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HOW DO RESIDENTIAL BURGLARS SELECT TARGET AREAS?

A New Approach to the Analysis of Criminal Location Choice

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This paper introduces the discrete spatial choice approach to the study of criminal target choice. The approach is used to assess whether residential burglars are attracted to target areas that are affluent, accessible, and poorly guarded. In addition, the importance of these criteria is postulated to vary across burglars. The theory is tested using data on 548 residential burglaries, committed by 290 burglars from the city of The Hague, the Netherlands. The likelihood of a neighbourhood's being selected for burglary is heightened by its ethnic heterogeneity, its percentage of single-family dwellings, and its proximity to where the offender lives. The results and prospects of the discrete spatial choice approach for spatial target selection research are discussed.

The problem of criminal location choice is a classical one in criminology. It pertains to the descriptive question of where offenders commit their offences, and to the explanatory question of why they commit them there, rather than somewhere else. In the literature, answers to the latter question have involved two general notions that have usually been dealt with separately. The first is the notion that for a crime to occur, a motivated offender must find a suitable target, in the absence of a capable guardian (Cohen and Felson 1979). The second is the notion that crimes tend to occur close to where the offender lives (Baldwin and Bottoms 1976: 78–98; Wiles and Costello 2000; Ratcliffe 2003). This paper combines these two notions, in an attempt to answer the question of how residential burglars select their target areas.

For that purpose, we introduce the *discrete spatial choice approach*. This approach analyses target selection as being influenced by target characteristics and by offender characteristics, simultaneously. We argue that the discrete spatial choice approach is able to integrate previous findings in this field of inquiry, and is a useful theoretical and methodological tool for research in criminal target choice.

In the next section, we present a review of the literature on target selection by burglars. Subsequently, we give an overview of earlier methods in the study of criminal location choice, and introduce the discrete spatial choice approach and the closely related conditional logit model. The approach is then applied to residential burglary in the city of The Hague, the Netherlands, using data from police records. The paper concludes with a summary of the main results, and a discussion of the potential and the pitfalls of the discrete spatial choice approach for studying criminal location choice.

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Theory

Burglars who select target areas can be presumed to behave like 'optimal foragers' (Johnson and Bowers 2004). Optimal foraging theory asserts that when predatory animals select hunting areas and prey, they optimize rewards by weighting the nutrition value of a potential prey with the efforts and risks involved in finding, attacking and eating it. In the same vein, burglars may be assumed to maximize their revenues by selecting neighbourhoods and dwellings that require little effort to enter, that appear to contain valued items, and that give the impression that the likelihood of being disturbed or apprehended there is low. This perspective from behavioural ecology is particularly attractive because it combines elements of rational choice theory—the assertion that burglars maximize rewards by purposefully selecting targets from a set of alternatives—with the notion that the actors may sometimes act impulsively and need, themselves, not necessarily to be aware of the laws that drive their behaviour.

Any theory of criminal choice should address at least two issues. It should define the set of relevant alternatives that offenders choose from, and it must specify the various decision criteria that offenders use when selecting a target. Both issues obviously are offence specific. Concerning the first issue, the factual set of alternatives of a typical burglar would consist of all premises in their city or region. However, several authors argue that burglars follow a spatially structured, sequential and hierarchical decision process when selecting their targets (Brantingham and Brantingham 1978; 1984; Brown and Altman 1981; Cornish and Clarke 1986; Kleemans 1996). In the first stage, they select a suitable area from the areas that form their awareness space, and only in the second stage do they select a suitable object. This sequential process implies that it makes sense to study the location choice of burglars living in a specific city in terms of a choice amongst a limited number of neighbourhoods.

A subsequent issue is which decision criteria offenders use when they select a neighbourhood for committing a burglary. Based on the classic 'routine activities' statement that the necessary minimal requirement for an offence to occur is the convergence in place and time of a motivated offender, a suitable target and the absence of capable guardians (Cohen and Felson 1979), a number of general criteria can be distinguished that burglars use when they compare the features of alternative target neighbourhoods for burglary.

The first criterion is the *affluence* of a neighbourhood in terms of the prospective profitability of a burglary if it is successful. Affluence refers to the 'suitable target' element in the above statement. As ethnographic research shows that most burglars are primarily driven by material profit (Reppetto 1974; Maguire and Bennet 1982; Bennet and Wright 1984; Rengert and Wasilchick 1985), they can be expected to prefer affluent neighbourhoods to poor ones, because the expected proceeds of the offence tend to be larger in the former. Residential units generally have visible cues that signal their value and thus the prosperity of their occupants. Thus, we formulate:[1]

[1] This hypothesis apparently contradicts the empirical finding in the literature that poor neighbourhoods are at greater risk of burglary than affluent neighbourhoods (Kershaw *et al.* 2000: 74). However, studies that generate this finding typically do not use information on where the offenders live. Thus, the finding that poor neighbourhoods have higher burglary risks could reflect that poor neighbourhoods are more attractive, but a more likely explanation would be that poor neighbourhoods are familiar and near the homes of burglars (also see hypothesis 3a).

Hypothesis 1: The higher the neighbourhood's average residential real estate value, the larger is the likelihood that a burglar will select it for burglary.

The second criterion is the *expected likelihood of a successful completion* of a burglary attempt. This criterion refers to the 'absence of capable guardians' element in the routine activities formulation. Brown and Altman (1981) suggest that burglars prefer neighbourhoods characterized by unstable and non-cohesive social structures, because the anonymity amongst residents in such neighbourhoods implies a lower level of 'territoriality'. According to this argument, residents of neighbourhoods that lack stability and social cohesion are less likely to identify strangers as strangers, less likely to be alarmed by suspect situations, and, even if they are alarmed, will be less eager to intervene in order to protect their neighbours' properties against attacks by intruders. Ethnographic research on burglars (Bennet and Wright 1984; Rengert and Wasilchick 1985; Taylor and Nee 1988; Cromwell *et al.* 1991; Wright and Decker 1994; Nee and Taylor 2000) provides some support for these claims, although the focus in most of these studies is on the level of guardianship of individual residential units, rather than on guardianship of larger entities like neighbourhoods.

