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The usefulness of past crime data as an attractiveness index for residential burglars

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Abstract

This study examines the effects of neighbourhood attractiveness on the residential burglar's crime location choice process using a discrete choice model. We show that past crime data are an important index of a neighbourhood's attractiveness and can be combined with other attractiveness indices adapted from previous studies. We used data from 369 solved cases committed by 70 offenders and related these data to 1,134 areas (500 m grid cells) in Sendai City, Japan. The results showed that residential burglars were attracted to the following potential locations for crimes: (a) areas in proximity to his or her own residence; (b) areas having many or at least a higher proportion of residential burglaries in the past; (c) areas having many residential units; and (d) areas having a higher proportion of single-family dwellings. The results confirm the validity of past crime data as an index of a neighbourhood's attractiveness for residential burglary.

KEYWORDS

attractiveness, criminal location choice, discrete choice, residential burglary

1 | INTRODUCTION

1.1 | Importance of the offender's criminal location choice process

The importance of understanding how offenders choose their targets or the location for their crimes has been well recognised in criminal investigations and crime prevention activities. Also, the importance of geographic profiling

techniques for analysing crime locations to determine the most probable area of an offender's residence (Rossmo, 2000) is also well recognised. However, many geographic profiling techniques currently use only locational information in their analytical constructs and do not include any information about the location choice processes used by criminals. However, as Rossmo (2012) proposed, the integration of location choice into the analytical procedures of geographic profiling should make such profiling more accurate and efficient.

Theories explaining the offender crime location choice processes have been proposed. One of these is *rational choice theory*, which assumes that offenders rationally decide on their criminal behaviour to maximise their benefit by increasing gains and reducing costs within the limitations of their time and ability and the availability of relevant information (Cornish & Clarke, 1986). According to the rational choice theory, the locations of criminal activities can be predicted because offenders behave with a certain regularity, based on understandable laws and rules. *Routine activity theory*, proposed by Cohen and Felson (1979), is another theory concerning an offender's criminal location choice process. This theory hypothesizes that crime is a result of the convergence, in time and space of a motivated offender, a suitable target, and the absence of capable guardians against violations. The absence of capable guardians can be caused by environmental factors, including certain types of land-uses, declining neighbourhoods, and the absence of natural surveillance. The *crime pattern theory* is a third theory that provides a basis for the understanding the offender crime location choice processes. Crime pattern theory argues that offenders commit crimes in their awareness space, which is established within their activity space, and includes a set of associated places such as the environs of travel routes (Brantingham & Brantingham, 1993). According to the crime pattern theory, criminal incidents normally occur near an offender's anchor points, such as their residences or workplaces. These theory is supported by contemporary research. For example, Nee and Taylor (2000) and Nee and Meenaghan (2006) conducted interviews with residential burglars and demonstrated that offenders choosing a target use search strategies based on environmental cues. Also, Malleson, Heppenstall, and See (2010) reported that residential burglars rationally decide on their criminal behaviour through an agent-based model. Therefore, areas that are located near anchor points that are considered to have suitable environmental features for committing crime and have sufficient potential targets should attract offenders. Therefore, if the specific indices of a neighbourhood's attraction can be identified, geographic profiling could be improved by the integration of indices of attractiveness into the analytical procedures for crime prevention used by authorities.

1.2 | The introduction of past crime data

Studies have suggested that past crime data could predict future crime locations (Johnson et al., 2007; Johnson & Bowers, 2004; Johnson, Summers, & Pease, 2009; Mohler, Short, Brantingham, Schoenberg, & Tita, 2011; Short, D'Orsogna, Brantingham, & Tita, 2009). Moreover, repeat victimizations have been explained by two approaches: the event dependent approach and the risk heterogeneity approach (Johnson & Bowers, 2004). The event dependent approach suggests that offenders often repeat crimes in the identical locations where they committed crimes in the past, and recent studies have confirmed the validity of this idea (Bernasco, Johnson, & Ruiter, 2015; Lammers, Menting, Ruiter, & Bernasco, 2015). The risk heterogeneity approach suggests that specific environments attract offenders when selecting a location to commit a crime. However, research has not confirmed the validity of this approach because the repeat victimisation of the same offender has a dramatic impact on the overall repeat victimisation. Furthermore, it has been reported that the repeat victimizations of the same offenders tend to decrease with time (Lammers et al., 2015), although repeat victimisation based on environmental attractions would be expected to continue. Therefore, if it is demonstrated that past crime data suggest attractive locations even if time passes, this knowledge could be applied to geographic profiling for new offenders.

