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# Residential burglary target selection: An analysis at the property-level using Google Street View

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ABSTRACT

*Objectives:* To quantitatively test findings from offender-based literature—primarily consisting of small-sample interviews or experimental scenarios with convicted burglars—to investigate the extent to which the physical attributes of residential homes and their immediate surrounding area contribute to the risk of burglary.
*Methods:* Collecting fresh, micro-level data using Google Street View (GSV) as a tool of Systematic Social Observation (SSO), we utilise a case-control design to isolate property-level effects. Analysis is carried out using conditional logistic regression.
*Results:* The ease of escape from a property, the extent to which the dwelling is accessible, and the extent to which it is closed to surveillance from neighbours and passers-by are all positively related to burglary risk. There is no evidence that indications of resident wealth are related to the likelihood of victimisation, or that the effect of surveillability varies depending on the extent of collective efficacy in a neighbourhood.
*Conclusions:* Burglary target selection does not stop at the selection of a target neighbourhood, but certain characteristics of individual properties within the same neighbourhood are in turn indicative of burglary risk. Quantitative analyses partly support findings from the offender-based research on residential burglary. We encourage future research to consider using GSV as a method of collecting fresh data, with the broader aim of explaining criminal behaviour at micro-spatial scales.


## 1. Introduction

Research on residential burglary target selection seeks to shed light on why burglars choose some areas over other areas, or some individual properties over other properties, and what factors affect the choice made. The majority of *quantitative* research in the field relies on macro-level data, sourced from a combination of community surveys and readily available demographic statistics, such as census data (e.g. Bernasco & Nieuwbeerta, 2005; Bernasco, 2006). Consequently, criminologists can claim to have an understanding of which neighbourhood characteristics draw burglars to operate in particular areas. Property-level target selection research has been largely neglected in the quantitative literature, not because it lacks scientific or societal relevance, but because appropriate data is such a rarity. One recent quantitative study utilised readily-available building registrar data, making use of variables that act as proxies for specific attributes mentioned by burglars during interviews or experimental scenarios (Vandeviver, Neutens, Van Daele, Geurts, & Vander Beken, 2015). Using variables not collected for the purposes of such research calls into question the statistical validity of measurements.

Studies exploring the features of individual residential properties have been primarily offender-based, involving interviews or experimental scenarios (see Nee & Taylor, 2000; Palmer, Holmes, & Hollin, 2002). Researchers have also accompanied informants to previously burglarised targets in order to assess how burglars respond to clues in the physical environment when selecting a property to victimise (Cromwell, Olson, & Avary, 1991). The principle disadvantage of this research is that it remains unclear whether the actual behaviour by burglars outside of the interview room concurs with these findings.

Researchers have recently come to acknowledge the role Google Maps can play in re-imagining the geospatial analysis of crime

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(Vandeviver, 2014), but its specific role in remedying the field's lack of micro-level data has not yet been established. We argue that collecting new Systematic Social Observation (SSO) data using Google Street View (GSV)—Google Maps' built-in virtual reality tool—offers a cost-effective way to investigate property-level burglary target selection. A recently introduced feature not yet recognised in criminological studies allows users to view urban environments for a number of years between 2007 and 2016. This offers researchers the opportunity to exploit existing crime event data that would otherwise remain underused due to the lack of explanatory data from a matching time period.

Thus, the present study uses quantitative data on burglary events and residential units to test the previous findings from offender-based literature, answering calls from recent research (Vandeviver et al., 2015). Moreover, the study considers whether the effects of these property-level attributes vary depending on the neighbourhood in which residences are nested. We argue that neighbourhood-level characteristics, specifically the ability and willingness of residents to intervene to stop deviant activity—collective efficacy—may moderate the effect of some property-level characteristics.

## 2. Theory

Routine activity theory states that motivated offenders, suitable targets and a lack of capable guardians must converge in order for a criminal act to occur (Cohen & Felson, 1979). It is considered a truism for all crime and is consequently taken as a given in respect of burglary. The theory incorporates a rational choice perspective from the offender. When presented with a set of alternatives to victimise, criminals consider the costs and benefits of each, and choose the alternative that offers the highest utility. Burglars are said to make considerations in two steps. In the first stage, they select a suitable area from within a city, such as a neighbourhood, and in the second stage a specific residential unit is selected from a set of alternatives for victimisation. That is, they operate a spatially structured, sequential and hierarchical decision process (Brantingham & Brantingham, 1978). Once an area has been selected, a burglar is imagined to consider an array of alternatives, and is presumed to rationally appraise them, assessing the costs and benefits of each in order to inform the final decision.