Two core variables that are traditionally associated with lack of social cohesion and lack of stability are residential mobility and ethnic heterogeneity (Sampson and Groves 1989). Both variables appear to capture quite well the increased likelihood of successful burglary in anonymous environments, because both high residential mobility and high levels of ethnic heterogeneity are conditions that provide relatively few opportunities for neighbourhood residents to get to know each other and integrate.[2]

Thus, with respect to the postulated effect of lack of guardianship and its effects on the likelihood of successful completion of burglary, the following hypotheses are formulated:

Hypothesis 2a: The higher the level of residential mobility in a neighbourhood, the larger is the likelihood that a burglar will select it for burglary.

Hypothesis 2b: The higher the neighbourhood's level of ethnic heterogeneity, the larger is the likelihood that a burglar will select it for burglary.

Homes are not only protected against intrusion by human guardians, but also by their *physical inaccessibility*. Units with doors and windows on the ground floor, and units that have access both at the street side and the backside, like most single-family houses do, are more easily accessible than apartments located on higher floors, situated in apartment buildings. Therefore, we also hypothesize:

Hypothesis 2c: The higher the percentage of single-family dwellings in a neighbourhood, the larger is the likelihood that a burglar will select it for burglary.

The third criterion is the *proximity* of a neighbourhood to a burglar's home address and refers to the 'convergence in space' element in the routine activities formulation (in case of residential burglary, the target is obviously fixed in space). According to ethnographic and theoretical studies, burglars prefer familiar neighbourhoods to

[2] Sampson and Groves (1989) include low economic status and family disruption as well. We contend that these two structural variables are theoretically related to *family* cohesion and, thereby, to supervision of youth, while residential mobility and ethnic heterogeneity apply more directly to the *neighbourhood* cohesion and thereby to the willingness to intervene in criminal acts on behalf of neighbours. Thus, in contrast to delinquency studies, our focus is on the role of social cohesion in the situational prevention of crime, irrespective of whether the offenders come from the local neighbourhood or from elsewhere.

neighbourhoods that they do not know, because, in familiar neighbourhoods, they are better able to move around without being viewed as 'strangers' (Brown and Altman 1981; Rengert and Wasilchick 1985). Furthermore, familiar areas provide advantages because burglars have better knowledge of the physical infrastructure (e.g. knowledge of escape routes) and of the inhabitants and their routines (Brantingham and Brantingham 1981). In addition, burgling in remote and unfamiliar areas requires more time and effort than burgling in nearby areas. The proximity hypothesis is corroborated in several empirical studies (Turner 1969; Phillips 1980; Rhodes and Conly 1981; Gabor and Gottheil 1984; Hesseling 1992), where it is found that the likelihood of an offender's choosing a particular target decreases with the distance of the target from his home (referred to as the *distance decay* pattern). In a recent study, Bernasco and Luykx (2003) indeed showed that proximity to areas where many burglars reside was the single best predictor of neighbourhood burglary rates, and remained significant when other factors were controlled for.

Hypothesis 3a: The greater the proximity of a neighbourhood to the home of a burglar, the larger is the likelihood he or she will select it for burglary.

As the city centre is generally, because of its concentration of public facilities and services, a part of the city that is known to many residents, the familiarity argument applies to the city centre as well: for the average burglar, it is a more familiar environment than many other areas of the city. Therefore, we formulate the additional hypothesis that postulates that a neighbourhood's proximity to the city centre is a factor that attracts burglars as well:

Hypothesis 3b: The greater the proximity of a neighbourhood to the city centre, the larger is the likelihood that a burglar will select it for burglary.

A fourth and final criterion that burglars are likely to use is simply the *number of residential units* located in the potential target neighbourhood. Although the number of burgled dwellings per crime trip is limited to one or, at most, a few, neighbourhoods that contain many potential targets provide better opportunities for selecting a suitable target than neighbourhoods in which the number of residential units is small, much like large malls provide shoppers with more opportunities to find what they are looking for than isolated shops. Thus, we postulate:

Hypothesis 4: The larger the number of residential units in a neighbourhood, the larger the likelihood that a motivated offender will select the neighbourhood for burglary.

It should be kept in mind, however, that this hypothesis is included more for control purposes than to test a substantive hypothesis; even if burglars would select target premises at random, we would expect the most densely built areas to have the highest burglary rates.

In addition to the enumeration of relevant choice criteria, which are assumed to be equally applicable to all burglars, we will now argue that the importance of certain choice criteria depends on attributes of the burglars themselves. In other words, we suggest that some neighbourhood attributes are more relevant for some groups of burglars than for others. In particular, we distinguish between minor and adult burglars, and between native and non-native burglars. These attributes were chosen mainly because they are the main offender attributes available in the police records that we had access to.

Although burglary, in general, has been characterized as an offence driven by material needs and as an offence that involves substantial planning and preparation, ethnographic studies have found that this general image applies less to juvenile burglars than it does to adult burglars (e.g. Bennet and Wright 1984). For example, besides the need for money, other needs, such as sensation seeking and loyalty to peers, appear to play a role in the motivation of young burglars. In addition, the burglaries committed by juvenile offenders tend to be more impulsive than those of adults. Of particular relevance is the argument that minors are more constrained in their mobility than adults, and, consequently, have a smaller awareness space, because they are less likely to have an automobile or other flexible motorized vehicle available to transport them across longer distances. Several studies indicate that, indeed, young offenders make shorter crime trips than older offenders (Baldwin and Bottoms 1976: 78–98; Phillips 1980; Rhodes and Conly 1981; Gabor and Gottheil 1984), suggesting that their mobility is more constrained than the mobility of adult offenders. Therefore, we postulate:

Hypothesis 5: The effect of proximity of a neighbourhood to the home of a burglar is stronger for juvenile burglars than for adult burglars.

