (Menting, Lammers, Ruiter, & Bernasco, 2019; Song et al., 2019), and co-offenders are more likely to target areas in their shared awareness space (Lammers, 2017). Next to the effects of these activity nodes, in several studies it was argued that the shape of the street network also affects offenders awareness spaces, and indeed the studies showed that offender target choices are related to how the street network connects places (Frith et al., 2017; Johnson & Summers, 2015). All these findings provide support for crime pattern theory.

2.1.1. *Physical barriers*

Because physical barriers such as rivers and major roads constrain the way people travel and reduce the interaction between residents on both sides (Doucette, 2012; Kramer, 2012), areas on the other side of such barriers are less likely to be part of people's awareness spaces. One reason is that crossing physical barriers always takes effort (Clare et al., 2009), as people have to spend more time and travel over longer distances, which would reduce their willingness to cross. Another reason is that physical barriers often coincide with administrative boundaries that are often related to how public services like kindergarten, schools, and community parks but also supermarkets are distributed (Eagleson, Escobar, & Williamson, 2002). When residents can meet their basic needs within their own administrative area, they will be less inclined to travel to other areas for which they might need to cross a physical barrier. Because physical barriers affect the awareness spaces of all people, also those of offenders, they should also affect where offenders commit crime. Indeed, several studies found that offenders were less likely to target areas on the other side of such barriers (Baudains et al., 2013; Clare et al., 2009; Summers, 2012). Although these studies were carried out in London and Perth, the mechanism should be equally applicable to any other country. This study therefore hypothesizes that *residential burglars are more likely to offend in areas on the same side of a physical barrier as their residential area* (Hypothesis 1a).

With the fast urbanization of Chinese cities, China's major roads are rapidly expanding. Building more roads has become an important strategy for the expansion and development of especially big Chinese cities (Chen, Claramunt, & Ray, 2014; Lin, Huang, Chen, & Huang, 2014). They usually have highly dense populations and have to build very complicated road networks to meet the traffic demand (Ji et al., 2014; Tian, 2006). These major roads often cut through and thus separate different parts of the city (Kim & Jang, 2017), making the communication between the areas divided by major roads less easy (Li et al., 2010). Some researchers have looked into the effects of road networks on crimes in China. For example, Yue, Zhu, Ye, Hu, and Kudva (2018) divided the road system in Wuhan, China into three levels - arterial roads (linking traffic hubs), secondary trunk roads (supplementary connections between arterial roads) and branch roads (linking secondary trunk roads), and found that residential burglaries had no significant differences in different types of roads, but roads with higher local permeability had fewer crimes compared to those with lower local permeability. However, they did not distinguish major roads with access control, which regulates ingress and egress for all traffic flows from those without access control, even though the former only allow for through traffic, which does not improve the accessibility of the area it runs through. Distinguishing between different categories of roads, this study hypothesizes that *residential burglars are less likely to offend in areas for which they have to cross major roads with access control than in areas for which they have to cross major roads without access control* (Hypothesis 1b).

Besides major roads, rivers are also important physical barriers that impede people's mobility (Peeters & Elffers, 2010). Numerous branches of rivers exist in the Pearl River Delta, where our study area is located. Even with bridges, the rivers still deter interaction of people living on different sides of the rivers. For example, Clare et al. (2009) studied the impact of a large river on burglary location choices in Perth, Australia, and found that burglars indeed were less likely to cross the river for committing burglary. Therefore, rivers are among important physical barriers that may affect burglars' decision-making process. Moreover, travel between parts of large cities might require that people overcome not just a single obstacle, but they could even have to cross multiple physical barriers. Cutler and Glaeser (1997) showed that people who live separated by multiple rivers have even less communication compared to those who are separated by only one. This effect of multiple physical barriers should also be reflected in the shape of people's awareness spaces and consequently also affect where residential burglars commit crime. Because large Chinese cities are spread out over very large areas, often containing many physical barriers, this study hypothesizes that *residential burglars are less likely to offend in areas for which they have to cross multiple physical barriers, such as rivers or major roads, than in areas for which they have to cross just one* (Hypothesis 2).

2.1.2. Social barriers

While the physical barrier hypotheses follow from how structural features of cities shape where people go, people's awareness spaces are also affected by the way different social groups live segregated lives. In general, people are more likely to interact with others with similar sociodemographic characteristics than to engage in activities with members of other social groups (McPherson, Smith-Lovin, & Cook, 2001). This homophily phenomenon combined with the fact that different social groups often live in different areas of a city leads to distinct awareness spaces for people of different social groups. Most people will do many activities within their own residential area, but when they travel to other areas, they are more likely to go to places where similar people live than to areas where other social groups live. This makes them more familiar to the former than to the latter (Liu et al., 2017; Massey, Condran, & Denton, 1987; Schnell & Yoav, 2001). Not only are people less likely to travel to areas where other social groups live, social segregation might also limit their perceptual comfort when they would travel there. This is especially important for offenders in racially/ethnically segregated cities. Rengert and Wasilchick (1985) argued that burglars of a particular racial/ethnic group would stand out in areas with a predominantly different racial/ethnic population. This could raise suspicion and increase the likelihood that they would not be able to commit a crime without being disturbed. It might thus even be more risky to try to commit crimes in areas dominated by other social groups (Rengert, Lockwood, & Groff, 2015). Several studies showed that offenders are indeed less likely to cross such social barriers for committing crime (Bernasco et al., 2013; Bernasco et al., 2017; Bernasco & Block, 2009; Chamberlain & Boggess, 2016; Rengert et al., 2015).

Social barriers in China are not primarily based on racial/ethnic differences, but they mainly exist between domestic migrant workers and local residents (Wang & Zuo, 1999; Zhu, 2007). Although local residents and domestic migrants (nonlocals) often do not differ much in their physical appearance as most of them belong to the same racial/ethnic groups, they can still be distinguished based on their *Hukou* status. Each household in China is required to have such a record in the government household registration system *Huji*. It officially registers a person as a resident of a particular area, which comes with social benefits to local residents, such as economic and comfortable public housing, healthcare, and social security (Johnson, 2017; Wu, 2002). While most domestic migrants usually have a low income and rent a room or live in dormitories that are affiliated to factories or other working places, local residents are usually more wealthy and often own their houses (Shen & Huang, 2003). When migrating from rural areas to the city, domestic migrants often end up living in marginal, unregulated, or legally ambiguous areas, whereas local residents tend to live in the more prosperous areas (Li & Fulong, 2008). Moreover, domestic migrants are generally excluded from these benefits and thus suffer from institutionalized discrimination based on the *Hukou* system (Johnson, 2017; Wang & Zuo, 1999; Zhu, 2015), which forces them to live in marginalized areas without much government support. This segregation also translates into differences in their activity spaces. Zhou et al. (2015) found distinct out-of-home activity spaces and showed limited interaction between wealthy and poor groups of people in Guangzhou, China. The social networks of domestic migrants and local residents also showed limited overlap. Even in places with a mixed high-density population, the two groups still tend to socialize only with their peers (Zhao & Wang, 2017). Renting a room from a local resident is often the only link between domestic migrants and local residents (Lin & Gaubatz, 2017).

In the analysis of spatial crime patterns in China, the places where migrants concentrate have been characterized as areas of high social disorganization. Population density is usually high and the people often live there in relatively high anonymity with low levels of social control (Chen et al., 2017; Du, Lin, Jiang, Long, & Lan, 2019; Song et al., 2018). Moreover, Feng, Lin, Long, and Liao (2019) and Liu, Feng, Ren, and Xiao (2018) argued that nonlocal and local offenders also have distinct crime patterns. Nonlocal offenders would be more likely to commit crimes in high population density areas. Because these migrant offenders usually live in villages in cities or work close to the urban areas that attract a considerable ambient population, while native offenders are more likely to live in suburban and less populated areas which attract fewer visitors (Feng et al., 2019; Liu et al., 2018). Meanwhile, different crime generators and attractors appear to have varying effects on migrant and native offenders. For example, migrant offenders are more likely to commit violent crimes close to hotels, trade markets, parks, and squares than native offenders, while the latter would be more likely to commit such crimes close to bars and restaurants (Feng et al., 2019). These findings indicate that nonlocal and native offenders have different crime location preferences.