This presumption of basic rationality in the decision-making of burglars is non-trivial. Research examining the cognitive reasoning of criminal behaviour has moved on from traditional econometric explanations (Nee & Ward, 2015). Researchers have sought to extend the rational choice perspective by proposing frameworks that assume both systematic ('cold') and more emotive, impulsive ('hot') decision-making processes (Van Gelder, 2013). The critiques of the rational choice perspective do not necessarily render the framework irrelevant, but rather serve to develop it in order to account for such complexities (Wortley, 2014). The value of such contributions is undeniable, but a statistical test of complex behavioural models is beyond the scope of this paper. For this reason, we rely on a parsimonious interpretation of rational choice theory in alignment with recent quantitative research in the field (e.g. Vandeviver et al., 2015). As a result, we are presented with the task of identifying the attributes that dictate a burglar's cost-benefit analysis.

As noted, research on *property*-level burglary target selection is primarily offender-based, involving interviews and experimental scenarios. We performed a literature review[1] to identify which attributes could be expected to inform the cost-benefit analysis of burglars. Due to the explorative nature of offender-based research using interviews, a multitude of characteristics are highlighted. Based on the reasons burglars mention for citing a particular house attribute, we categorise characteristics into four broad genres: the extent to which the property is under surveillance, the accessibility of the property, indications of resident wealth and the ease of escape (see Bennett & Wright, 1984; Nee & Meenaghan, 2006; Nee & Taylor, 2000; Palmer et al., 2002). Each of these characteristics will be considered in turn within the context of routine activity theory to derive hypotheses on property-level burglary target selection. Consideration is also given to whether these effects would be expected to vary by neighbourhood.

The surveillability of residential units refers to the extent to which a home is visible to third parties, in particular passers-by and neighbours, who may act as guardians (Hollis-Peel, Reynald, van Bavel, Elffers, & Welsh, 2011). The more potential onlookers to a criminal act, the more likely that the offender will be stopped or even apprehended and sanctioned, either through informal social control or by law enforcement. Consequently, the expected utility of a target decreases with the number of potential onlookers. Offender-based research using interviews or experimental scenarios concur with such expectations. Convicted burglars were enthusiastic about choosing homes with physical characteristics that would aid their concealment during the act itself, such as thick vegetation (Maguire & Bennett, 1982; Palmer et al., 2002). In the same vein, houses considered to be isolated from neighbours were deemed more attractive (Wright & Decker, 1994).

**H1**. The higher the surveillability of a property, the less likely it will be selected as a target for burglary.

Residential units are nested within neighbourhoods that may have the communal spirit and will to intervene in order to stop a criminal act, or to alert law enforcement to intercede on their behalf. Such 'collective efficacy', the social cohesion of neighbours along with their willingness to intervene on behalf of the common good (see Bruinsma, Pauwels, Weerman, & Bernasco, 2013; Sampson, Raudenbush, & Earls, 1997), is considered to be constant within neighbourhoods, but may vary across them and *moderate* the effect of some property-level attributes. Specifically, a residential unit that lends itself to complete surveillability has little value in terms of deterrence if those who witness deviant acts have neither the communal spirit nor the resolve to enforce social control. On the other end of the scale, in close-knit neighbourhoods with social cohesion and a strong will to intervene, one would expect an enhanced effect of surveillability. Consequently, there is an expectation that the effect of surveillability is moderated by the level of collective efficacy in neighbourhoods.

**H1a**. The higher the collective efficacy in a neighbourhood, the more surveillability will reduce the likelihood of a property being selected as a target for burglary.

The accessibility of a property refers to the extent to which the residential unit may be entered by a potential burglar. One may be inhibited by 'target hardening' techniques such as fencing surrounding a property, which physically hinder individuals from entering (Cozens, Saville, & Hillier, 2005; Logie, Wright, & Decker, 1992). Such defensive attributes are costly to a burglar in terms of difficulty and effort, but also in terms of injury. Not all hardening techniques are directly in control of residents, however. The urban design in which dwellings lie can make some more accessible than others, specifically in relation to their openness to public areas (Brown & Altman, 1983). Concerns of burglars also go beyond the physical capability to enter a private residential space. Defensive

[1] Please see the online supplementary material for this review in tabular format. For a more exhaustive summary of the literature, we refer readers to Nee (2015).

deterrents can also be symbolic, such as low decorative fences (MacDonald & Gifford, 1989) that clearly define the boundaries between public and private space. Such territorial markers, although not physically inhibiting passage, convey a message of deterrence to strangers (Perkins, Meeks, & Taylor, 1992).

