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Modelling the effects of street permeability on burglary in Wuhan, China

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ABSTRACT

Crime is spatially concentrated as a result of many contributing factors. In this study, we evaluate the influence of street network permeability on the spatial distribution of burglary in Wuhan, China. First, we review previous research on the effects of street permeability on crime as well as the underlying interpretations and assumptions. Then, we explain the method used in this study and evaluate the influence of street permeability, together with a series of socio-economic and public facilities variables, on burglaries at the street segment level. The results suggest that streets with higher local (non-local) permeability are expected to be safer (dangerous).

1. Introduction

Environmental criminology contends that physical environmental features play a central role in the formation of crime's spatial distribution (Brantingham & Brantingham, 1999). The street network serves as the "skeleton" of an area because it reveals where the environmental components of the area are located (Davies & Johnson, 2015). As movements of people along roads are largely constrained as they travel from one place to another, the street network also facilitates the occurrence of motivated offenders with suitable targets and a lack of qualified guardians at a specific place and time, presenting conditions under which criminal activity will occur (Brantingham & Brantingham, 1999; Frith, Johnson, & Fry, 2017).

The street segment is a natural micro-level unit of analysis that has been widely adopted to better identify the environmental factors contributing to the formation of crime patterns (Davies & Johnson, 2015; Groff, 2017). In this study, a street segment represents the section of road that connects two intersections. When discussing the relationships between road segments and crime, the concept of street permeability is frequently applied (Birks & Davies, 2017; Brantingham & Brantingham, 1993; Johnson & Bowers, 2010). Permeability refers to the manner in which street configuration impacts the extent to which the neighborhood is opened to external pedestrian and vehicular traffic, and hence influences criminal activity (Cozens & Love, 2009; Johnson & Bowers, 2010). Some parts of a road structure are less permeable and difficult to use to arrive at a destination via a reasonably direct route; by contrast, others are more permeable and easier to reach because they are well connected (Frumkin, Frank, & Jackson, 2004).

In this study, we examine the influence of street permeability on burglary in one of the largest metropolitan cities in central China. The research is carried out in a large district by using a three-year dataset to assure the reliability of the results. In addition, socio-economic and facilities variables are taken into account, as these factors influence crime patterns.

2. Literature review

This study focuses on the effects of street permeability on burglary, which belongs to the area of environmental criminology (Brantingham & Brantingham, 1999). According to this theory, the physical environment is a crucial consideration when offenders choose targets (Nee & Taylor, 2000). For example, Wright and Decker (1994) demonstrated that "layout" features such as the location of the house on the street (indicating ease of access and escape) and its size (indicating level of wealth) are the most important factors; they also showed that burglars tend to avoid public dwellings and target affluent residences. Indeed, the possibility of a neighborhood being chosen for burglary is positively correlated with its spatial proximity to where the burglar lives, its accessibility, its lack of guardianship, and the number of possible objects in the neighborhood (Bernasco & Nieuwbeerta, 2004). High-rise residences with elevators, long dark corridors, and easy access to the public are prone to crime (Mayhew, 1979). Burglars prefer unoccupied houses as they are less guarded (Waller & Okihiro, 1978), while detached houses are naturally more vulnerable because they are easy to

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enter and there are usually multiple escape routes (Nee & Taylor, 2000).

The physical environment is also correlated with the popular repeat and near-repeat phenomenon of burglaries, namely shortly after a location is burgled, the same location and locations nearby are exposed to an elevated risk of victimization (Bernasco, 2008). Bernasco (2008) demonstrated that after committing a burglary, the offender gains knowledge about the location of the property, how it can be accessed, the interior layout, and places where precious items are to be found. Hence, a rational burglar tends to return to that property or share information with other burglars (Bowers & Johnson, 2004). These same offenders or their associates are responsible for repeat and near-repeat burglaries (Bowers & Johnson, 2004). Moreover, compared with unrelated burglary cases, near-repeat burglaries show a certain similarity in burglars' modus operandi such as the means and point of entry (Bowers & Johnson, 2004).

As to the effect of street permeability on burglary, there are two main opposing perspectives, namely the "enclosure" and "encounter" models (Cozens & Love, 2009). According to the "enclosure" model, more "enclosed" or less permeable residential areas are safer. People are likely to visit certain places more frequently than other places in their routine everyday activities, such as their homes, workplaces, and places for entertainment and shopping (Cohen & Felson, 1979; Summers & Johnson, 2017). These frequently visited places constitute people's awareness spaces (Beavon, Brantingham, & Brantingham, 1994; Brantingham & Brantingham, 1993; Cohen & Felson, 1979). Rational choice theory further contends that burglars rarely aimlessly hunt for crime opportunities outside their awareness space; instead, they tend to select targets from places they already know (Brantingham & Brantingham, 1984; Nee & Taylor, 2000). For example, Felson (1993) demonstrated that burglars hunt for a property within attractive areas noted during their routine activities. Davidson and Davidson (1981) also found that burglars choose familiar properties near where they live. Less permeable areas, however, are less accessible and hence only known to local residents; they are less likely to appear on non-residents' daily routes and thus less likely to lie in the awareness space of potential offenders (Dovey, 2000; Summers & Johnson, 2017).