Because of the strong segregation between local residents and domestic migrants, their distinct activity spaces and isolated social networks, the awareness spaces of members of one group will often not contain areas where the other group lives. Therefore, this study hypothesizes the following two social barrier hypotheses. *Residential burglars who are local to the city are more likely to offend in areas with a majority local resident population* (Hypothesis 3a). *Residential burglars from a domestic migrant background are more likely to offend in areas with a majority domestic migrant population* (Hypothesis 3b).

3. Data and methods

3.1. Study area and spatial units of analysis

In order to test the hypotheses, this study analyzed residential burglary data obtained from the Municipal Public Security Bureau of ZG city,[1] a large city located in the southern part of China. Since the reform and opening up of China in the 1980s, ZG city has developed rapidly, attracting a large number of domestic migrant workers. In 2015, it had a total population of 14 million, of which one third were nonlocal residents. All residential burglaries were geocoded to one of the 2643 communities in ZG city. Communities have a relatively homogeneous

[1] Because of the confidentiality agreement with police authorities, the real name of the city cannot be mentioned in publications.

population and their average size is 2.74 km-sq., which closely resembles the size of the units of analysis in many other crime location choice studies (e.g., Menting et al., 2016). Community size has a skew distribution though, with half of all communities smaller than 0.92 km-sq., but the smallest area only 0.01 km-sq. and the largest 82.49 km-sq. Communities in the downtown area are generally smaller with a higher population density, whereas communities in the suburbs often have a lot of farmland or woodland and are thus usually bigger in size with relatively low numbers of residents.

3.2. Residential burglaries and burglars

The Municipal Public Security Bureau of ZG city provided crime data for the period January 2012 to June 2016. As a common practice in all crime location choice studies (Ruiter, 2017), this analysis is limited to arrested offenders only. The key variables related to the Hukou status and the residential addresses of offenders are only available for arrested offenders, and these variables are essential for testing the hypotheses of this study. Research shows that distance from the offender's home is by far the most important factor in crime location choice (Bernasco, 2010; Bernasco & Block, 2009; Clare et al., 2009; Ruiter, 2017), which is why it is so important to include such information in this study.

In this study, for each recorded residential burglary for which at least one offender was arrested, the data contained unique offender identifiers, their home addresses, *Hukou* status, and where and when the burglary they were arrested for was committed. In total, 6664 burglaries committed by 8953 burglars were recorded. 257 burglars were registered for committing more than one burglary and for 1501 burglaries multiple offenders were recorded. Because the aim was to analyze all burglaries committed in ZG city by burglars that lived within the city boundaries, all burglars that lived outside of ZG city and those their home locations could not successfully be geocoded (2778 burglaries committed by 4023 burglars) were excluded, and also excluded are those target locations that could not successfully be geocoded (23 burglaries committed by 21 burglars). This practice of omitting offenders living outside of the study area and those that could not be geocoded is consistent with those of other studies (Frith et al., 2017; Vandeviver et al., 2015).

All burglaries committed by burglars for which their *Hukou* status is unknown were also excluded (3 burglaries committed by 3 burglars), because *Hukou* status is one of the key variables for testing the hypotheses. As is common in crime location choice research (Lammers, 2017), a single burglar was randomly sampled for each burglary for which multiple burglars were arrested. There are three reasons for this sampling procedure. First, the discrete choice modeling framework assumes a single decision-making agent, but we do not have information on the decision-making dynamics in pairs and groups of co-offenders, which is why multi-offender groups were treated as single decision-making units. Second, there is some evidence that co-offending offenders and single offenders are characterized by the same set of choice criteria (Bernasco, 2006). Third, random sampling is widely used in scientific research because it does not lead to systematic bias in included or excluded cases. After excluding all cases that failed to meet the study requirements, 3860 burglaries are included in the analyses. All home addresses of the burglars were geocoded to the centroids of their respective residential communities.

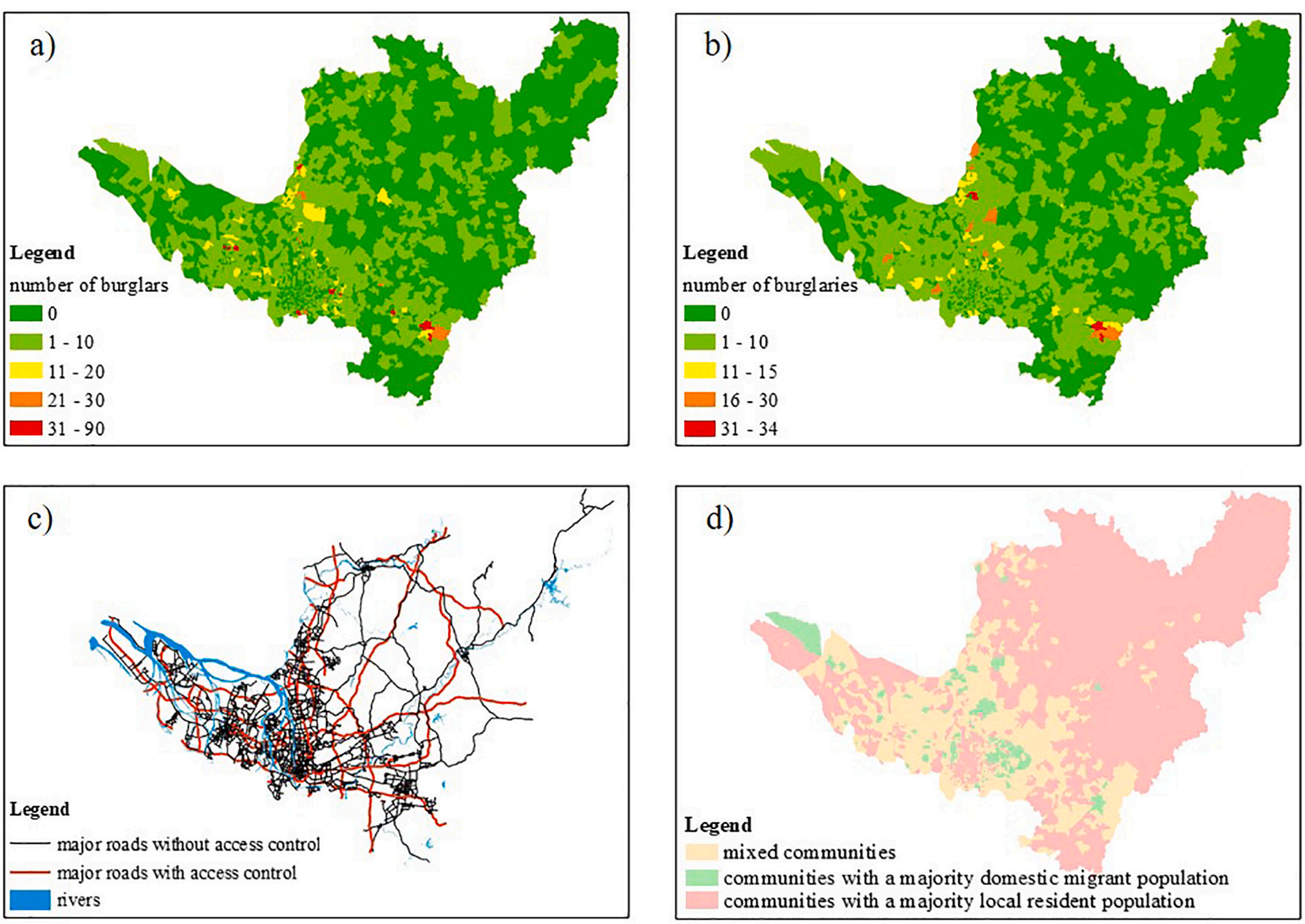

Fig. 1. Distributions of burglars, burglaries, physical barriers and social barriers in ZG city.