We further presume that ethnic heterogeneity is a more important criterion for non-native burglars than for native burglars. This hypothesis is based on the idea that a native burglar who enters an ethnically mixed neighbourhood is less easily identified by the local residents to be an outsider, and, in addition, might feel less uncomfortable than a non-native burglar who enters an ethnically homogeneous neighbourhood. This idea applies to all cities in the Netherlands, including the city of The Hague, where our study is situated, because, in the Netherlands, ethnically homogeneous neighbourhoods are, without exception, native 'white' neighbourhoods, while ethnic heterogeneous neighbourhoods contain many different ethnic groups, including a native minority of substantial size. Therefore, whether due to a greater likelihood of being identified by local residents as a stranger, or due to a stronger personal feeling of alienation in unfamiliar territory, non-natives can be hypothesized to have a greater stake in choosing neighbourhoods characterized by ethnic heterogeneity than natives do. Accordingly, the effect of ethnic heterogeneity is hypothesized to be larger for non-native than for native burglars.

Hypothesis 6: The effect of a neighbourhood's ethnic heterogeneity is stronger for a burglar who is a non-native than for a burglar who is a native.

Analysing Criminal Location Choice

Prior approaches

To test hypotheses on criminal location choice, in earlier studies, three approaches have been applied, each with its own strengths and weaknesses. The approaches differ in terms of the unit of analysis used and the dependent variable analysed. The offender-based approach uses offenders as units of analysis and analyses the lengths of their journeys-to-crime, the target-based approach uses potential targets as units of analysis and analyses victimization rates, and the mobility approach uses pairs of geographical locations and analyses the number of crime trips from departure locations to destination locations.

The offender-based approach comprises studies on the length of the journey-to-crime (Turner 1969; Phillips 1980; Rhodes and Conly 1981; Gabor and Gottheil 1984; Hesseling 1992). These studies typically show that the likelihood of an offender's choosing a particular target decreases with the distance of the target from his home (referred to as the distance decay pattern). With respect to studying criminal location choice, a disadvantage of the offender-based approach is that it considers distance as the only choice criterion, and ignores other selection criteria, such as the profits and risks associated with particular targets. Furthermore, the offender-based approach uses only information on targets that were actually chosen. Information on targets that could have been chosen but were not is ignored, and, therefore, the analysis cannot establish in which ways the chosen target differs from the potential targets that were forsaken.[3] In other words, a method that analyses why offenders prefer certain targets over others should use distance as an explanatory variable, whereas, in the offender-based approach, distance is viewed as the dependent variable (Kleemans 1996: 95).

The target-based approach relates victimization rates of potential targets to characteristics that might affect their attractiveness to offenders. This approach is used in studies of individual or household victimization, in ecological studies of variation in crime rates between neighbourhoods, and in multi-level studies in which individual and neighbourhood influences on victimization are studied in a single integrated framework (Boggs 1965; Sampson and Wooldredge 1987; Smith and Jarjoura 1989; Sampson and Groves 1989; Miethe and McDowall 1993; Rountree *et al.* 1994; Rountree and Land 2000; Hakim *et al.* 2001; Vélez 2001). The target-based approach is relevant for location choice problems because conclusions can be drawn on the role that specific target attributes play as choice criteria for offenders. A disadvantage, however, is that no information is used on who the offenders are and where they live. Therefore, it is neither possible to assess whether offenders differ in the way in which they choose targets, nor to establish the role of distance in the target selection process.[4]

Recognizing that both the offender-based and the location-based approach, when applied separately, cannot effectively answer questions on the relative roles of distance and other target attributes in criminal location choice, some criminologists have attempted to merge both approaches by turning to models that were originally developed in geography. In these *gravity models*, the number of crime trips from one neighbourhood to another neighbourhood is modelled as a function of the distance between the two neighbourhoods, as well as of 'push' and 'pull' factors that indicate the extent to which neighbourhoods 'produce' burglars and 'attract' burglaries. Empirically, the models use aggregated journey-to-crime data, analysing as the dependent variable the number of crime trips between pairs of locations, i.e. trips from each potential offender home area to each potential target area. This approach had been

[3] Ignoring the locations of alternative potential targets is equivalent to assuming that all potential targets are uniformly distributed in space. For most offences, this assumption is far too rigid, as residential units, commercial banks, parked automobiles, shops, humans, and many other potential targets tend to display spatial clustering.

[4] Ignoring the home locations of offenders is equivalent to assuming either that the spatial distribution of burglars' home addresses is uniform (equally spaced), or that distance does not constitute a serious constraint at all for offenders. Both assumptions are untenable. The first assumption is untenable because since Shaw and McKay's (1942) work on the spatial distribution of juvenile delinquency, it has consistently been found in numerous empirical studies that the homes of offenders cluster in deprived neighbourhoods. The second assumption is questionable because the phenomenon of distance decay has consistently been shown to apply to criminal behaviour.

applied to the location choice of offenders in general (Smith 1976) and of residential burglars in particular (Rengert 1981; Kleemans 1996). A disadvantage of this approach is that gravity models require aggregated crime trip data, and thus cannot incorporate offender characteristics and their effect on location choice in a single analysis. For example, in order to test whether distance is a more important criterion for young offenders than for older offenders when choosing a target area, a separate analysis must be performed for each age group. When effects of multiple individual characteristics (e.g. age, ethnicity, gender) and multiple choice criteria (e.g. distance, target attractiveness) are studied, it is not a serious option to break down the sample into many subgroups.

In conclusion, the three approaches discussed above have relevance for the problem of criminal location choice, but each of them has disadvantages when it comes to testing theories. In this paper, we apply an approach that combines the advantages of these prior approaches, but lacks their disadvantages: the discrete spatial choice approach.