When considering the "enclosure" model, increased permeability means more access for all citizens (potential offenders included) (Cozens & Love, 2009). Because of the mixed use of spaces by residents and non-residents, the territoriality of neighbors would decrease as it is not clear who should take responsibility for the natural surveillance of the neighborhood (Johnson & Bowers, 2010). Therefore, the more permeable a place is, the more opportunities for crime there are (Cozens & Love, 2009). Hence, less permeable areas are safer because non-residents are less likely to visit these places, the ownership of these neighborhoods is evident, and neighbors act in their role as natural guardians (Newman, 1972).

Newman's (1972) proposed idea of a defensible space also supports the "enclosure" model. As access to such spaces is usually restricted, they are mostly dominated by local residents. In this way, residents' sense of territoriality or responsibility over a residential space motivates them to act as natural guardians. Non-residents are obvious in these areas and thus easy to recognize and challenge (Cozens & Love, 2009; Newman, 1972). A modern method for crime control, referred to as Crime Prevention through Environmental Design (CPTED), is based on the defensible space concept (Jeffery, 1969; Sohn, 2016). CPTED is proposed to reduce fear and the occurrence of crime by designing the built environment properly (Crowe, 2000). Based on design principles such as territoriality and access control, it suggests the separation of private and public areas, use of road closures, and development of physical barriers to deny potential offenders' access (Sohn, 2016). In summary, a non-permeable street layout is an effective design for crime reduction (Cozens, 2008; Cozens, Pascoe, & Hillier, 2004; Town, Davey, & Wooton, 2003).

By contrast, the "encounter" model suggests that permeable streets are safer (Dovey, 1998). Streets with high permeability are well connected to the street network and provide easy access for arrival at a destination. Such "central" streets promote the use of permeable areas by all citizens. The abundant use of the street is beneficial because more strangers will be present, increasing the level of "eyes on the street." These strangers are therefore beneficial to community safety because, together with residents, they provide informal surveillance in that space (Jacobs, 1961). In this way, less crime could be expected on streets with the highest permeability (Davies & Johnson, 2015). Less permeable spaces with few people are dangerous because they are likely to suffer more crimes as there are few witnesses (Beavon et al., 1994).

The evidence of the "encounter" model is mainly supported by studies using the space syntax methodology (Cozens & Love, 2009). For example, Jones and Fanek (1997) controlled for the influence of demographic characteristics and examined the effect of spatial configuration on crime. They found that crime was concentrated in isolated and less accessible streets, while lower crime rates should be expected in areas with higher permeability (see also Chih-Feng Shu, 2000). Hillier (2004) suggested that community safety could be optimized through spatial design. Permeable environments such as reasonably regular street layouts, well-integrated streets, and constituted linear streets are secure (Hillier, 2004).

3. Research design

3.1. Study region

The study region is Jianghan District, Wuhan City, China. Wuhan is a megacity and is the political, economic, financial, cultural, educational, and transportation center of central China (Bureau, 2014). It is composed of seven urban districts and six suburban districts, and is divided into three parts by the Yangtze and Hanshui Rivers: Han Kou, Han Yang, and Wu Chang (Ye, Xu, Lee, Zhu, & Wu, 2015). As shown in Fig. 1, Jianghan District is located at the confluence of the two rivers in the center of Wuhan City. It is the most densely populated district with an area of 33.43 km^2 and a population of about 710,000 (Bureau, 2014). It has convenient transportation facilities with a dense highway network and three subway lines. Hankou Railway Station, the largest railway station in central China, is also located in Jianghan District. Jianghan District also has convenient waterway transportation.

The district is the core area of financial business in Wuhan City. It has a well-developed service industry, including retail, finance, insurance, business, and tourism services. It also features well-equipped leisure and entertainment facilities such as squares, pedestrian walkways, and parks. However, as a developing city, this area is still under urbanization. There are five urban villages in the west and north as well as a large-scale CBD under construction in the southwest. A floating population of more than 100,000 live in this district (Bureau, 2014). The interaction of these complicated geographical, demographical, and economic features means that Jianghan District has a high level of crime.

3.2. Data

3.2.1. Crime data

An official residential burglary dataset was provided by the Wuhan Municipal Bureau of Public Security. These data comprised all residential burglaries that occurred between January 1, 2013 and December 31, 2015 (6982 cases). The location of each case was recorded as XY coordinates by using the World Geodetic System 1984. Each case was projected to the nearest street segment by using Geographical Information System software.

3.2.2. Road data

The road network geographic data were sourced from the Wuhan Police Geographic Information System (WH-PGIS). All the street