**H2**. The more accessible a property is, the more likely it will be selected as a target for burglary.

Indications of resident wealth signal that goods of value are on offer inside (Bennett & Wright, 1984), making the particular property a suitable target. The reward for burglary is dependent on the value of goods obtained, which informs a burglar's decision-making process when evaluating the potential benefits of a deviant act. Residential dwellings that are well maintained and have overtly looked-after private residential spaces are said to signal that items of worth lie inside, making them more attractive targets (Wright & Decker, 1994). Those convicted burglars who participated in simulated scenarios noted similarly, adding that the size of the property itself can be used as an accurate indicator of potential remuneration (MacDonald & Gifford, 1989). Other quantitative studies consider the presence of a garage as an indicator of higher perceived rewards (Vandeviver et al., 2015).

**H3**. The wealthier the residents of a property appear, the more likely it will be chosen as a target for burglary.

The ease of escape for burglars after the deviant act itself considers the extent to which the offender can leave the area as swiftly as possible and with a high probability of evading apprehension. Burglars are explicit about their preference for dwellings that have multiple routes of escape (Hearnden & Magill, 2004; Maguire & Bennett, 1982; Nee & Taylor, 2000). Others note more generally that 'get-away routes' are important when selecting a target (Nee & Meenaghan, 2006). This is substantiated by academic expectations that locations near major roads are more likely to be subject to property crime (Beavon, Brantingham, & Brantingham, 1994). Contrary to previous research exploring the journey-to-crime (e.g. Bernasco, 2010; Elffers, 2004), this expectation focuses on the 'journey after crime'.

**H4**. The greater the ease of escape from a property, the more likely it will be chosen as a target for burglary.

## 3. Methods & data

### 3.1. Methods: case-control design

Investigating target selection on individual residential properties demands a research design that isolates property-level effects from those on the neighbourhood-level, and takes the hierarchical structure of the data into consideration. To address this, we adopt a case-control sampling procedure. This sampling technique is largely associated with epidemiological observational studies that investigate the incidence and distribution of disease. The total sample is split between the 'treatment' group of observations, suffering from the disease of interest, and the 'control' group, which are free of the disease. The two groups can then be systematically compared, and potential causes of the disease identified based on, for the example, how the lifestyles of each group differ. This study uses the approach to disentangle micro-macro effects, and to minimise the assumptions made when using spatially sensitive hierarchical data. Although the use of case-control designs in criminological research was promoted some time ago (see Loftin & McDowall, 1988), it is still not widely used in the field.

Researchers that statistically compare observations across a geographical area must give consideration to the possibility that micro-level predictors may be dependent on their macro-level environments. In the case of burglary, the relationship between property-level physical features and the likelihood of being burglarised may be moderated by the contextual attributes of neighbourhoods. To compare properties irrespective of their neighbourhood would assume that the contextual attributes are independent of property-level mechanisms, or are invariant across the entire geographical study area. Researchers may expect these characteristics to vary, and potentially moderate property-level associations, but attempt to control away the interference by including them in a random effects model. However, this approach is likely to suffer from omitted variable bias.

Utilising a case-control design grouped by neighbourhood allows researchers to investigate micro-level target selection behaviour without having to make such strong assumptions. In this study, the 'treatment' observations are those properties that were burgled, and the 'control' observations are those that were not. By sampling treatments and controls by neighbourhood, observations can be systematically compared whilst keeping all contextual characteristics on the neighbourhood-level constant, and no assumptions have to be made regarding omitted variable bias. The downside of this research design is that one cannot estimate predicted probabilities of burglary, given that the sample is not representative. A 'fixed effects' analysis is used to control for property-level invariant characteristics, allowing one to control for stable characteristics even if they are not measured (Allison, 2009). Conditional logistic regression models were fitted by conditional maximum likelihood using the statistical environment *R*.