Levine and Block (2011) proposed a Bayesian approach to use past crime data for geographic profiling. A Bayesian approach combines past offender's crime data including an offender's anchor points and crime locations for estimating the journey-to-crime based on considering the offender's territory. However, the Bayesian approach can only be applied to crime locations where past offences have been committed, whereas it cannot estimate the

residence probability when a crime occurs in a new place where an arrested offender has not previously committed a crime. In contrast, if past crime data are used as an index of the attractiveness of neighbourhoods in geographic profiling, then that no crime has occurred at a given place in the past would be significant. If a crime occurred in a place where there had been no or little crime in the past, there would be a low possibility that the offender travelled from far because it could be assumed that the place was not attractive to offenders. In other words, it can be presumed that the possibility that the offender lives nearby is high. O'Leary (2009a) suggested that past data relating to the same types of crime should be introduced to geographic profiling as a crime series analysis index of a neighbourhood's attractiveness to criminals. Mohler and Short (2012) also stated that a neighbourhood's attractiveness as a base for criminal activity can be estimated from past crime data when we cannot obtain potential target densities, such as in person to person crime. O'Leary (2009b) suggested that we must use "same crime type" data because the geographic distribution of past crimes may differ from type to type, and we must collect enough data because the density of sparse past crime for predictive purposes becomes broader and smoother. However, no study to date has examined whether data on past crime would be a useful index of the attractiveness of a neighbourhood for new offenders.

Past crime data have an advantage, as it is more easily obtainable for different crime types than many of the other indices of neighbourhood's attractiveness that have been used in previous studies. For example, potential target density has been shown to be an important index of neighbourhood's attractiveness for criminals (Bernasco & Nieuwbeerta, 2005), but potential targets also differ from crime types and are unavailable for person to person crime. Another possible index of neighbourhood's attractiveness is the nature of the road structure in an area. Bernasco (2014) referred to the different risks of residential burglary produced by proximity to a major thoroughfare or a location in a dead-end street. In addition, Davies and Johnson (2015) showed that more sinuous streets have a higher risk of residential burglary, and Chang (2011) showed that intelligible road patterns in an area have a lower risk of this crime. Although road structures can represent visibility and accessibility as ease of incursion and getaway in an area, constructing this measurement for a road structure is a difficult task. Finally, the existence of crime attractors is also an index of a neighbourhood's attractiveness. Brantingham and Brantingham (1995) explained that crime attractors are places that are known to have many criminal opportunities, for example, bars, drug markets, large shopping malls, insecure parking areas, and so on. However, what landmarks behave as crime attractors is not clearly defined for each crime type, so integration of this variable into the analytical procedures of geographic profiling is not easy. If the validity of past crime data as an index of neighbourhood's attractiveness is proven, these data should be introduced to the analytical procedures of geographic profiling as an integrated index of attractiveness.

1.3 | Discrete choice approach

Studies examining factors affecting an offender's crime location choice process have been conducted energetically in the last decade or so, probably because some general paradigms of the spatial behaviour of offenders have been provided (Townsley et al., 2015). As one of these general paradigms, Bernasco and Nieuwbeerta (2005) proposed using a *discrete choice* approach in the examination of an offender's crime location choice process. The purpose of the discrete choice model is to explain the outcome of behaviour when an individual decision maker must choose a single alternative from a set of finite distinct alternatives (Ben-Akiva & Bierlaire, 1999). Most discrete choice models are derived from random utility maximisation theory, where a decision maker evaluates each available alternative based on its utility (profits, satisfaction, and so on) and chooses the alternative that maximises his or her utility (McFadden, 1973). The use of random utility maximisation theory to study the criminal location choice process can be supported by rational choice theory. That is, offenders choose crime areas by considering the costs (e.g., travel distance and labour to find targets), the risks (e.g., public places and security cameras), and the benefits (e.g., expected value of a target), and maximise their net profit by choosing an area from a pool of potential locations. The discrete choice model will provide a solution that is the result of the effect of a single variable under the condition of all the other variables being fixed. If random error terms are independent and identically (Gumbel or Type I extreme value) distributed, then the parameters can be estimated with a multinomial logit model known as the conditional logit model

(Ben-Akiva & Bierlaire, 1999). The conditional logit model has been widely used in previous studies. Therefore, it is appropriate that past criminal data are included in the conditional logit model, together with other indices of neighbourhood's attractiveness as shown in previous studies, to allow the validity of past crime data as an index of this attractiveness to be examined.