The distributions of offenders' home locations and target locations are shown in Fig. 1a and b respectively. Both are mainly concentrated in the periphery of the city center, with the former being more clustered than the latter. For example, the highest number of offenders living in the same community is 90, while the highest number of offenders committing crimes in the same community is 34.

3.3. Physical barrier measures

Physical barriers can only obstruct travel if they are in between the origin and destination of a trip. Because crime data do not contain the actual routes travelled by offenders, this study operationalized physical barriers as all major roads and rivers that lie in between the centroid of a burglar's residential community and those of all 2643 potential target communities within ZG city. If a straight line from the burglar's residential community centroid to a potential target community centroid crossed a major road or river, the target community was considered to lie on the other side of a physical barrier. Data on the road and river structure in ZG city is from RITU, an electronic map navigation company. The major roads and rivers that function as physical barriers are shown in Fig. 1c.

This study consider two types of roads wide enough to act as physical barriers, because these are generally hard to cross: (1) urban expressways and freeways, which are uninterrupted roads with full access control, and (2) urban arterial roads, national roads and provincial roads, which generally carry large volumes of traffic and although they have no access control, they have relatively few intersections and traffic lights (Huang, Cai, & Li, 2017). For each combination of a burglar's residential community (origin) and all 2643 communities in the city (potential burglary target destinations), this study calculated the number of major roads that had to be crossed. Based on these counts, four physical barrier variables were constructed: (1) *one major road with access control* (yes = 1, no = 0), which captures whether one major road with access control had to be crossed in order to reach the potential target community, (2) *multiple major roads with access control* (yes = 1, no = 0), (3) *one major road without access control* (yes = 1, no = 0), and (4) *multiple major roads without access control* (yes = 1, no = 0).

Roads are not the only physical barriers that cut through ZG city. It is also a city with many rivers and other large bodies of water that are not easily crossed. In order to construct a physical barrier measure related to these rivers, this study first selected only those bodies of water that encompass areas larger than 1 km-sq., because smaller bodies of water would not really obstruct travel as much. This study then calculated the number of rivers that had to be crossed in order to reach potential burglary target communities the same way as that for roads, and further constructed the following two variables: (1) *one river* (yes = 1, no = 0), which captures whether one river had to be crossed in order to reach the potential target community, and (2) *multiple rivers* (yes = 1, no = 0).

3.4. Social barrier measures

To test the hypothesized social barrier effects, this study used the most recent census data from 2010 for constructing social barrier measures. The census data contained community-level statistics of demographic and housing characteristics, among which the *Hukou* status of the residents. Based on these data, the proportion of residents in each community that were local residents with a ZG city *Hukou* status was calculated. Communities were subsequently divided into three categories (Fig. 1d): (1) communities with a majority local resident population, (2) communities with a majority domestic migrant population (with a *Hukou* status outside ZG city), and (3) mixed communities. Following Bernasco et al. (2013), the majority threshold was defined at 75%, but 70 and 80% thresholds were also used as a robustness check, which resulted in no substantive differences. In total, there were 1517 communities with a majority local resident population, 142 with a majority domestic migrant population, and 984 mixed communities.

These community-level measures were combined with the offender-level *Hukou* status in order to create six mutually exclusive combinations to capture social barriers: (1) local burglar-local majority community, (2) local burglar-mixed community, (3) local burglar-nonlocal majority community, (4) nonlocal burglar-nonlocal majority community, (5) nonlocal burglar-mixed community, and (6) nonlocal burglar-local majority community. Four dummy variables were created to represent combinations (1, 2, 4, 5), with combinations (3, 6) being used as reference categories in the statistical analysis.

3.5. Control variables

The hypothesized barrier effects are not the only important characteristics that affect where offenders commit crimes. Crime location choice studies generally show the strongest effects for distance from the offender's home (Ruiter, 2017). Offenders are much more likely to commit crimes close to home than to strike at distant places. Because the likelihood of having to cross a physical or social barrier increases with distance, it is important to control for the effect of distance when testing the hypotheses. Euclidian distances between the centroids of residential communities of the offenders and those of all 2643 potential target communities were calculated. The distances for burglaries committed within the offenders' own residential communities (843 offenses) were approximated by calculating the mean inter-point distance for 100 randomly distributed points within the residential community. This better accounts for the irregular shapes of communities than the standard approximation technique based on Ghosh (1951) that most crime location studies used. The median Euclidian distance of the 3860 arrested offenders here is 3.024 km, and the mean is 7.204 km with standard deviation 10.343 and the maximum distance is 90.403 km. Because distances between offenders' homes and their crime target areas generally follow a non-linear distance decay function with relatively many short trips and only a few long trips, this study used the negative value of the natural log of distance (*−log (Distance)*) as a control variable in the model.

The spatial distribution of crime not only depends on how offenders move through space in their daily life, but also on the attractiveness of targets. Therefore, this study needed to include community attractiveness measures in the models. Residential burglars are financially motivated and might thus prefer more affluent communities that could provide them with a higher expected profit (Bernasco & Luykx, 2003). This study included two measures related to the level of affluence of communities: the *proportion of houses built after 2000* and *rent prices*. Houses built after 2000 are generally more luxurious, because the abolition of the welfare housing policy in 1998 resulted in the development of the housing market economy, which effectively improved the living conditions of residents (Chen, Guo, & Ying, 2011; Jim & Chen, 2007). Next to this property characteristic, this study also used the average rent price in a community to capture the relative wealth of its residents. Based on the census data, this study distinguished four categories: no rent communities, low, medium and high rent communities. The first category contained those communities in which there simply are no houses for rent, which are usually communities in the rural areas far away from the city center. For all other communities, this study first calculated the average rent price by multiplying the number of houses in the eight different rent price categories –below 100, 100–200, 200–500, 500–1000, 1000–1500, 1500–2000, 2000–3000 and more than 3000 yuan/month– as distinguished in the census (the mid-points between the cut-off values were used for all but the lowest and highest categories, for which 50 and 4000 were used respectively). Subsequently, this study classified all communities into three categories: (1) *low rent communities* are all communities for which the average rent price falls within the lowest quartile, (2) *medium rent communities* are those communities with average rent prices between the lowest 25% and the highest 25%, and (3) *high rent communities* are all communities that have the highest 25% average rent prices. In the analyses, no rent communities were used as the reference category.

Burglars' target choices are not only assumed to depend on the perceived rewards, but they are also assumed to take the risks into account (Vandeviver et al., 2015). Areas with high levels of guardianship and few escape routes would be relatively unattractive. Because high-rise buildings in ZG city are commonly equipped with more security measures than low-rise buildings and they are also harder to escape from (Gu et al., 2016), the risk a burglar gets caught when committing a burglary is greater in a high-rise than a low-rise building. Therefore, the *proportion of high-rise buildings* in a community was included as well. Buildings over 9 floors were coded as high-rise buildings and all other buildings were considered low-rise buildings (Shi et al., 2013; Wu, Peng, & Lin, 2017).

Finally, this study also controlled for the natural log of the *number of households in a community*, because areas with more households simply provide more opportunity for burglary and previous burglary location choice studies showed that burglars indeed prefer to target areas with relatively many households (Bernasco & Nieuwbeerta, 2005; Townsley et al., 2015). Table 1 presents descriptive statistics for all control variables included in the models.