For this study, a selection of 150 dwellings that were burglarised during daylight hours in 2009 is made from geocoded, time-stamped data from The Hague Police Force, the Netherlands. These are then grouped by neighbourhood with another 150 units that were not burglarised in the same year. The physical characteristics of these residential units and their immediate surrounding area are measured through Systematic Social Observation (SSO), using Google Maps and its built-in virtual reality tool, Google Street View (GSV).[2] Neighbourhood-level variables are sourced from a community survey conducted in The Hague. Each of these data sources will now be outlined in turn.

### 3.2. Data sources

#### 3.2.1. Key registrar for addresses and buildings (BAG)

Part of official municipality data registrations, this data source provides information on all addresses and buildings in the Netherlands. This includes the full street address, build year, size, purpose and geographical location up until the year 2012. This study focuses on what we term 'single houses' in the city of The Hague. That is, residential buildings where the official street address is a private front door accessible only to one household. This selection was made primarily due to the method of data collection on the property-level, namely Google Maps, which inhibited data collection on residential buildings containing multiple households such as apartment buildings. Single-family homes are also considered to be more vulnerable to burglarisation than communal properties such as apartments (Weisel, 2002). As such, 51,378 single-household buildings that had the sole purpose of residential living were retained from the dataset.

[2] The main disadvantage of the data collection method is that we cannot include resident occupancy during the burglary event in this analysis.

#### 3.2.2. The Hague Police Force crime records

Sourced from The Hague Police Force, the crime event data contains information on all reported burglary incidences reported in the year 2009. Only those within the category of 'breaking and entering' were selected. After cases with overt data errors were removed, the final sample consisted of 2911 cases.

At this stage, consideration was given to the neighbourhood-level data from the community survey. The details of this data are outlined later, but it was crucial to consider its usability when selecting the burglarised sample. Previous research using this survey removed 24 of the 110 administratively-defined neighbourhoods from analyses because fewer than 20 respondents returned the survey or because relevant census data was unsuitable (Bruinsma et al., 2013). The present study followed suit, and consequently only burglary events within the remaining 86 neighbourhoods were kept in the data. It could therefore be guaranteed that the burglarised sample on the property-level would be nested within usable neighbourhood-level data.

Previous research has indicated that the property-level burglary strategies differ between the hours of daylight and darkness (Coupe & Blake, 2006). In order to hold this factor constant, only burglaries that occurred in daylight[3] *and* were in the 'single houses' dataset were retained, leaving 221 break and enter events.

#### 3.2.3. Systematic Social Observation data

Data on the attributes of individual street addresses was primarily collected through Systematic Social Observation (SSO). That is, the recording and encoding of behaviours and environments 'in situ', carried out in accordance with specific procedures in alignment with the aims of empirical research (Reiss, 1971). For this study, the web-based platform Google Maps is used as method of SSO, primarily through its built-in virtual reality tool Google Street View (GSV), which offers comprehensive street-level and satellite images of The Hague urban environment in the years 2008 and 2009, taken during daylight hours. Traditional SSO methods used in conjunction with crime event data often fail to capture the urban environment *before* the event occurred. The availability of GSV images within Google Maps gives the prospect of matching crime data with images that were taken prior to the criminal event. Physical attributes of residential units are therefore captured as close as 1-month beforehand.

Of the 221 single houses that were burglarised during daylight hours in 2009, some were on streets or within neighbourhoods of The Hague not covered by GSV. Others were covered, but the date of the GSV images were post-burglary. Due to these restrictions, data on 155 burglarised houses could be collected using GSV across 55 neighbourhoods. The non-burglarised control group consists of a further 155 residential homes randomly sampled from the BAG single houses dataset. The sampling technique ensured that at least one pair (burglarised and non-burglarised) were nested within each neighbourhood. The neighbourhoods of The Hague that were used in this study are exhibited in Fig. 1, along with a single demonstrative neighbourhood to visualise the case-control design, using synthetic crime data. Two observations were dropped from the collected sample due to outliers and three due to errors during data collection. After balancing out, the final sample used for analysis therefore consisted of 300 single houses, evenly split between burglarised and non-burglarised dwellings.