Moreover, Bernasco (2007) examined the accuracy of geographic profiling using the conditional logit model with computer simulations and demonstrated that introducing data on the attraction of targets improves accuracy more than estimations made by distance alone. We can use the same method to calculate the probability of an offender's residence by using past crime data to indicate the attraction of a target.

1.4 | Indices affecting the criminal location choice process of residential burglary

Most studies using the discrete choice model to examine crime location choice processes have used residential burglary as the target crime type, because the number of these crimes is much greater than those of other felonious crimes such as homicides and arson. In addition, residential burglaries are more serious crimes than they seem because they can cause severe damage/violence when a burglar encounters a resident at the target residence (Haginoya, 2014). Moreover, previous studies have clarified the process of choosing crime locations by residential burglars to a certain extent (Nee & Meenaghan, 2006; Nee & Taylor, 2000). Major indices adapted in previous studies using the discrete choice model to examine the criminal location choice process of residential burglars are as follows:

1.4.1 | Distance from offender's residence

Almost all studies on the spatial behaviour of criminals have indicated that the greater the distance from an offender's place of residence has a negative effect on the likelihood of an area to be chosen as a crime location (Bernasco, 2006; Bernasco, 2010a; Bernasco et al., 2015; Bernasco & Nieuwbeerta, 2005; Clare, Fernandez, & Morgan, 2009; Townsley et al., 2015; Townsley, Birks, Ruiter, Bernasco, & White, 2016). This phenomenon is referred to as the distance decay pattern. This pattern accords with crime pattern theory, and the general least-effort principle that assumes that the proximate destination will be preferred if the desirability of each destination is equal. Empirical studies (Haginoya, 2014; Haginoya et al., 2017; Kan, Haginoya, Hosokawa, Gamo, & Ishiuchi, 2016) have shown that the distance decay pattern of residential burglary clearly appears in Japan.

1.4.2 | Number of residential units

The number of residential units can be indicative of the number of potential targets for residential burglary. Therefore, an area having a lot of residential units has a raised likelihood of being chosen as a location for criminal activities (Bernasco, 2010a; Bernasco et al., 2015; Bernasco & Nieuwbeerta, 2005; Clare et al., 2009; Townsley et al., 2015; Townsley et al., 2016).

1.4.3 | Proportion of single-family dwellings

A higher proportion of single-family dwellings can be regarded as conferring greater physical accessibility for residential burglary, because in most single-family dwellings, doors and windows on the ground floor are accessible directly to the street or the back of a property (Bernasco & Nieuwbeerta, 2005). Nee and Taylor (2000) showed that residential burglars prefer detached houses rather than terrace house when selecting crime targets. Previous research thus indicates that the higher the proportion of single-family dwellings, the more an area will attract residential burglars (Bernasco & Nieuwbeerta, 2005; Townsley et al., 2015; Townsley et al., 2016). However, the proportions of the criminal cases that occurred at single-family dwellings in the test data are largely unspecified in previous studies, even though the proportion of single-family dwellings may have the function of increasing potential target density when residential burglars prefer single-family dwellings over apartment houses. It must be recognised, however, that the proportion of cases affecting single-family dwellings targeted in test data should be sufficiently small to make clear the relevance of the connection between the proportion of single-family dwellings and physical accessibility.

1.4.4 | Degree of ethnic heterogeneity and degree of residential mobility

Ethnic heterogeneity and residential mobility are seen to lead to the absence of capable guardians in routine activity theory (Bernasco & Nieuwbeerta, 2005). However, some previous studies (Bernasco, 2006; Bernasco & Nieuwbeerta, 2005; Clare et al., 2009; Townsley et al., 2015) have shown that there is no significant relation between the degree of residential mobility and the likelihood of an area being chosen as a location for criminal activity. The degree of ethnic heterogeneity has usually been defined using the country of birth of the subjects and their parents in previous studies (Bernasco & Nieuwbeerta, 2005), but there are no such demographic data available in Japan. Most previous studies have been conducted in multi-ethnic nations, such as the Netherlands, the United Kingdom, and Australia, but Japan is mostly an ethnically homogeneous nation, if ethnicity is defined as being based on a subject's birth nation. Thus, in this study, the proportion of foreigners is used as a surrogate for the degree of ethnic heterogeneity in Japan.

1.4.5 | The real estate value of residences

The real estate value of residences has been used as an index of the affluence of an area (Bernasco & Nieuwbeerta, 2005), but only a few studies (e.g., Bernasco, 2010a) have shown a significant correlation between the real estate value of residences and the likelihood of being chosen as a location for criminal activity. However, the relationship between the real estate value of the residences in an area and the affluence of the area might be diluted when being described by using the mean values for each property in a larger area. Therefore, smaller areas should be preferred when these values are used as an index of the affluence of an area. Bernasco (2010a) used postal code areas, smaller areas than the neighbourhood areas used in other studies (e.g., Bernasco & Nieuwbeerta, 2005), as the unit to calculate the real estate value of residences as an index of the affluence of an area.