3.6. Methods

This study first presents the distribution of the barrier variables as well as their respective bivariate relationships with the residential burglary locations in ZG city (Table 2). Then it tests the hypotheses and analyzes why residential burglars prefer to target particular communities over others using discrete spatial choice models. These models originally developed in transportation research (Ben-Akiva & Lerman, 1985; McFadden, 1973) were introduced into the geography of crime by Bernasco and Nieuwbeerta (2005) and have been used in many different studies on the spatial decision-making of offenders since (Ruiter, 2017). The models assume rational decision-makers (i.e. the offenders) to choose the highest utility option from a finite set of discrete alternatives (the potential target communities). These models are capable of simultaneously assessing the effects of characteristics of the decision-maker and the choice alternatives on the outcome of the decision.

For testing the hypotheses, this study used the conditional logit model originally proposed by McFadden (1973) and recently used in crime location choice research (Ruiter, 2017). The dependent variable indicates which target community (out of all 2643) was chosen for a particular burglary (yes = 1, no = 0). The sheer size of the dataset, with 3860 burglaries committed in one of 2643 communities (resulting in a matrix over 10 million rows), prohibited the estimation of the more flexible mixed logit model that was recently used in crime location choice research (Frith, 2019; Frith et al., 2017; Townsley, Birks, Ruiter, Bernasco, & White, 2016).

In the conditional logit model, each offender *i* chose 1 community out of the full set of 2643 potential target communities. The utility of offender *i*'s choosing target community *j* is shown in Eq. (1).

$$U_{ij} = \boldsymbol{\beta x_{ij}} + e_{ij} = \beta_{pb}PB_{ij} + \beta_{sb}SB_{ij} + \beta_{di}DI_{ij} + \beta_j X_j + e_{ij} \quad (1)$$

Table 1
Descriptive statistics for control variables.

	Mean	SD	Minimum	Maximum
Community-level control variables ($N = 2643$)				
Proportion of houses built after 2000	0.308	0.264	0	1
Low-rent community	0.199		0	1
Medium-rent community	0.399		0	1
High-rent community	0.199		0	1
Proportion of high-rise building	0.114	0.230	0	1
log number of households	7.019	0.922	0	9.974
Individual-community-level control variable ($N = 3860*2643$)				
-log(Distance)	−3.256	0.809	−4.985	2.726

Table 2
Bivariate Relations between Burglary Locations and Physical and Social Barriers.

	# burglaries	% burglaries	# cases	% cases
River barriers				
0 rivers	3043	78.83	2,367,578	23.21
1 river	470	12.18	2,690,534	26.37
>1 river	347	8.99	5,143,868	50.42
Total	3860	100.00	10,201,980	100.00
Major roads with access control				
0 major roads	2506	64.92	1,431,816	14.03
1 major road	631	16.35	1,940,097	19.02
>1 major road	723	18.73	6,830,067	66.95
Total	3860	100.00	10,201,980	100.00
Major roads without access control				
0 major roads	1511	39.15	106,926	1.05
1 major road	568	14.72	253,095	2.48
>1 major road	1781	46.14	9,841,959	96.47
Total	3860	100.00	10,201,980	100.00
Local burglars				
Local majority community	355	62.28	864,690	57.40
Mixed community	193	33.86	560,880	37.23
Nonlocal majority community	22	3.86	80,940	5.37
Total	570	100.00	1,506,510	100.00
Nonlocal burglars				
Nonlocal majority community	538	16.35	467,180	5.37
Mixed community	1903	57.84	3,237,360	37.23
Local majority community	849	25.81	4,990,930	57.40
Total	3290	100.00	8,695,470	100.00

where U_{ij} denotes the utility of offender *i*'s choosing target community *j* and $\boldsymbol{x_{ij}}$ represents all the variables. For simplicity, PB_{ij} is the measure of physical barriers between offender's home community *i* and a potential target community *j*. SB_{ij} is the measure of social barriers between offender *i* and a potential target community *j*. X_j represents the control variables at the community level. DI_{ij} refers to the logged distance between offender's home community *i* and a potential target community *j*. The βs are the coefficients that need to be estimated and e_{ij} is the error term.

The probability of each offender *i* choosing target community *j* is estimated as follows:

$$\text{Prob}(Y_i = j|\boldsymbol{x_{ij}}) = \frac{exp(\boldsymbol{\beta x_{ij}})}{\sum_{j=1}^{2643} exp(\boldsymbol{\beta x_{ij}})} \quad (2)$$

where Y_i indicates whether offender *i* chose community *j*.

Only if the likelihood of arrest of ZG city-based offenders varies systematically across the different communities and is correlated with the community-level predictor variables and burglaries in blocks with high arrest probabilities are overrepresented, the analysis of only arrested offenders might potentially result in biased estimates. In order to address possible sample selection bias due to differences in arrest rates between communities, the weighted exogenous sample maximum likelihood (WESML) estimation method proposed by Bernasco et al. (2013) was used. This estimator was obtained in two steps. First, a binary logit model for the probability of arrest was estimated on the large burglary dataset. The logit model included all community-level covariates (see Appendix A). The predicted conditional probabilities of arrest were calculated using the results of this logit model. Second, these predicted probabilities were used as weights in the conditional logit model. The resulting odds ratios (OR) represent the increase in the odds of a community being targeted with a one-unit increase in the independent variable. Effect size differences were assessed using Wald Chi-squared tests. Estimating the effects of all independent variables simultaneously caused no collinearity issues as the average VIF value for all independent variables was 1.90, with a maximum value of 3.44, which is much lower than the acceptable threshold of 10 (O'Brien, 2007). The models were estimated using Stata/MP version 15.

4. Findings

4.1. Bivariate relationships

Based on the first two columns of Table 2, most burglaries were committed without crossing a river (78.83%) or a major road with access control (64.92%), and many burglaries (39.15%) without crossing a major road without access control. These bivariate statistics underscore the validity of the physical barrier hypotheses. For social barriers, it can be seen that local burglars committed 355 burglaries (62.28%) in communities with a majority of local residents, followed by 193 (33.86%) in mixed communities, and only 22 (3.86%) in nonlocal majority communities. However, domestic migrant or nonlocal burglars committed 1903 (57.84%) burglaries in mixed communities, followed by 849 (25.81%) in local majority communities, and 538 (16.35%) in nonlocal majority communities. These bivariate statistics suggest that the social barriers have different effects between local and nonlocal burglars.

However, many cases involve both physical barriers and social barriers simultaneously. Therefore, it is important that both types of barriers be tested in the same model.

4.2. Model results

Table 3 presents the results of the conditional logit models with WESML estimator, which provides a simultaneous test of all barrier hypotheses controlling for possible confounders. The odds ratios (ORs) presented here are reflective of relative preferences already accounting for the marginal in the distribution.

Four models are offered here, with the first as the baseline model without barriers, the second with physical barriers, the third with social barriers and the last with both physical and social barriers. Based on the AIC, BIC and pseudo R^2, the goodness of fits of model 4 is the highest, followed by model 2 and then model 3. All three outperform the baseline model (model 1). It verifies the importance of considering both barriers at the same time.