The items collected using SSO were selected for the purposes of objectively measuring the four principle concepts deemed particularly prominent in offender-based research. Many of the items are specific attributes of residential buildings that were highlighted by burglars during their interviews or experimental scenarios as important in selecting a suitable target. Consideration was given to existing research that investigated the use of Google Maps, in particular GSV, for the purposes of quantifying the urban environment (for a systematic review see Charreire et al., 2014). These studies serve to highlight items that may be particularly unreliable for the purposes of empirical research. For instance, time-variable indicators of physical disorder (e.g. vandalism, graffiti) were not considered, given the concerns over its reliability (e.g. Rundle, Bader, Richards, Neckerman, & Teitler, 2011; Taylor et al., 2011; Wilson et al., 2012).[4]

#### 3.2.4. Community survey

Measures for collective efficacy were sourced from a community survey conducted in the city of The Hague in 2009 (see Bruinsma et al., 2013), which was based on the PADS + community survey in Peterborough, United Kingdom (Wikström, Oberwittler, Treiber, & Hardie, 2012; Wikström & Butterworth, 2006). As outlined in Bruinsma et al.'s paper, the survey was distributed to 11,505 residents, with 3696 being returned and 3545 remaining useful for the purposes of analyses. As stated earlier, only 86 out of the 110 neighbourhoods sample were retained. The average response per neighbourhood was 36 respondents, giving a net-response rate of 31 percent (Bruinsma et al., 2013). Of these 86, only those that contained at least one burglarised house *and* comprehensive coverage of GSV were retained, leaving 55 usable neighbourhoods.

### 3.3. Variables

#### 3.3.1. Dependent variable

The outcome variable in this study was whether or not a residential unit was burgled in The Hague during the year 2009. The variable was given a value of 1 if the property was victimised, and a value of 0 if it was not victimised.

#### 3.3.2. Property-level explanatory variables

The explanatory variables on the property-level were primarily collected based a variety of GSV images, which allows users to 'move' up and down the street to get different angles of the property, including nearby streets from which the unit is visible. Google satellite images and the standard Google Maps layer were also used when appropriate. These self-collected variables were augmented with two variables in the BAG data, namely the build year and square metres of each property. A descriptive table of the unstandardised items can be found in Table 1. To create the total score for each concept identified in the theoretical framework, items were range-standardised and then summed. A descriptive table of the unstandardised constructs can be found in Table 2. These items, and their constructions to form the broad concepts, are now outlined in turn.[5]

[3] The definition of 'daylight' was made based on sunrise and sunset times in The Hague in 2009, by month.

[4] Items that were deemed potentially subjective were subject to an interrater reliability (IRR) test before collection began. This involved the principle rater collecting data on a sample of single houses (one from each administrative district) using the SSO checklist. Data on the same sample was then collected by an independent rater for the purpose of comparing the scores given by each rater. Only items with an interrater reliability score of 0.65 or above were retained for the purposes of this study (note that there is debate over the ideal cut-off point for IRR statistics; for a concise summary see Gisev, Bell & Chen [2013]). The result was 19 usable, relevant and reliable items on the property-level.

[5] The creation of such constructs (e.g. accessibility) necessitates that decisions are made on the classification of single-items. The reasoning behind burglars being attracted to houses on street corners, for example, could hypothetically be due to a number of reasons, for example both accessibility and escape. We recognise that other researchers may have made different decisions in this regard, and encourage future research to explore alternative combinations of single-items.