1.4.6 | Distance from the city centre

Bernasco and Nieuwbeerta (2005) insist that areas near a city centre are at greater risk of residential burglaries because the layout of the city centre is commonly known by many individuals, including potential burglars, through visitation and experience. Some studies (Bernasco et al., 2015; Townsley et al., 2015) have identified the significant impact of the distance from the city centre on crime rates, but there are others that show no significant effects (Bernasco, 2006; Bernasco & Nieuwbeerta, 2005; Townsley et al., 2016). The definition of city centre used in previous studies differs by countries and cities though; for example, the neighbourhood called Zuidwal is defined as a city centre in the Hague (Bernasco, 2006; Bernasco & Nieuwbeerta, 2005), whereas the Central Business District is defined as a city centre in Brisbane, Australia (Townsley et al., 2016). The definition of the city centre is even left unspecified in some previous studies (Bernasco et al., 2015), and the mixed results that can be caused by this are evident in these studies.

Bernasco and Luykx (2003) demonstrated that attractiveness, opportunity, and accessibility were the key drivers of a residential burglar's crime location choice. *The number of residential units*, *the proportion of single-family dwellings*, and *the real estate value of residences* are indicative of attractiveness; *the degree of ethnic heterogeneity* and *residential mobility* are indicative of opportunities; and *the distance from offender's residence* and *the city centre* are indicative of accessibility. The suitability of past crime data for the construction of an index of neighbourhood's attractiveness as part of a residential burglars' crime location choice process can nevertheless be examined when the above-mentioned indices and past crime data are included in the conditional logit model.

1.5 | The research purpose

The goal of this study was to examine past crime data to determine whether such data could be used as an index of the attractiveness of neighbourhoods for residential burglary, which is the first step to introducing past crime data for geographic profiling. The number of residential burglaries in the past several years is a valid variable describing past crime data to be introduced to the conditional logit model of a residential burglar's process of choosing the location

for a crime. Furthermore, *the past residential burglary rate* calculated by dividing *the number of past residential burglaries* by *the number of residential units* is considered a variable describing the attractiveness of neighbourhoods by excluding the effects of potential target density. *The number of past residential burglaries* is highly correlated with *the number of residential units*. Therefore, it was necessary to consider *the past residential burglary rate* to examine the influence of factors other than the number of potential targets. To examine the usefulness of past crime data, we introduced *the number of past residential burglaries* and *the past residential burglary rate* to the conditional logit model together with indices of attractiveness that has been clarified to date.

We can use data from the Japanese national census as surrogate variables for the indices described above—the number of residential units, the proportion of single-family dwellings, the degree of ethnic heterogeneity, and the degree of residential mobility—in Japan. In addition, the proportion of foreigners can be used as a descriptor for the degree of ethnic heterogeneity in Japan. Moreover, the Japanese national census includes data describing the population who lived in a different place for 5 years previously that we can use to describe the degree of residential mobility. The Japanese national census, in addition to neighbourhood units, makes data aggregated by grid cell unit available. The size of grid cells is 500 m on a one side and comes with specified longitude and latitude data. Using grid cells as alternatives in the conditional logit model allows the unbiased comparison of alternatives, because the grid cells are equal in size. Ratcliffe (2003) showed that physical boundaries separating neighbourhoods, such as highways and parkland, do not form barriers to the movement of residential burglars. Unfortunately, other attributes, such as the real estate value of residences in Japan, are not readily available. And given that it is relatively common that elements of the city centre (e.g., main stations, government buildings, public facilities, and commercial facilities) are distributed widely inside cities in Japan, it is difficult to define a single point as the city centre in Japan. Therefore, we were only able to use *the distance from offender's residence*, *the number of residential units*, *the proportion of single-family dwellings*, *the proportion of foreigners*, and *the proportion of newcomers* as variables that could be integrated into the conditional logit model of residential burglar crime location choice process in this study. Different results from previous studies are expected from this study because the results of using the indices described above vary among countries and cities (Townsley et al., 2015). And in framing our study, we considered that *the distance from offender's residence* would have a negative effect; *the number of residential units*, *the proportion of single-family dwellings*, *the proportion of foreigners*, and *the proportion of newcomers* would have positive effects on the residential burglars' crime location choice process.