The Discrete Spatial Choice Approach

The discrete spatial choice approach applies a general micro-economic framework to discrete choice behaviour. This approach can be traced back to Thurstone (1927), Marschak (1959) and Luce (1959), but its further econometric development and its introduction into mainstream-applied economic analyses are due to 2000 Nobel laureate McFadden (1973), who extensively used it in his studies of urban travel demand. The micro-economic framework and its close statistical counterpart, the conditional logit model, have been applied in many fields and to a wide variety of discrete choice problems, including problems of location choice. As far as we know, however, it has so far not been applied to the location choice of offenders, although it incorporates all the features that are of theoretical importance.

The point of departure of the discrete spatial choice approach is an actor who is faced with a choice amongst a number of discrete spatial alternatives, of which he must choose only one. The actor is supposed to evaluate the utility (net gain, profits, satisfaction) that he would derive from choosing each alternative, and the utility derived by actor i from alternative j is given by the following equation:

$$U_{ij} = \beta' z_{ij} + e_{ij}, \tag{1}$$

where z_{ij} is a set of attributes that varies across choices, and possibly across individuals as well, β is a column vector of coefficients to be estimated empirically, and e_{ij} is a random error term that contains unmeasured aspects of the utility that actor i derives from alternative j. The e_{ij} term represents unmeasured relevant attributes of actors and alternatives, as well as measurement error.

When the discrete spatial choice approach is applied to burglary location choice, burglars can be assumed to evaluate the utility of each potential target area in terms of affluence, expected likelihood of a successful completion, physical accessibility and proximity (see our hypotheses 1–4). When indicators of these choice criteria are entered into the general utility equation, this yields:

$$U_{ij} = \beta_V V_j + \beta_S S_j + \beta_E E_j + \beta_R R_j + \beta_P P_{ij} + \beta_C C_j + \beta_T T_j + e_{ij}, \tag{2}$$

where V_j is the neighbourhood's average value of residential real estate, S_j is the neighbourhood's percentage of single family dwellings, E_j is the neighbourhood's ethnic heterogeneity, R_j is its residential mobility, P_{ij} is the proximity of the neighbourhood to the burglar's home, C_j is its proximity to the city centre, and T_j is the number of potential targets (residential units) in the neighbourhood. Note that the proximity to each neighbourhood is different for each individual burglar (so that P has both an i and a j subscript). Hypothesis testing boils down to estimating the values of the β parameters and testing whether they are (significantly) higher than zero.

In order to formalize the hypotheses specifying differences between minor and adult burglars and between native and non-native burglars (hypotheses 5 and 6), terms for interactions between neighbourhood attributes and burglar attributes are to be inserted into the utility function:

$$U_{ij} = \beta_V V_j + \beta_S S_j + \beta_M R_j + \beta_C C_j + \beta_T T_j + \beta_{FE} F_i E_j + \beta_{NE} N_i E_j + \beta_{AP} A_i P_{ij} + \beta_{MP} M_i P_{ij} + e_{ij}, \tag{3}$$

where M_j is a variable with value 1 if the burglar is a minor and 0 if he or she is adult, A_i is an inversely coded variable with value 1 if the burglar is adult and with value 0 if he or she is a minor, N_i is a variable with value 1 if the burglar is native and value 0 if he or she is native, and F_i is its inversely coded equivalent (the F is for 'foreign'). The other symbols are the same as in equation (2). Note that the effect of proximity equals β_{AP} for adults and β_{MP} for minors, so that the test of the hypothesis that the proximity effect is larger for minors than for adults is $\beta_{MP} > \beta_{AP}$, and, similarly, $\beta_{FE} > \beta_{NE}$ with regard to the postulated larger effect of ethnic heterogeneity for non-native ('foreign') than for native burglars.

In order to test hypotheses on the effects of choice criteria, the theoretical model of discrete spatial choice needs to be linked to a corresponding statistical model. Assuming that burglars choose the alternative from which they derive most utility, the discrete spatial choice model can be derived to take the form of the *conditional logit model* (McFadden 1973; Greene 1997).[5] In this model, the probability of a burglar i's choosing an alternative j is:

$$\text{Prob}(Y_i = j) = \frac{e^{\beta' z_{ij}}}{\sum_{j=1}^{J} e^{\beta' z_{ij}}}, \tag{4}$$

where Y_i is the choice actually made by burglar i, and z_{ij} are attributes of alternatives that vary across choices and possibly across individuals as well.[6] The values e^{β} can be

[5] McFadden (1973) shows that if the probability that burglar i chooses alternative j is $\text{Prob}(U_{ij} > U_{ik})$ for all $k \neq j$, and if the e_{ij} are independent and identically distributed according to an Extreme Value Type I distribution, then the discrete choice model takes the form of the conditional logit model.

[6] It is in this respect that the conditional logit model differs from the multinomial logit model that is more familiar to criminologists. The former can incorporate attributes of both the alternatives (here, neighbourhoods) and individual actors (burglars), whereas the latter can only include attributes of the individual actors. Furthermore, the proposed conditional logit model is far more parsimonious, since only alternative-specific attributes are included (i.e. here, seven neighbourhood characteristics), whereas a corresponding multinomial logit model would require 89 dummy variables—one for each alternative.

interpreted as multiplicative effects of a unit increase in some attribute of a potential target on its odds of being chosen by the offender.[7] For example, if z_{ij} represents the distance in kilometres between a potential target and the offender's home, and if the corresponding $\beta = -0.70$, then the odds of the target's being attacked by the offender inflates by a factor $e^{-0.70} = 0.50$ for every kilometre further away it is located from the offender's home base.

Data and Analytical Strategy

Geographical domain and case selection

To test the hypotheses, data were used that pertain to all single-offender burglaries committed by burglars living in the city of The Hague, the Netherlands, in the period 1996—2001. The Hague is situated at the coast of the North Sea. With a population of about 440,000, it is the third largest city in the Netherlands. The Hague comprises 89 residential neighbourhoods. The average neighbourhood has a surface of 0.65 square kilometres, is home to 4,952 residents and contains 2,380 residential units (DSO 2001). The geometric positions of the 89 residential neighbourhoods are displayed in Figure 1.