The results in model 4 show that communities closer to the home of the burglar are more likely targeted (OR = 4.33). The same holds for communities with a higher proportion of houses built after 2000 (OR = 1.83). Although communities with a higher average rent are obviously more prosperous and burglars could potentially obtain higher rewards, it is observed that low-rent (OR = 0.75), medium-rent (OR = 0.70) and high-rent communities (OR = 0.50) are actually less likely targeted than no rent communities. It is also assessed whether the effects of consecutive pairs were statistically significantly different and the results of post-hoc Wald tests indeed showed that low-rent communities have no significant difference in attracting residential burglars than medium-rent communities ($\chi^2(1) = 2.20$, $p = .138$) and medium-rent communities are more attractive to residential burglars than high-rent communities ($\chi^2(1) = 34.38$, $p = .000$). This suggests that communities with a higher average rent are actually less attractive to residential burglars. In line with the expectation, the results show that communities with more high-rise buildings are less (OR = 0.38) and communities with more households more (OR = 2.11) likely targeted.

Table 3 provides strong support for Hypothesis 1a and 1b, as it shows statistically significant odds ratios between 0 and 1 for all physical barrier measures. The odds to commit a burglary in a community are reduced by 43% (1–0.57) if burglars have to cross a river to get there compared to communities for which no river needs to be crossed. As hypothesized, major roads also function as physical barriers to crime journeys. Compared to communities for which burglars do not have to cross any major road, the odds a community is targeted are reduced by 18 (1–0.82) and 45 (1–0.55) percent respectively if a burglar has to cross a major road with and without access control. So, residential burglars in ZG city are indeed less likely to choose targets on the other side of rivers and major roads. The results further show that they are even less likely to do so if they have to cross multiple rivers ($\chi^2(1) = 29.38$, $p = .000$) than when they only need to cross one river, which corroborates Hypothesis 2. However, no statistically significant differences between the effects of multiple versus a single major road crossing (for major roads with access control, $\chi^2(1) = 0.33$, $p = .567$, and for major roads without access control, $\chi^2(1) = 0.65$ $p = .420$) were found. So, Hypothesis 2 is only partially supported.

Table 3
Conditional logit model with WESML of residential burglars' target location choices.*

	Model 1	Model 2	Model 3	Model 4
	OR	OR	OR	OR
0 rivers (ref.)		1.00		1.00
1 river		0.56***		0.57***
>1 river		0.36***		0.37***
0 major roads with access control (ref.)		1.00		1.00
1 major road with access control		0.82***		0.82***
>1 major road with access control		0.82***		0.85**
0 major roads without access control (ref.)		1.00		1.00
1 major road without access control		0.54***		0.55**
>1 major road without access control		0.56***		0.57**
Local burglars				
Local majority community			4.57***	4.53***
Mixed community			3.52***	3.42***
Nonlocal majority community (ref.)			1.00	1.00
Nonlocal burglars				
Nonlocal majority community			0.90	0.89
Mixed community			1.44***	1.39***
Local majority community (ref.)			1.00	1.00
Control variables				
-log(Distance)	6.10***	4.30***	6.00***	4.33***
Proportion of houses built after 2000	1.99***	1.78***	1.99***	1.83***
No rent community (ref.)	1.00	1.00	1.00	1.00
Low-rent community	0.79**	0.83**	0.71***	0.75***
Medium-rent community	0.68***	0.74***	0.64***	0.70***
High-rent community	0.52***	0.56***	0.46***	0.50***
Proportion of high-rise building	0.36***	0.41***	0.35***	0.38***
log(Number of households)	2.00***	2.00***	2.12***	2.11***
AIC	1,042,417	1,033,176	1,038,183	1,029,330
BIC	1,042,516	1,033,360	1,038,339	1,029,570
Pseudo-R^2	0.3194	0.3255	0.3222	0.3280

OR = odds ratio.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

The social barrier hypothesis is also only partially supported. Local burglars are indeed much more likely to target communities with a majority of local residents (OR = 4.53) than communities with a nonlocal majority. Mixed communities are also more likely targeted, but less so than local majority communities ($\chi^2(1) = 7.02$, $p = .008$). These effects are in line with Hypothesis 3a. However, nonlocal burglars are more likely to choose targets in mixed communities (OR = 1.39) than local majority communities and equally likely to target local and nonlocal majority communities (OR = 0.89). So, the social barrier hypothesis is only supported for local burglars. Local burglars are much more likely to target communities with residents that are predominantly native to the city, whereas nonlocal burglars do not have a tendency to commit crimes in communities with a majority nonlocal population. Hypothesis 3b is thus refuted.

5. Discussion and conclusions

This burglary location choice study from China tested how physical and social barriers affect which areas are targeted by residential burglars. This is the first attempt in simultaneous assessment of the impact physical and social barriers on target selection.

Physical barriers obstruct travel and people therefore have limited knowledge about areas on the other side of such barriers, thus reducing the likelihood a burglar would target those areas because offenders are assumed to commit crimes within their awareness space. The study also assessed the impact rivers and major roads have on where residential burglars commit their crimes in a major Chinese city. The distinct size and urban layout of the study area also allowed for testing how multiple physical barriers (roads and rivers) affect burglary location choices, whereas prior studies only tested whether offenders were less likely to target areas on the other side of a single barrier like the river Thames in London (e.g., Baudains et al., 2013).

In addition to these physical barriers, the study further tested how the social segregation between residents local to the city and domestic migrants differently affect the burglary location choices of burglars of both groups. All prior studies were done in Western cities where social segregation is mostly related to racial/ethnic differences, which also makes a person of one group stand out in a community dominated by the other. For offenders, this could be related to their risk of apprehension, which might be a second reason why they would not cross such social barriers for committing crime. However, in the Chinese context, most people belong to the same racial/ethnic group and people do not differ much in their physical appearance, which makes the test of the social barrier hypothesis in this study more strongly related to differences in awareness spaces and less confounded by this second explanation.

Overall, residential burglars are indeed to some extent “blocked” by physical and social barriers, but the findings were most consistent for physical barriers. Consistent with the hypothesis, residential burglars are less likely to commit crimes in areas for which they need to cross a physical barrier than in comparable areas for which they do not have to cross. Although this study hypothesized that having to cross multiple barriers would further reduce the chance of targeting an area, only rivers were found to have such a cumulative blocking effect, whereas the likelihood of targeting an area does not depend on having to cross one or multiple major roads. From the tests of the social barrier hypothesis, it can be concluded that burglars local to ZG city face strong social barriers as they mainly target communities with a majority local population, whereas no such barrier effect for nonlocal burglars from domestic migrant groups was observed. The main differences between previous research and the current study are summarized in Table 4.

Although some of the hypotheses were (partly) refuted, the findings provide support for the idea that offenders’ target choices are largely driven by the shape of their awareness spaces, as suggested by crime pattern theory. As in all crime location choice studies, a very strong distance decay effect was observed, so offenders are much more likely to target areas close to home than further away (Ruiter, 2017). This fits with the fact that people in general do most activities relatively close to home (Song et al., 2019). Controlling for distance though, it was still observed that offenders are more likely to target areas for which they do not have to cross physical or social barriers. Although this study has no data on how the offenders go about their daily lives and the actual shape of their awareness spaces, it is known that barriers constrain people’s mobility patterns to a certain extent and thus affect the shape of their awareness spaces (Brantingham & Brantingham, 1993). The finding that

Table 4
Comparison of the present study to previous research.

Topics	Previous research	the present study	Conclusion
Crime location choice and barriers	Western context, physical and social barriers separately studied	Chinese context, physical and social barriers examined simultaneously	Physical and social barriers should be considered concurrently
Physical barriers	A single physical barrier (major road or major river)	Multiple physical barriers (major roads and rivers)	Having to cross multiple physical barriers (in particular rivers) decreases the likelihood of targeting the area
Social barriers	Based on racial/ethnical differences	Based on the Hukou status (i.e., local vs nonlocal)	A conceptualization adjusted to the Chinese context

burglars in ZG city are more likely to target communities for which they do not need to cross either physical or social barriers thus provides support for crime pattern theory. The two findings that were inconsistent with the hypotheses are discussed in the next paragraphs.