2 | METHOD

2.1 | Targeted area

To examine the residential burglar crime location choice process using the conditional logit model, we chose an area of Sendai City in northern Honshu as the location for our study. Sendai City has a population of approximately 1,080,000, an area of about 786 km^2, and is north of Tokyo in Japan.

Using the grid cell method described earlier, we narrowed down the study area to covering the area not flooded during the Great East Japan Earthquake and Tsunami on March 11, 2011 (Pasco, 2011) because the tsunami may have changed the environment. In addition, the study area always included residential units because we considered that including non-residential units would not be appropriate given that these are equal to nontargets for residential burglary. Ultimately, we used 1,134 grid cells as the study area. The geometric position of the study area is displayed in Figure 1.

2.2 | Solved cases data

Solved cases data were collected from the Japanese national police register on detected residential burglaries committed by solitary burglars between 2007 and 2015 who lived in the study area in Sendai City. Only the data of those

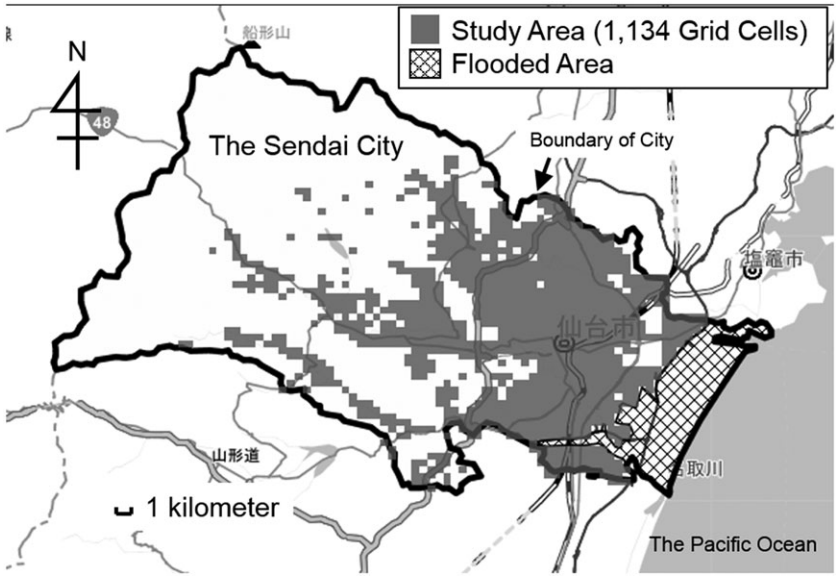

FIGURE 1 The geometric positions of the study area and the flooded area in Sendai City

of residential burglars who started committing crime after 2007 were included. And residential burglaries that were committed outside the study area were disregarded. Further, any duplicated data that showed residential burglaries committed in the same grid cell by the same residential burglar were excluded from the analysis. After applying these filters, we could use 369 solved cases committed by 70 residential burglars as our solved case data (cases by each offender: minimum = 1, maximum = 46, and mean = 5.29). The proportion of residential burglaries that occurred at single-family dwellings was 42.0% of all the solved cases used.

Based on the work of Bernasco and Nieuwbeerta (2005), we calculated for each burglar *the distance from offender's residence*, using the centroid of both grid cells. Bernasco (2006) stated that the distance from an offender's residence to a chosen target grid cell, and to all other grid cells, should be measured in the same way. Thus, we used the centroids of grid cells to describe an offender's residence and the location of a crime, rather than their exact physical location, to calculate this distance.

2.3 | Neighbourhood characteristics

Variables describing neighbourhood characteristics—*the number of residential units*, *the proportion of single-family dwellings*, *the proportion of foreigners*, and *the proportion of newcomers*—were obtained from 2010 Japanese national census data. *The proportion of single-family dwellings* was calculated by dividing the number of these dwellings by *the number of residential units* in each grid cell. *The proportion of foreigners* was calculated by dividing the population of foreigners by the total population. *The proportion of newcomers* is the proportion of residents who lived in a different place for 5 years previously, calculated from the population of newcomers and the total population of each grid cell. A part of the calculated values is more than 100%, this was because the national census includes errors caused by blank returns or mistakes by respondents. Therefore, concerning *the proportion of single-family dwellings*, *the proportion of foreigners*, and *the proportion of newcomers*, we decided that, as a matter of convenience, if the calculated *proportion* in the grid cells was more than 100%, the figure of 100% was applied equally to those alternative grid cells.