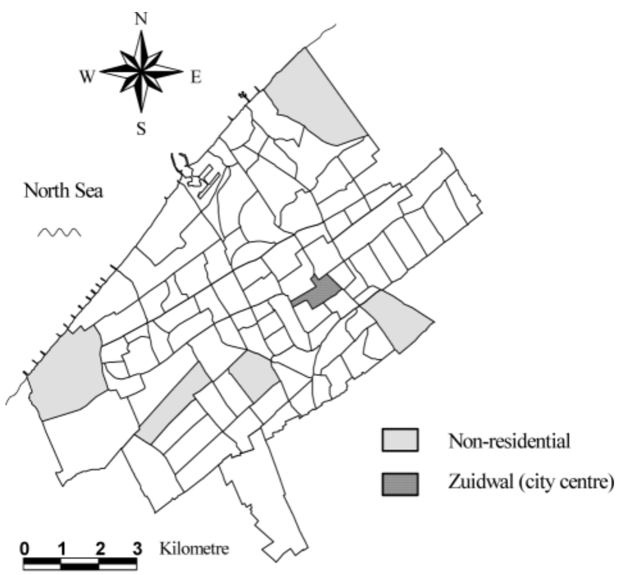

FIG. 1 City of The Hague, the Netherlands

[7] An assumption of the conditional logit model is that the β estimates do not change when one or more alternatives are removed from the full set of alternatives (here, all 89 neighbourhoods). This is known as the assumption of the independence from irrelevant alternatives (IIA) (Greene 1997). In a spatial choice context, the main reason to suspect a violation of the IIA assumption would be the existence of neighbourhoods that are separately labelled but are not distinguished as separate alternatives by burglars. To test the validity of the IIA assumption, we applied Hausman's specification test (Hausman and McFadden 1984). This test compares the β estimates of the full models (see Tables 1 and 2) with β estimates of a restricted model from which one alternative (neighbourhood) is removed. The test was performed $2 \times 89 = 178$ times, i.e. in each test, one neighbourhood was removed. In only 15 of the 178 tests, the Hausman test is significant ($p < 0.05$). Furthermore, these few violations of the IIA assumption are inconsequential: inspection of the differences between β estimates reveals that leaving out these 15 neighbourhoods yields nearly identical β estimates.

Data on residential burglaries were obtained from the Haaglanden (greater The Hague area) police force. The police register all (attempted and completed) burglaries that are officially brought to their attention by victims, by bystanders or by police officers themselves. The data system contains information on characteristics of the burglary committed, including the address at which the burglary took place, as well as information (if an offender is detected and arrested) on some characteristics of the burglar, i.e. sex, age, address, and country of birth. The detection rate for residential burglary in The Hague is 7 per cent, which is low but not much lower than the detection rates reported elsewhere. For example, the average burglary detection rate is 12 per cent for England and Wales, including the London Region (Simmons and Dodd 2003: 122), and 10 per cent in Canberra, Australia (Ratcliffe 2003).

From the police records, all residents of The Hague who had been arrested at least once for committing a residential burglary, anywhere in the Netherlands, during the years 1996–2001 (n = 671) were selected. Burglaries committed outside the city of The Hague (about 15 per cent) were removed. Further, multiple-offender burglaries (i.e. burglaries that were committed by a pair or a group of offenders) were excluded from the analysis because the complexity of the theoretical and statistical models would move us far beyond the purpose of the present exposition. After making these selections, we analysed 548 single-offender burglaries in the period 1996–2001 in the city of The Hague, committed by 290 burglars who were living in The Hague at the time of the burglary.

Neighbourhood characteristics

Our measures of neighbourhood characteristics—i.e. ethnic heterogeneity, residential mobility, real estate value of residential units, the percentage of single-family dwellings and the number of residential units—all were taken from statistical publications of the municipality of The Hague (DSO 2001). Descriptive statistics of the relevant neighbourhood characteristics are given in Table 1. The correlation table of these measures is presented in the Appendix.

The measure of *ethnic heterogeneity* was constructed from data on the ethnic composition of neighbourhoods. Ethnicity is defined on the basis of country of birth of the person and his or her parents, such that a person's origin was coded in a non-native category if he or she was born abroad or if at least one of his or her parents was born

TABLE 1 *Descriptive statistics of the neighbourhood variables (n = 89). Averages over the years 1996–2001*

Variable (unit)	Mean	s.d.	Min.	Max.
Distance to city centre (kilometres)	3.00	1.50	0.20	6.99
Residential mobility (%)	36.92	12.33	13.45	63.20
Ethnic heterogeneity · (100)	35.91	22.44	1.83	80.83
Residential real estate value · (€100,000)	1.12	0.74	0.45	3.75
Single-family dwellings (%)	16.67	17.14	0.31	93.82
Number of residential units	2,380	1,462	212	7,476

abroad.[8] The measure of a neighbourhood's ethnic heterogeneity that we use is the index for qualitative variation (Agresti and Agresti 1978). In the present context, the index represents the likelihood that two randomly selected members of a neighbourhood are of different ethnic origin.[9] It was calculated for each of the years 1996–2001 separately.

Residential mobility was calculated as the sum of the annual number of residents who moved out of the neighbourhood and the annual number who moved into the neighbourhood, relative to the total population of the neighbourhood. This measure was calculated for each of the years 1996–2001.

The *average real estate value of residential units* was based on the real estate tax administration of the municipality of The Hague. The value assessment applies to all residential units, either rented or owned, and the assessment procedure is the same for both types. The source data contain, for each neighbourhood, the average assessed value of residential units in 1993 and in 1999. In order to obtain an estimated value for all years, we assumed a linear trend in real estate value within neighbourhoods, and imputed the values for the years 1996–1998 and for 2000–2001, accordingly.