The results showed that burglars in ZG city are equally likely to cross more than one major road as they are to cross a single road to commit their crimes. It was, however, hypothesized that more barriers would actually further reduce the likelihood of targeting a community, but this additional hypothesis was thus refuted. This might be due to the fact that the analysis could only account for barriers between the offenders’ home communities and the potential target communities without including information on how these areas were actually connected (Clare et al., 2009). In addition, the street network and other connectors like subways could also provide and efficient way to overcome physical barriers in the city. Further studies might test this by taking the topology of the street network and the public transportation system into account.

Although support for the social barrier hypothesis was found for local burglars, the hypothesis was not corroborated for nonlocal burglars, as the results showed that nonlocal burglars were actually more likely to choose targets among mixed communities and equally likely to target majority local communities as they were to target majority nonlocal communities. The failure to support the hypothesis for nonlocal burglars could be due to the fact that they are not a homogeneous group. Even though they are most distinct from local ZG residents due to the rights related to their *Hukou* status, the nonlocal population in ZG city is quite diverse and residential segregation not only exists between local residents and nonlocal migrant workers, but also among nonlocal groups from different places of origin. In fact, migrant workers from the same origin cities and regions usually congregate both in their living and working spaces. They often share information among members of the same origin group concerning housing and jobs, often because old migrants from a particular origin help their fellow new arrivals to adapt to big city life (Gu & Shen, 2003). Because of this internal heterogeneity, nonlocal burglars will often be also entirely unfamiliar with many of the majority nonlocal communities if they are of different origins. Migrants, including offenders, often have more ties with those from their hometowns (Orozco & Rouse, 2007), which is also an important reason for why co-offenders are also often from the same region of origin (Chen & Lu, 2018). The dichotomy used in this study obviously obscures this internal heterogeneity and potentially washes out the expected social barrier effects. Unfortunately, the census data obtained at the community level only allowed for the coarse distinction between those local and nonlocal to ZG city based on people’s *Hukou* status. Another reason for this asymmetrical social barrier effect may be found in differences in activity spaces between local and nonlocal residents of ZG city. If local residents have little reason to visit the communities that are predominantly inhabited by domestic migrants while domestic migrants do visit the communities of locals, nonlocal burglars would have more awareness of criminal opportunities in communities of local residents than the other way around. Interestingly, the results contribute to a better understanding of previous research findings. Several Chinese studies have shown that communities with a high percentage of nonlocal migrant residents have relatively high crime rates (Song et al., 2018; Song et al., 2019). The findings in this study, however, show that neither the nonlocal offenders nor the local offenders prefer to target those communities. This suggests that these communities only have high crime rates because nonlocal migrants have relatively high offending rates and combined with the strong distance decay effect, this causes these communities to suffer more from crime.

It is important to mention some limitations of this study. The first limitation is actually inherent to all studies that use the discrete spatial choice framework. Using this analytical framework reduces the analysis to the set of cleared burglaries only, because key offender-level variables need to be included in the model. For this reason, only the location choices of arrested burglars were analyzed, with non-arrested burglars left out of the study. The findings presented here are only reflective of arrested burglars in ZG city, and they may or may not be generalized to all ZG city burglars. However, there exists evidence from the Netherlands based on the analysis of DNA traces found at crime scenes that the spatial offending patterns of arrested and non-arrested offenders do not differ much (Lammers, 2014). Because this is the first such research in China, whether the results presented here reflect the spatial decision-making patterns of non-arrested burglars in ZG city needs to be explored in future studies. Second, census data from 2010 were used to construct the social barrier and control variables, while the study analyzed burglary data from 2012 to 2016. While this temporal mismatch is not desirable, it is rather common in all research that use the official decennial census data. Third, social disorganization theory (Sampson & Byron Groves, 1989) predicts that communities of high concentrated disadvantage would be attractive for burglars. In Chinese crime studies, the proportion of nonlocals is often used as the key variable of concentrated disadvantaged because majority of nonlocals are rural migrant workers with lower income and less education. That being said, it should be acknowledged that some nonlocal residents of ZG city do not fit this description. Those migrated from other cities tend to be better educated and have higher paying jobs (Liu & Shen, 2014a; Liu & Shen, 2014b). However, these exceptions do not affect the overall trend of non-locals being in a more disadvantageous status. Fourth, due to the difficulty of data acquisition, the variables such as income level that directly measure the level of wealth of the population are not included in the study, and they are substituted by the proportion of houses built after 2000 and the rent prices.

To conclude, this study showed that both physical and social barriers are important for understanding where Chinese residential burglars commit their crimes. Although these barriers do not entirely block offenders' mobility, they do limit their criminal mobility. This study showed that the principles of crime pattern theory help explain where offenders commit crimes in the Chinese context. Similar to Western cities, physical barriers like major rivers and roads impede offenders' movement in China. Different from Western societies, social barriers need to be conceptualized based on the distinction between local residents and domestic migrant workers in China. This study provides support for the idea that offenders' distinct spatial crime patterns are mainly based on their non-overlapping activity spaces and not so much driven by their risk assessments based on differences in appearance and the idea that they would stand out.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgements

This research was funded by the Research Team Program of Natural Science Foundation of Guangdong Province, China (No. 2014A030312010), National Key R&D Program of China (Nos. 2018YFB0505500, 2018YFB0505503), National Natural Science Foundation of China (Nos. 41531178, 42001171, 41901177), and Key Project of Science and Technology Program of Guangzhou City, China (No. 201804020016).

Appendix A

Table A1
Logistic Regression of Probability of Residential Burglary arrest By Characteristics of Target Community.

Variable	β	se(β)	e^{β}
(1) Proportion of high-rise building	0.581*	(0.064)	1.789
(2) Proportion of houses built after 2000	−0.005	(0.046)	0.995
(3) No rent community (ref.)			
Low-rent community	−0.366*	(0.052)	0.694
Medium-rent community	−0.471*	(0.049)	0.625
High-rent community	−0.243*	(0.054)	0.784
(4) log(Number of households)	−0.143*	(0.015)	0.866
Pseudo-R-sq.			0.0078

* $p < .001$ two-sided.

References

Baudains, P., Braithwaite, A., & Johnson, S. D. (2013). Target choice during extreme events: A discrete spatial chocie model of the 2011 London riots. *Criminology, 51*(2), 251–285.

Ben-Akiva, M. E., & Lerman, S. R. (1985). *Discrete choice analysis: Theory and application to travel demand.* Cambridge: MIT Press.

Bernasco, W., Ruiter, S., & Block, R. (2017). Do street robbery location choices vary over time of day or day of week? A test in Chicago. *Journal of Research in Crime and Delinquency, 54*(2), 244–275.

Bernasco, W. (2006). Co-offending and the choice of target areas in burglary. *Journal of Investigative Psychology and Offender Profiling, 3*(3), 139–155.

Bernasco, W. (2010). A sentimental journey to crime: Effects of residential history on crime location choice. *Criminology, 48*(2), 389–416.

Bernasco, W., & Block, R. (2009). Where offenders choose to attack: A discrete choice model of robberies in Chicago. *Criminology, 47*(1), 93–130.

Bernasco, W., Block, R., & Ruiter, S. (2013). Go where the money is: Modeling street robbers' location choices. *Journal of Economic Geography, 13*(1), 119–143.

Bernasco, W., Johnson, S. D., & Ruiter, S. (2015). Learning where to offend: Effects of past on future burglary locations. *Applied Geography, 60*, 120–129.

Bernasco, W., & Luykx, F. (2003). Effects of attractiveness, opportunity and accessibility to burglars on residential burglary rates of urban neighborhoods. *Criminology, 41*(3), 981–1002.