The number of past residential burglaries and *the past residential burglary rate* were calculated from reported cases collected in the Japanese national police register between 2004 and 2006. The number of past residential burglaries was defined as a median value for the total reported cases per year in each grid cell, although O'Leary (2009a) proposed using kernel density estimations to simulate the attractiveness of grid cells. This correction was used because

the kernel density estimates values of grid cells having a few past residential burglaries but adjoining a grid cell having large numbers of past residential burglaries are in danger of the overestimation of attractiveness. To calculate *the past residential burglary rate*, *the number of past residential burglaries* was divided by *the number of residential units*. However, *the past residential burglary rate* was sometimes overestimated when grid cells had a small number of residential units as a denominator and had recorded vanishingly few reported cases for 3 years. Therefore, 0 was allocated to *the number of past residential burglaries* of those grid cells that had just one reported case in 3 years, because it can be assumed that there is almost no residential burglary in the locations covered by these cells.

Descriptive statistics of the relevant neighbourhood characteristics are given in Table 1. In Table 2, correlations of these variables are presented at the upper right and partial correlations at the lower left of the table.

3 | RESULTS

The estimation results of the conditional logit model are presented in Table 3. This model describes the decision making of burglars under the assumption that all choice criteria are equally important for all burglars. Table 3 reports on the values of e^{β}—the exponent of β—as the independent variable increases by one unit, the standard errors, and the standard partial regression coefficients. Values of e^{β} between 0 and 1 indicate that the odds decrease, and values above 1 indicate that the odds increase as a function of the values of the independent variables. The standard partial regression coefficient is the value of the change in an objective variable per one standard deviation of the independent variable, under the condition that holds all other variables constant. The standard partial regression coefficient is independent of the units of each variable and indicates the effect of the size of each variable. Moreover, two-sided statistical tests were employed.

The result of conditional logit model introducing *the number of past residential burglaries* supported that *the distance from offender's residence* decreases the odds of certain grid cell's being selected by a burglar. When *the distance from offender's residence* increases by 1 km, the grid cell becomes only 0.70 times as likely to be chosen. *The number of residential units* had a positive effect on the likelihood that a burglar will select grid cell for committing his or her offence. When residential units increase by 100, the odds of the grid cell being chosen is 1.05. The results also showed that *the proportion of single-family dwellings* makes a cell more likely to be chosen by burglars as a target area. When *the proportion of single-family dwellings* increases by 10%, the grid cell is 1.06 times as likely to be chosen. However, the effects of *the proportion of foreigners* and *the proportion of newcomers* were neither positive nor negative. Moreover, the results show that the larger the *number of past residential burglaries*, the greater are the odds of a burglar selecting that grid cell. When past residential burglaries have increased by 1, the probability of being chosen will rise 1.16 times.

The distance from offender's residence also had the largest standard partial regression coefficients (−2.02) within the pattern of significant variables. In other words, proximity from offender's residence had biggest impact on the crime location choice process of the residential burglar. The size of the standard partial regression for *the number of past residential burglaries* had larger standard partial regression coefficients (0.23) than *the number of residential units* (0.22) and *the proportion of single-family dwellings* (0.20).

TABLE 1 Descriptive statistics of neighbourhood characteristics (n = 1,134)

Variable (unit)	Mean	*SD*	Min.	Max.
Number of residential units	406.73	477.02	1.00	3,470.00
Single-family dwellings (%)	66.36	33.04	0.00	100.00
Foreigners (%)	0.53	1.28	0.00	21.43
Newcomers (%)	22.17	15.67	0.00	100.00
Number of past burglaries	0.92	1.56	0.00	13.00
Past burglary rate (per 100 residential units)	0.15	0.31	0.00	6.25

TABLE 2 Correlations (at the upper right) and partial correlations (at the lower left) between neighbourhood characteristics (n = 1,134)

Variable	A	B	C	D	E	F
A. Number of residential units		−0.68***	0.17***	0.41***	0.70***	0.23***
B. Single-family dwellings	−0.49***		−0.20***	−0.64***	−0.44***	−0.17***
C. Foreigners	0.09***	−0.10***		0.12***	0.06*	−0.02
D. Newcomers	−0.01***	−0.54***	−0.02***		0.24***	0.08**
E. Number of past burglaries	0.63***	0.06***	−0.06*	−0.03***		0.56***
F. Past burglary rate	−0.25***	−0.08***	−0.03	−0.02**	0.55***	

*p < .10. **p < .01. ***p < .001, two-sided.