Burglar characteristics

The *age* of the burglar is measured at the date of the offence. In the analyses, a distinction is made between minors (under 18 years of age) and adults (aged 18 years and above). In the Netherlands, 18 years is the minimum age at which citizens can apply for a driver's license. Of the 548 burglaries, 29 (5.3 per cent) were committed by offenders who were below the age of 18 at the time of the burglary and 519 (94.7 per cent) were adults.

The *ethnic origin* of the burglar is measured on the basis of his country of birth. If the burglar was born in the Netherlands, then he is taken to be native Dutch.[10] In all other cases, he is referred to the non-native group. The burglar sample consists of 55 per cent natives and 45 per cent non-natives.

Proximity measures

Our data contain two spatial proximity measures. The first, actually a neighbourhood characteristic, is the proximity of a neighbourhood to the central business district of the city of The Hague. The second, a characteristic specific for each combination of a burglar and a neighbourhood, is the proximity of the burglar's neighbourhood of residence to a potential burglary target neighbourhood.

In order to create these measures, we first established a distance matrix, defining the distances in kilometres between the centroids of all pairs of neighbourhoods. Using this matrix, the distances between the burglar's neighbourhood of residence and each of the

[8] Second-generation members of ethnic minority groups born in the Netherlands here are assigned as non-natives. The data allowed us to distinguish between six ethnic groups. The members of the first group (native) have their origins in the Netherlands, in another West-European country or in North America. The members of four other groups have their origins in Surinam, in the Dutch Antilles, in Turkey and in Morocco, respectively. These four ethnic groups are relatively large ethnic minority groups in the Netherlands. The sixth group has its origin in any other non-industrialized country.

[9] In calculating the measure, it is assumed that within a single category, e.g. Morocco, all members have the same ethnicity. The exception is the mixed category 'other non-industrialized countries', where it is assumed that all members are of different origin.

[10] Since no information on parents' country of birth was available, we only could identify first-generation immigrants.

potential target neighbourhoods were coded.[11] Following Ghosh (1951), an adjustment was made for the zero values on the diagonal of the distance matrix, which were replaced by the average distance between two random points in the neighbourhood, defined as half the square foot of the surface of the neighbourhood in square kilometres.

The proximity of each neighbourhood to The Hague's city centre was calculated in the same way (using only a single column of the distance matrix). The city centre in The Hague is the central neighbourhood called *Zuidwal*. Located between the two main railway stations of The Hague, this neighbourhood and the area in its direct vicinity include the city hall, a number of government offices and a concentration of shops, restaurants and theatres.

Analytical strategy

To test the hypotheses on location choice, we apply the conditional logit model. The practical issue of estimating a conditional logit model boils down to creating a data-set that contains, for every burglary, not only the chosen alternative (i.e. the neighbourhood in which the burglary took place), but also all other neighbourhoods that could have been chosen but were not. Thus, for a single case of burglary, the data-set contains 89 records—one for every residential neighbourhood in The Hague. A separate indicator variable is constructed that contains the value 1 for the neighbourhood that was actually chosen by the burglar, and the value 0 for the 88 other neighbourhoods that were not chosen. This indicator variable is the dependent variable in the conditional logit estimation procedure.

Parameter estimation of the conditional logit model is performed with maximum likelihood methods, and is relatively straightforward (see, e.g. Greene 1997). Some care is required, however, in dealing with the fact that for some burglars, the data contain information on more than one burglary. Thus, the data-set has a hierarchical structure in which burglaries are nested within burglars. In general, analysing burglaries as independent observations by ignoring this nested structure may yield estimated standard errors that are downwardly biased. In order to construct valid standard error estimates, we calculated so-called 'robust standard errors' according to the method proposed by White (1982), with a correction for the nested structure of the data.[12] These upwardly adjusted standard error estimates result in more conservative hypothesis tests.

Results

The estimation results of the conditional logit model that corresponds to equation (2) are presented in Table 2. This model describes the decision-making of burglars under

[11] In the analyses, we also estimated models with non-linear distance discounting. Non-linear distance accounting may be defended on several grounds, including the likelihood of *travel mode changes* (from walking to bicycle or car or public transport) at certain threshold distances. We applied four alternative proximity measures, all based on distance, in the analysis. The first, and the one reported, is simply negative linear distance ($P=-D$), the second is inverse distance ($P=1/D$), the third is inverse squared distance ($P=1/D^2$), and the fourth is the negative logarithm of distance ($P=-\ln D$). Empirically, we did not find substantial differences between the outcomes of models with alternative specifications.

[12] The estimate is known as the White/Huber estimate (referring to the authors who independently developed it), as the 'sandwich' estimate (referring to its mathematical form) and as the robust estimate (referring to claims made about it) of the standard error. A short but illuminating discussion of the relation between robust estimates and conventional estimates of standard errors is given in StataCorp (2001: 254–258).

TABLE 2 *Conditional logit model corresponding to equation (2). Multiplicative (odds ratio) parameters and nesting-adjusted robust standard errors. Based on 548 burglaries, committed by 290 burglars in The Hague*

Symbol	Variable (unit)	e^{β}	s.e.
β_V	Real estate value (· €100,000)	1.05	0.13
β_S	Single-family dwellings (10%)	1.13*	0.07
β_R	Residential mobility (10%)	0.97	0.07
β_E	Ethnic heterogeneity (· 10)	1.15**	0.05
β_P	Proximity (kilometres)	1.67**	0.15
β_C	Proximity to city centre (kilometres)	0.92	0.07
β_T	Residential units (· 1,000)	1.35**	0.05

* $p < 0.05$ for one-sided test of $e^{\beta} > 1$.
** $p < 0.01$ for one-sided test of $e^{\beta} > 1$.

the assumption that all choice criteria are equally important for all burglars. Table 2 reports the parameters that represent the multiplicative factor by which the odds of a neighbourhood's being chosen by the burglar rises if the associated explanatory variable increases by one unit. Note that all effects are postulated to be positive (i.e. $\beta > 0$ and $e^{\beta} > 1$). Therefore, one-sided statistical tests are employed.