Bernasco, W., & Nieuwbeerta, P. (2005). How do residential burglars select target areas? A new approach to the analysis of criminal location choice. *British Journal of Criminology, 45*(3), 296–315.

Brantingham, P. L., & Brantingham, P. J. (1993). Nodes, paths and edges: Considerations on the complexity of crime and the physical environment. *Journal of Environmental Psychology, 13*(1), 3–28. https://doi.org/10.1016/S0272-4944(05)80212-9.

Brantingham, P. J., & Brantingham, P. L. (2008). Crime pattern theory. In R. Wortley, & L. Mazerolle (Eds.), *Environmental criminology and crime analysis* (pp. 78–93). Cullompton, UK: Willan Publishing.

Chamberlain, A. W., & Boggess, L. N. (2016). Relative difference and burglary location. *Journal of Research in Crime and Delinquency, 53*(6), 872–906.

Chen, J., Lin, L., Zhou, S., Xiao, L., Song, G., & Ren, F. (2017). Modeling spatial effect in residential burglary: A case study from Zg City, China. *ISPRS International Journal of Geo-Information, 6*(5), 138. https://doi.org/10.3390/ijgi6050138.

Chen, J., Guo, F., & Ying, W. (2011). One decade of urban housing reform in China: Urban housing Price dynamics and the role of migration and urbanization, 1995–2005. *Habitat International, 35*(1), 1–8. https://doi.org/10.1016/j.habitatint.2010.02.003.

Chen, P., & Lu, Y. (2018). Exploring co-offending networks by considering geographic background: An investigation of electric bicycle thefts in Beijing. *The Professional Geographer, 70*(1), 73–83.

Chen, S., Claramunt, C., & Ray, C. (2014). A Spatio-temporal modelling approach for the study of the connectivity and accessibility of the Guangzhou metropolitan network. *Journal of Transport Geography, 36*, 12–23. https://doi.org/10.1016/j.jtrangeo.2014.02.006.

Clare, J., Fernandez, J., & Morgan, F. (2009). Formal evaluation of the impact of barriers and connectors on residential Burglars' macro-level offending location choices. *Australian & New Zealand Journal of Criminology, 42*(2), 139–158.

Cutler, D. M., & Glaeser, E. L. (1997). Are ghettos good or bad? *The Quarterly Journal of Economics, 112*(3), 827–872.

Doucette, C. C. (2012). *An agent based model to study the barrier effect on an urban Neighborhood*. Master of Science, Mathematical Sciences. Virginia Commonwealth University.

Du, F., Lin, L., Jiang, C., Long, D., & Lan, M. (2019). Discerning the effects of rural to urban migrants on burglaries in Zg city with structural equation modeling. *Sustainability, 11*(3), 561.

Eagleson, S., Escobar, F., & Williamson, I. (2002). Hierarchical spatial reasoning theory and Gis technology applied to the automated delineation of administrative boundaries. *Computers, Environment and Urban Systems, 26*(2), 185–200.

Feng, J., Lin, L., Long, D., & Liao, W. (2019). An examination of spatial differences between migrant and native offenders in committing violent crimes in a large Chinese City. *ISPRS International Journal of Geo-Information, 8*(3), 119.

Frith, M. J. (2019). Modelling taste heterogeneity regarding offence location choices. *Journal of Choice Modelling, 33*, 100187. https://doi.org/10.1016/j.jocm.2019.100187.

Frith, M. J., Johnson, S. D., & Fry, H. M. (2017). Role of the street network in Burglars' spatial decision-making. *Criminology, 55*(2), 344–376. https://doi.org/10.1111/1745-9125.12133.

Ghosh, B. (1951). Random distances within a rectangle and between two rectangles. *Bulletin of the Calcutta Mathematical Society, 43*, 17–24.

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

Gu, J., Zhou, S., & Yan, X. (2016). Research on characteristics of urban burglary based on family in Guangzhou. *Human Geography, 31*(5), 87-92+140.

Huang, J., Cai, J., & Li, C. (2017). Review and thinking on code for transport planning on urban road: Importance of traffic organization in road network planning. *City Planning Review, 5*, 49–58.

Ji, W., Wang, Y., Zhuang, D., Song, D., Shen, X., Wang, W., & Li, G. (2014). Spatial and temporal distribution of expressway and its relationships to land cover and population: A case study of Beijing, China. *Transportation Research Part D: Transport and Environment, 32*, 86–96. https://doi.org/10.1016/j.trd.2014.07.010.

Jiang, S., Lambert, E., & Wang, J. (2007). Correlates of formal and informal social/crime control in China: An exploratory study. *Journal of Criminal Justice, 35*(3), 261–271.

Jim, C. Y., & Chen, W. Y. (2007). Consumption preferences and environmental externalities: A hedonic analysis of the housing market in Guangzhou. *Geoforum, 38*(2), 414–431. https://doi.org/10.1016/j.geoforum.2006.10.002.

Johnson, L. (2017). Bordering Shanghai: China's Hukou system and processes of urban bordering. *Geoforum, 80*, 93–102.

Johnson, S. D., & Summers, L. (2015). Testing ecological theories of offender spatial decision making using a discrete choice model. *Crime & Delinquency, 61*(3), 454–480.

Kim, S., & Jang, K. (2017). Urban form and walking activity: Analyzing their relation within De-facto boundaries for walkers (poster). *Journal of Transport & Health, 7* (Supplement S13). https://doi.org/10.1016/j.jth.2017.11.022.

Kramer, R. (2012). *What is on the other side of the tracks? A spatial examination of neighborhood boundaries and segregation*. Doctor of Philosophy. University of Pennsylvania.

Lammers, M. (2014). Are arrested and non-arrested serial offenders different? A test of spatial offending patterns using DNA found at crime scenes. *Journal of Research in Crime and Delinquency, 51*(2), 143–167. https://doi.org/10.1177/0022427813504097.

Lammers, M. (2017). Co-offenders' crime location choice: Do co-offending groups commit crimes in their shared awareness space? *The British Journal of Criminology, 0*(0), 1–19. https://doi.org/10.1093/bjc/azx069.

Lammers, M., Menting, B., Ruiter, S., & Bernasco, W. (2015). Biting once, twice: The influence of prior on subsequent crime location choice. *Criminology, 53*(3), 309–329.

Li, T., Shilling, F., Thorne, J., Li, F., Schott, H., Boynton, R., & Berry, A. M. (2010). Fragmentation of China's landscape by roads and urban areas. *Landscape Ecology, 25*(6), 839–853.

Li, Z., & Fulong, W. (2008). Tenure-based residential segregation in post-reform Chinese cities: A case study of Shanghai. *Transactions of the Institute of British Geographers, 33*(3), 404–419.

Lin, J., Huang, B., Chen, M., & Huang, Z. (2014). Modeling urban vertical growth using cellular automata—Guangzhou as a case study. *Applied Geography, 53*, 172–186. https://doi.org/10.1016/j.apgeog.2014.06.007.

Lin, S., & Gaubatz, P. (2017). Socio-spatial segregation in China and Migrants' everyday life experiences: The case of Wenzhou. *Urban Geography, 7*(38), 1019–1038.

Liu, L., Feng, J., Ren, F., & Xiao, L. (2018). Examining the relationship between Neighborhood environment and residential locations of juvenile and adult migrant burglars in China. *Cities, 82*, 10–18. https://doi.org/10.1016/j.cities.2018.04.014.

Liu, L., Huang, Y., & Zhang, W. (2017). Residential segregation and perceptions of social integration in Shanghai, China. *Urban Studies, 0*(0), 1–20. https://doi.org/10.1177/0042098016689012.

Liu, L., & Li, J. C. M. (2017). Progress and future directions of crime research in China with selected case studies. *Journal of Research in Crime and Delinquency, 54*(4), 447–453.