TABLE 3 Conditional logit model of choice of burglary destination tract

Variable (unit)	e^{β}	Std. error	Std. partial β
Model introducing the number of past burglaries			
Distance (kilometres)	0.70***	0.02	−2.02
Number of residential units (**100)	1.05***	0.01	0.22
Single-family dwellings (10%)	1.06*	0.03	0.20
Foreigners (0.1%)	0.99	0.01	−0.10
Newcomers (10%)	1.01	0.06	0.02
Number of past burglaries	1.16***	0.03	0.23
Model introducing the past burglary rate			
Distance (kilometres)	0.70***	0.02	−2.03
Number of residential units (**100)	1.08***	0.01	0.39
Single-family dwellings (10%)	1.06**	0.03	0.21
Foreigners (0.1%)	0.99	0.01	−0.10
Newcomers (10%)	1.00	0.06	0.0
Past burglary rate (per 100 residential units)	1.79***	0.09	0.18

Note. Based on 369 burglaries, committed by 70 burglars in Sendai.

*p < .10. **p < .05. ***p < .001 for the two-sided test.

Similarly, the results of the conditional logit model introducing *the past residential burglary rate* showed that *the distance from offender's residence* (0.70), *the number of residential units* (1.08), and *the proportion of single-family dwellings* (1.06) were significant (odds ratio). *The past residential burglary rate* also had a positive effect on the likelihood that a burglar will select a grid cell for committing his or her offence. When *the past residential burglary rate* increases by 1 per 100 residential units, the odds of the grid cell's being chosen rises to 1.79. The standard partial regression coefficient of *the distance from offender's residence* was the largest (−2.03), in second place was *the number of residential units* (0.39), next was *the proportion of single-family dwellings* (0.21), and last was *the past residential burglary rate* (0.18), within the significant variables.

4 | DISCUSSION

In this study, we examined the residential burglars' crime location choice process in Japan, using a discrete choice model. We used past crime data, social statistics, and distance as indices of this choice process. The results show that *the distance from offender's residence* had a negative effect, and *the number of residential units*, *the proportion of single-*

family dwellings, *the number of past residential burglaries*, and *the past residential burglary rate* had positive effects on the choice process, as our hypotheses suggested. *The distance from offender's residence* had the largest impact of all the examined variables. *The number of residential units* had a larger effect than *the proportion of single-family dwellings* and *the past residential burglary rate*, when we introduced *the past residential burglary rate* to the conditional logit model. On the other hand, when we replaced *the past residential burglary rate* with *the number of past residential burglaries*, the impact of *the number of past residential burglaries* was larger. Finally, *the proportion of foreigners* and *the proportion of newcomers* had no significant impact on choice of location for crimes, contrary to our hypotheses.

4.1 | Usefulness of the past crime data

Both *the number of past residential burglaries* and *the past residential burglary rate* introduced to the discrete choice model of locations for residential burglaries in this study had positive effects on the likelihood of an area being chosen as a location for such crimes. *The number of past residential burglaries* had a more significant effect than *the number of residential units* or *the proportion of single-family dwellings*. *The number of past residential burglaries* includes the effect of *the number of residential units* as can be seen from the partial correlation between these variables. This result showed that the number of past crime cases is a useful surrogate variable in determining a neighbourhood's attractiveness for offenders when we analyse cases that we cannot obtain potential target densities for, as Mohler and Short (2012) remarked. *The past residential burglary rate* is an independent variable from virtually all other variables given the partial correlations we discovered, though it had a smaller impact than *the number of residential units* and *the proportion of single-family dwellings*. *The past residential burglary rate* might, therefore, represent various indices of neighbourhood's attractiveness, such as its road structure and having the crime attractors that were discussed above. Therefore, accuracy might be increased by including *the past residential burglary rate* to geographic profiling with other indices of neighbourhood's attractiveness.

It might be that increases in *the number of past residential burglaries* are due to the many residential burglars living in an area and their propensity to repeat crimes in that area, when we consider our result that residential burglars tend to commit subsequent offences near their own residence and repeat crimes in proximity in space and time (Bernasco, 2008; Bernasco et al., 2015; Lammers et al., 2015). However, the results presented were obtained from a conditional logit model that can examine the effect of a variable under the condition that all the other variables are fixed. Moreover, the data of solved cases did not always include data on past residential burglaries. Furthermore, the two sets of data were independent. Therefore, we were able to demonstrate that residential burglars are attracted to those areas having a larger *number of past residential burglaries* or a higher *past residential burglary rate*.