The first hypothesis to be tested states that the *affluence* of a neighbourhood increases the odds of that neighbourhood's being selected for a burglary. It turns out, however, that the effect of neighbourhood affluence, as indicated by the average value of residential real estate, is neither positive nor negative. Apparently, when the other neighbourhood attributes are controlled for, burglars do not show a specific preference for wealthy neighbourhoods. The results of previous studies on this topic are mixed (e.g. Sampson and Groves 1989; Rountree *et al.* 1994; Vélez 2001), as some suggest that burglars are indeed attracted by wealthy targets and wealthy areas, while others do not. Evans (1989: 93–94) summarizes findings from the United Kingdom that suggest that burglars even prefer low-status neighbourhoods over middle-class neighbourhoods (Evans 1989: 93–94). It should be noted, however, that the referenced studies did not use information on where the offenders came from, and many also did not use information on the physical attributes of potential burglary targets and target areas.

In line with hypothesis 2c, a higher percentage of single-family dwellings increases the odds of a burglar's selecting that neighbourhood. As the number of single-family dwellings increases by 10 per cent, the neighbourhood becomes 1.13 times as likely to be chosen. This result is in line with Kleemans' (1996) similar finding in the city of Enschedé, the Netherlands. Using the gravity model approach, Kleemans found that, in addition to inverse distance and total number of residential units, the percentage of detached or semi-detached houses in a neighbourhood significantly increased the likelihood of being selected by burglars.

The estimated effects of neighbourhood measures of instability and lack of social cohesion are mixed. In contrast to hypothesis 2a, a neighbourhood's residential mobility neither heightens nor lowers the likelihood of the neighbourhood's being chosen for burglary. In line with hypothesis 2b, however, neighbourhood ethnic heterogeneity does increase the odds of the neighbourhood's being targeted for burglary by a factor of 1.15, so that, as ethnic heterogeneity increases by 10 on its scale from 1 to 100, it becomes 1.15 times as likely to be chosen. While this finding is generally in line with those of most (ecological) studies on urban crime, it should be noted that, in the current study, the support is based on an analysis that is conditional upon the residence of the offender.

The results also confirm that proximity to the burglar's home (hypothesis 3a) has a positive effect on the likelihood that a burglar will select it for committing his offence. The odds of a neighbourhood's being chosen increases by a factor of 1.67 for every kilometre closer to the burglar's home it is located. This 'distance decay' pattern is in line with virtually all earlier research in this area (see the works referenced in the section on the offender-based approach).

The effect of proximity to the city centre, however, is not in line with the expectation (hypothesis 3b) that neighbourhoods close to the city centre have a comparatively high risk of being selected for burglary (when the position of the home base of the burglar is controlled for). Indeed, quite the opposite is true, because the odds of a neighbourhood's being chosen decreases with every kilometre closer to the city centre it is (the one-sided test $B_C < 0$ is significant at $p < 0.05$). Thus, given the fact that the homes of most burglars in The Hague are located close to the city centre and given that they tend to travel short distances, burglars are more likely to travel outbound than inbound—a result that differs from other studies that suggest that burglars tend to travel towards the city centre (Rengert 1981). As Rengert notes, the most likely directional flow of offenders depends critically on where burglars live in relation to where their routine activities bring them and where opportunities for crime exist.

Finally, in line with hypothesis 4, the number of residential units in a neighbourhood makes it more likely to be chosen by burglars as a target area. When the number of residential units increases by 1,000, the odds of the neighbourhood's being chosen rises by a factor of 1.35.

In Table 3, the parameter estimates of the model that corresponds to equation (3) are presented. This model relaxes the assumption that the importance of choice criteria is equal for all burglars. In particular, it allows us to test whether proximity is a more important decision criterion for minor burglars than for adults (hypothesis 5), and whether neighbourhood ethnic heterogeneity is a more important criterion for non-native than for native burglars (hypothesis 6). Because the estimated effects of the

TABLE 3 *Conditional logit model corresponding to equation (3). Multiplicative (odds ratio) parameters and nesting-adjusted robust standard errors. Based on 548 burglaries, committed by 290 burglars in The Hague*

Symbol	Variable (unit)	e^{β}	s.e.
β_V	Real estate value (· €100,000)	1.05	0.13
β_S	Single-family dwellings (10%)	1.13*	0.07
β_R	Residential mobility (10%)	0.98	0.07
β_C	Proximity to city centre (kilometres)	0.92	0.07
β_T	Residential units (· 1,000)	1.36**	0.05
β_{NE}	Ethnic heterogeneity (· 10) *natives*	1.10*	0.06
β_{FE}	Ethnic heterogeneity (· 10) *non-natives*	1.20**	0.07
β_{AP}	Proximity (kilometres) *adults*	1.63**	0.15
β_{MP}	Proximity (kilometres) *minors*	2.22**	0.55

* $p < 0.05$ for one-sided test of $e^{\beta} > 1$.
** $p < 0.01$ for one-sided test of $e^{\beta} > 1$.

other neighbourhood attributes are almost identical in Table 3 as in Table 2, we will only discuss the two effects that are postulated to vary in strength across offender types.

The effect of ethnic heterogeneity is positive for both natives and non-natives, and, in line with hypothesis 6, it is larger for non-natives (1.20) than for natives (1.10). Because the difference is statistically significant (one-sided Wald test of $\beta_{FE} > \beta_{NE}$, $p < 0.05$), we conclude that ethnic heterogeneity is a more important choice criterion for non-natives than for natives. The effect of proximity to the home of the burglar is positive and substantial both for minors and adults, and it is larger for minors (2.22) than for adults (1.63). However, the difference provides no support for the hypothesis that proximity is a more important choice criterion for minor burglars than for adults, because the test statistic (one-sided Wald test χ^2 test of $\beta_{MP} > \beta_{AP}$) is not statistically significant.