Liu, Y., & Shen, J. (2014a). Spatial patterns and determinants of skilled internal migration in China, 2000–2005. *Papers in Regional Science, 93*(4), 749–771.

Liu, Y., & Shen, J. (2014b). Jobs or amenities? Location choices of interprovincial skilled migrants in China, 2000–2005. *Population, Space and Place, 20*(7), 592–605.

Lo, T. W., & Jiang, G. (2006). Inequality, crime and the floating population in China. *Asian Journal of Criminology, 1*(2), 103–118.

Long, D., Lin, L., Feng, J., Zhou, S., & Jing, F. (2018). Assessing the influence of prior on subsequent street robbery location choices: A case study in Zg city, China. *Sustainability, 10*(6), 1818.

Massey, D. S., Condran, G. A., & Denton, N. A. (1987). The effect of residential segregation on black social and economic well-being. *Social Forces, 66*(1), 29–56.

McFadden, D. L. (1973). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in econometrics* (pp. 105–142). Cambridge, MA: Academic Press.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology, 27*(1), 415–444.

Menting, B., Lammers, M., Ruiter, S., & Bernasco, W. (2016). Family matters: Effects of family members' residential areas on crime location choice. *Criminology, 54*(3), 413–433.

Menting, B., Lammers, M., Ruiter, S., & Bernasco, W. (2019). The influence of activity space and visiting frequency on crime location choice: Findings from an online self-report survey. *The British Journal of Criminology.*. https://doi.org/10.1093/bjc/azz044.

Noonan, D. S. (2005). Neighbours, barriers and urban environments: Are things "different on the other side of the tracks"? *Urban Studies, 42*(10), 1817–1835.

O'Brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity, 41*(5), 673–690.

Orozco, M., & Rouse, R. (2007). *Migrant hometown associations and opportunities for development: A global perspective*. Washington, DC: Migration Policy Institute for the Department of International Development.

Peeters, M., & Elffers, H. (2010). Do physical barriers affect urban crime trips? The effect of a highway, a railroad, a park or a canal on the flow of crime in the Hague. *Crime Patterns and Analysis, 3*(1), 38–49.

Rengert, G., Lockwood, B., & Groff, E. R. (2015). Burglary in a segregated city: Race of offenders and community of offending. In M. A. Andresen, & G. Farrell (Eds.), *The criminal act: The role and influence of routine activity theory* (pp. 214–239). London: Palgrave Macmillan UK.

Rengert, G., & Wasilchick, J. (1985). *Suburban burglary: A time and a place for everything.* Springfield, IL: Charles C. Thomas.

Roberto, E., & Hwang, J. (2016). *Barriers to integration: Institutionalized boundaries and the spatial structure of residential segregation*. Princeton University. https://arxiv.org/abs/1509.02574. Unpublished Working Paper.

Ruiter, S. (2017). Crime location choice: State-of-the-art and avenues for future research. In W. Bernasco, H. Elffers, & J.-L. V. Gelder (Eds.), *The oxford handbook of offender decision making* (pp. 398–420). Oxford, UK: Oxford University Press.

Sampson, R. J., & Byron Groves, W. (1989). Community structure and crime: Testing social-disorganization theory. *American Journal of Sociology, 94*(4), 774–802. https://doi.org/10.1086/229068.

Schnell, I., & Yoav, B. (2001). The Sociospatial isolation of agents in everyday life spaces as an aspect of segregation. *Annals of the Association of American Geographers, 91*(4), 622–636.

Shen, J., & Huang, Y. (2003). The working and living space of the floating population in China. *Asia Pacific Viewpoint, 44*(1), 51–62.

Shi, J., Wei, S., Zhu, M., Chen, H., Pan, Y., Wan, S., & Wang, Y. (2013). Solar water heating system integrated Design in High-Rise Apartment in China. *Energy and Buildings, 58*, 19–26.

Song, G., Bernasco, W., Lin, L., Xiao, L., Zhou, S., & Liao, W. (2019). Crime feeds on legal activities: Daily mobility flows help to explain Thieves' target location choices. *Journal of Quantitative Criminology*, 1–24. https://doi.org/10.1007/s10940-019-09406-z.

Song, G., Lin, L., Bernasco, W., Xiao, L., Zhou, S., & Liao, W. (2018). Testing indicators of risk populations for theft from the person across space and time: The significance of mobility and outdoor activity. *Annals of the American Association of Geographers, 108*(5), 1370–1388. https://doi.org/10.1080/24694452.2017.1414580.

Song, G., Lin, L., Bernasco, W., Zhou, S., Xiao, L., & Long, D. (2018). Theft from the person in urban China: Assessing the diurnal effects of opportunity and social ecology. *Habitat International, 78*, 13–20. https://doi.org/10.1016/j.habitatint.2018.04.010.

Summers, L. (2012). *The role of place in outdoor serious violence*. Doctor of Philosophy. University of London, London.

Tian, L. (2006). Impacts of transport projects on residential property values in China: Evidence from two projects in Guangzhou. *Journal of Property Research, 23*(4), 347–365. https://doi.org/10.1080/09599910601095365.

Townsley, M., Birks, D., Ruiter, S., Bernasco, W., & White, G. (2016). Target selection models with preference variation between offenders. *Journal of Quantitative Criminology, 32*(2), 283–304.

Townsley, M., Birks, D., Bernasco, W., Ruiter, S., Johnson, S. D., White, G., & Baum, S. (2015). Burglar target selection: A cross-national comparison. *Journal of Research in Crime and Delinquency, 52*(1), 3–31.

Vandeviver, C., Neutens, T., Van Daele, S., Geurts, D., Beken, T. V., Zhang, L., … Liu, J. (2015). A discrete spatial choice model of burglary target selection at the house-level. *Applied Geography, 64*, 24–34.

Wang, F., & Zuo, X. (1999). Inside China's cities: Institutional barriers and opportunities for urban migrants. *The American Economic Review, 89*(2), 276–280.

Wu, W. (2002). Migrant housing in urban China. *Urban Affairs Review, 38*(1), 90–119.

Wu, X., Peng, B., & Lin, B. (2017). A dynamic life cycle carbon emission assessment on green and non-green buildings in China. *Energy and Buildings, 149*, 272–281.

Ye, X., Xu, X., Lee, J., Zhu, X., & Ling, W. (2015). Space-time interaction of residential burglaries in Wuhan, China. *Applied Geography, 60*, 210–216.

Yuan, J., Yu, Z., & Xie, X. (2012). Discovering regions of different functions in a city using human mobility and Pois. In *Paper presented at the proceedings of the 18th ACM SIGKDD international conference on knowledge discovery and data mining*.

Yue, H., Zhu, X., Ye, X., Hu, T., & Kudva, S. (2018). Modelling the effects of street permeability on burglary in Wuhan, China. *Applied Geography, 98*, 177–183. https://doi.org/10.1016/j.apgeog.2018.06.005.

Zhao, M., & Wang, Y. (2017). Measuring segregation between rural migrants and local residents in urban China: An integrated Spatio-social network analysis of Kecun in Guangzhou. *Environment and Planning B: Urban Analytics and City Science, 0*(0), 1–17. https://doi.org/10.1177/2399808317710658.

Zhou, S., Deng, L., Kwan, M.-P., & Yan, R. (2015). Social and spatial differentiation of high and low income groups out-of-home activities in Guangzhou, China. *Cities, 45*, 81–90.

Zhu, P. (2015). Residential segregation and employment outcomes of rural migrant Workers in China. *Urban Studies, 53*(8), 1635–1656.

Zhu, Y. (2007). China's floating population and their settlement intention in the cities: Beyond the Hukou reform. *Habitat International, 31*(1), 65–76.