4.2 | Comparing these results with those of previous studies

Many studies have identified the distance decay pattern in several types of crime (Canter & Hammond, 2006; Emeno & Bennell, 2013; Hammond & Youngs, 2011; Kent, Leitner, & Curtis, 2006; Snook, Cullen, Mokros, & Harbort, 2005). This study of residential burglary patterns in Japan also showed similar results, so the distance decay pattern is a strong guide to an offender's criminal location choice processes. The causes of the distance decay in residential burglary are that offenders need to cut down travel costs and that offenders are committed in areas they know well. Offenders commit in an awareness space according to crime pattern theory (Brantingham & Brantingham, 1993), so it is a natural result that the density of crime locations increases around their residences. However, we must not just consider residence, because there are other anchor points apparent when we analyse actual cases that result from the fact that awareness space is built up around every activity space and its associated characteristics. Moreover, as Bernasco (2010b) and Bernasco and Kooistra (2010) showed, offenders tend to commit crimes not only near their current residence but also near their past residences.

This study produced the natural result that the larger the *number of residential units* representing potential targets in an area, the more that area tends to be chosen as a location for criminal activity. *The proportion of single-family dwellings* also seems related to the density of potential units, but we cannot explain the result that *the proportion of single-family dwellings* had a positive effect on the likelihood of choosing an area as a location for criminal activity, because the proportion of residential burglaries that were committed at single-family dwellings was a minority within the solved cases data. Thus, *the proportion of single-family dwellings* can be explained as simply being a measure of physical accessibility to potential targets in an area, as Bernasco and Nieuwbeerta (2005) remarked. However, *the number of residential units* and *the proportion of single-family dwellings* had positive effects on the residential burglar's location choice process regarding their criminal activity, although there appears to be a negative partial correlation between these variables. Thus, we must consider both variables simultaneously when examining the probability of choosing an area.

The proportion of newcomers had no effect on residential burglars' crime location choice processes, although it did have a negative partial correlation with *the proportion of single-family dwellings*. This result is like that of some previous studies (Bernasco, 2006; Bernasco & Nieuwbeerta, 2005; Clare et al., 2009; Townsley et al., 2015). *The proportion of foreigners* had neither a partial correlation with other variables nor an effect on the crime location choice process. The reason why *the proportion of foreigners* had no effect might be that Japan is a racially homogeneous nation, with only a small population of foreigners. Bernasco and Nieuwbeerta (2005) explain that the degree of ethnic heterogeneity and residential mobility is expected to influence the choice of locations to commit crimes, but the effect of these indices seems to be differ among countries.

4.3 | Limitation of the study and future implications

The results of this study showed that the past crime data have a significant impact on the choice of location for crimes made by later offenders. However, neither *the number of past residential burglaries* nor *the past residential burglary rate* is explanatory indices. As mentioned above, road structure and crime attractors might have influenced as latent variables. However, we did not consider this possibility in this study. Therefore, it is necessary to examine this possibility in the future. For example, Davies and Johnson (2015) attempted to digitise the road structure of an area, so that the correlation of *the past residential burglary rate* and variables of the road structure in a small area can be examined. Although there are certain limitations in this study, the study is significant because it indicated that past crime data are effective for indexing the attractiveness of neighbourhoods for residential burglars.

We should examine the effect of the past crime data of other types of crimes on an offender's choice of location for crimes because this index is applicable to the analysis of every type of crime. Previous studies that have examined an offender's crime location choice process in relation to nonintrusive theft or sex crimes using the discrete choice model were not found, but there are some previous studies that examine robbery (Bernasco & Block, 2009, 2011; Bernasco, Block, & Ruiter, 2012), so it is particularly worthwhile to use past crime data to examine the location choices relating to person to person crime. Furthermore, we must examine effectiveness when *the number of past residential burglaries* or *the past residential burglary rate* introduce the analytical procedures of geographical profiling as a new index. For example, an expected outcome would be that integration of *the number of past residential burglaries*—an easily obtainable variable—will improve the accuracy of geographical profiling enough, without the integration of other variables of neighbourhood's attractiveness. The method of application to geographical profiling was suggested in previous studies (Bernasco, 2007; Mohler & Short, 2012; O'Leary, 2009a).

Finally, these results are obtained only from the data of Sendai City in Japan and might not be applicable to all countries and cities. Tseloni, Wittebrood, Farrell, and Pease (2004) and Townsley et al. (2015) suggested that factors influencing the crime differ depending on the country and the city. Therefore, future studies will require additional tests with data from other areas. This study showed that, in Japan, residential burglars are attracted to areas close to their residence, and even more attracted to areas that has had more residential burglaries, has a larger number

of residential units, or has a higher rate of single-family dwellings. These results are expected to contribute not only to the development of geographical profiling but also to crime investigations and crime prevention.

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CONFLICT OF INTEREST

There is no conflict of interest with regard to this manuscript.

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