Discussion

In this paper, the discrete spatial choice approach is applied to analyse residential burglars' target area choice in the city of The Hague. In line with the results of studies using the target-based approach—analysing neighbourhoods' burglary rates and effects of neighbourhood characteristics—we find that the likelihood of a neighbourhood's being selected for burglary is positively influenced by its supposed lack of guardianship, as indicated by ethnic heterogeneity, by its physical accessibility as measured by the percentage of single-family dwellings, and by the number of potential objects in the neighbourhood. In line with earlier studies using the offender-based approach is our finding that the likelihood of a neighbourhood to be selected for burglary by an offender increases with its proximity to where the offender lives. Contrary to some studies, we did not find independent effects of residential mobility and affluence. Neither did we find a significant positive effect of proximity to the city centre. Future studies should establish to what extent these unexpected findings are specific to the city of The Hague, or whether they originate from the fact that in the discrete spatial choice approach, neighbourhood and offender characteristics are examined simultaneously.

Some remarks concerning our empirical analyses are in order. First, because our analysis requires information on the age, ethnicity and residence of the offender, it is based on less than 7 per cent of all police-registered cases of burglary, i.e. only on solved cases. As we noted, a 7 per cent detection rate is quite low, but not much lower than what is reported and subsequently analysed elsewhere. The low detection rate could bias the results if a relationship exists between criteria of location choice and the probability of arrest. For example, if the detection rate in affluent neighbourhoods would be higher than in deprived neighbourhoods, then we would overestimate the effect of affluence. Separate analyses, however, show no systematic relationship between neighbourhood characteristics and burglary clearance rates. A second remark is that only burglaries committed in the city of The Hague itself were taken into account, whereas burglaries committed in more distant areas were left out (about 15 per cent). This was necessary because information on relevant characteristics of all neighbourhoods in the Netherlands was not available. Although most burglars are locally oriented, this restriction might somewhat bias the effects of neighbourhood and offender characteristics on location choice.

In order to test hypotheses on burglary location choice in The Hague, we introduced a new approach, i.e. the discrete spatial choice approach. This approach overcomes some disadvantages of approaches used in prior research on location choice, because it (1) takes into account (the attributes) of alternative target locations, (2) simultaneously takes into account travel distance and other attributes of potential targets, and (3) models individual differences in the importance of location choice criteria. The statistical model closely associated with the discrete spatial choice approach—the conditional logit model—is relatively easy to estimate and interpret. In addition, the approach offers a solid theoretical model of individual choice behaviour. Thereby, it forces the analyst studying location choice to be explicit in postulating hypotheses.

We end the discussion with a short list of possibilities for further applications of the discrete spatial choice approach in research on criminal location choice.

An obvious first suggestion is to apply the approach to the study of burglary in other European and non-European cities. Different societies can have markedly different urban social structures, e.g. due to differences in the role of social housing. It is of interest to examine to what extent our findings are transferable to other urban contexts.

In future applications, the discrete spatial choice approach may also be extended to study more complex questions on the location choice of residential burglars. For example, it can be extended to the problem of how pairs and groups of burglars decide on where to offend, and in which ways the criteria they use differ from those used by burglars who work on their own. Further, the model can be used to study developmental patterns in location choice of burglars who offend repeatedly. We could, for example, establish whether, over time, changes take place in the role of affluence and distance in their decision process, postulating that, as burglars grow more experienced, the role of distance diminishes while the role of the affluence criterion becomes more important. It could also be used to study repeat offending against the same target or against targets in the proximity of the target previously selected (Farrell *et al.* 1995; Townsley *et al.* 2000; 2003; Johnson *et al.* 1997; Johnson and Bowers 2004).

A related issue is whether the choice for a specific target neighbourhood would depend not only on characteristics of the neighbourhood itself, but also on characteristics of adjacent neighbourhoods. For example, the model could be used to test whether affluent neighbourhoods surrounded by poor neighbourhoods have higher burglary risks than comparable neighbourhoods surrounded by other affluent neighbourhoods (Bowers and Hirschfield 1999).

Also, the model could be extended to spatial–temporal choice problems by including daily or weekly variations in burglary opportunity in the choice set. In that case, the model could be adapted to reflect that burglars take into account the timing of routine activities of the occupants of their targets.

The discrete spatial choice approach also appears to be applicable to the location choice in offences other than residential burglary. Each application to another type of offence, however, requires a new substantive theory. Such a theory must define the choice set, suggest relevant choice criteria and may postulate differences between offenders in the importance of these choice criteria. For example, if the discrete spatial choice approach is to be applied to commercial robbery, a substantive theory is required that enumerates all potential targets (e.g. retail businesses), and that postulates which target attributes are used as criteria (e.g. distance, expected value of the proceeds, presence of escape routes, presence of security measures, opening hours).

Finally, the new approach might also be a fruitful in geographic profiling, which is the task of finding the home of an unknown (serial) offender on the basis of the locations where he is known to have offended (Rossmo 2000; Canter *et al.* 2000). Existing approaches to this estimation problem use a reversed journey-to-crime estimation approach, estimating the offender's most likely area of residence on the basis of a specific distance decay function and the locations where he committed offences. Because the advantage of the discrete choice approach over the traditional offender-based approach is that it takes into account the spatial distribution and the attributes of all potential targets, rather than only the distances to the targets actually chosen, it appears that it could also be fruitfully applied in this field. For example, when the police search for the home of a serial bank robber, they should not only take into account the locations (and attributes) of the banks being robbed, but they should also ask themselves what distinguishes the locations (and attributes) of the robbed banks from those that were not. Further research is needed to establish whether the discrete spatial choice approach can be useful tool in this applied field.

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Appendix

Correlations between neighbourhood variables (n = 89)

Variable	A	B	C	D	E
A. Proximity to city centre					
B. Residential mobility	0.69*				
C. Ethnic heterogeneity	0.60*	0.69*			
D. Real estate value	–0.11	–0.26*	–0.52*		
E. Single-family dwellings	–0.30*	–0.21*	–0.42*	0.68*	
F. Residential units	0.08	0.12	0.27*	–0.44*	–0.24*

*$p < 0.05$, two-sided.