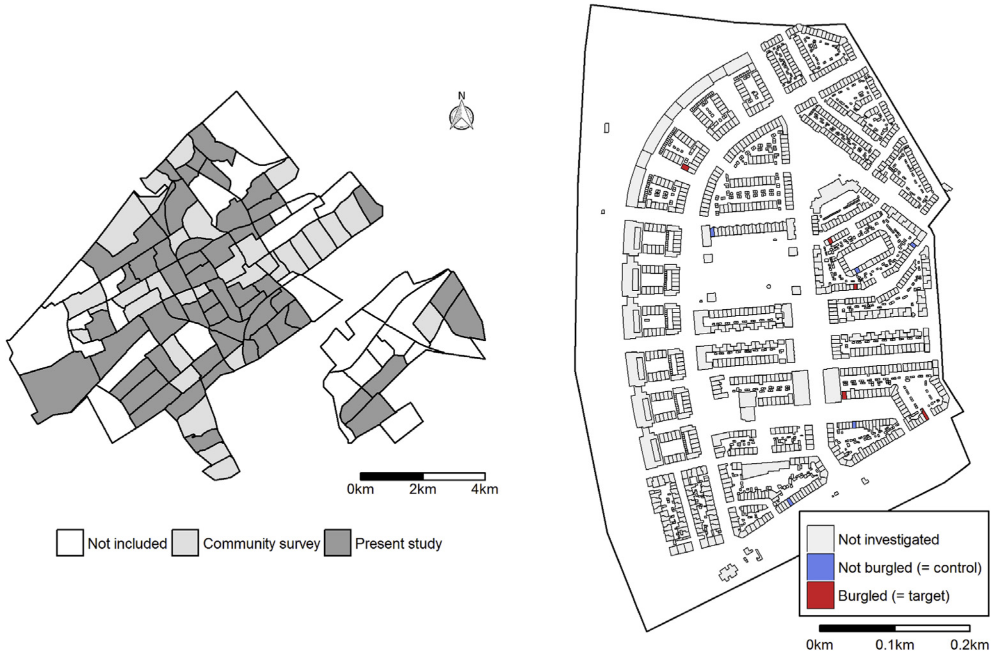


**Fig. 1. (Left) map of The Hague** with neighbourhood boundaries, shaded by use of the community survey and present study; (right) single demonstrative neighbourhood visualising the case-control design using synthetic crime data to protect confidentiality. (©Kadaster/Statistics Netherlands, 2008/2012).

**Table 1**
Unstandardised property-level items, stated unreversed (N = 300).

| Variable | Type | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Front door visibility | Surveillability | 3.35 | 0.89 | 1 | 4 |
| Street width[a] | Surveillability | 28.94 | 25.98 | 4 | 100 |
| Window count | Surveillability | 4.98 | 5.24 | 0 | 24 |
| Build age | Accessibility | 57.33 | 39.71 | 8 | 192 |
| Public sides | Accessibility | 1.62 | 0.71 | 1 | 4 |
| Row end | Accessibility | 0.27 | 0.45 | 0 | 1 |
| Alarm[a] | Accessibility | 0.07 | 0.26 | 0 | 1 |
| Sealed[a] | Accessibility | 0.20 | 0.40 | 0 | 1 |
| Set back[a] | Accessibility | 0.53 | 0.51 | 0 | 1 |
| Amenities unit[a] | Accessibility | 0.23 | 0.42 | 0 | 1 |
| Condition[a] | Wealth | 1.78 | 0.60 | 1 | 4 |
| Squared area | Wealth | 142.27 | 60.67 | 46 | 384 |
| Garage | Wealth | 0.11 | 0.31 | 0 | 1 |
| Corner distance[a] | Escape | 39.07 | 28.47 | 0 | 210 |
| Escape count | Escape | 5.20 | 1.19 | 2 | 10 |
| Main road distance[a] | Escape | 194.17 | 122.95 | 0 | 550 |
| Business presence | Control | 0.17 | 0.38 | 0 | 1 |
| Mixed land-use | Control | 0.67 | 0.47 | 0 | 1 |
| House type | Control | 1.13 | 0.48 | 1 | 3 |

[a] Variable reversed before standardisation and summing, for the purposes of constructs only.

**Table 2**
Unstandardised property-level constructs from standardised, summed items.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Surveillability | 300 | 1.73 | 0.57 | 0 | 2.93 |
| Accessibility | 300 | 3.72 | 0.89 | 1.43 | 6.42 |
| Wealth | 300 | 1.14 | 0.47 | 0.18 | 2.70 |
| Escape | 300 | 1.92 | 0.31 | 0.94 | 2.67 |

Property *surveillability* was measured by three items, namely (1) the number of windows from neighbouring residential units with a direct view of the front ground floor, (2) the distance between the property and the building on the other side of the street, and (3) the visibility of the front door from the street. The first item was considered to be a reasonable proxy for the view neighbouring properties would have of burglars entering the property from the street. The distance in metres from the property to the adjacent neighbour, who would usually have the most direct view, reflects the extent to which the property is isolated from peering neighbours. This item was reverse coded so that a higher score indicated greater surveillability.[6] The visibility of the front door from the street measured to what extent passers-by may be able to observe burglars breaking and entering the property, with the ordinal categories: 'Not visible from any angle', 'Hidden from most angles, but visible from some'. 'Visible from most angles, but hidden from some', and 'Visible from all angles'. A higher score on the surveillability scale is indicative of a property that is under more surveillance.

Property *accessibility* was measured through seven items, namely (1) whether the property was at the end of a row of properties, (2) number of boundaries the property shared with public areas, (3) whether the private space of the property could be sealed off with physical barriers, (4) whether the property has a burglar alarm, (5) whether the property was setback from the street, (6) the age of the building and (7) whether the property had amenities, such as plant pots and benches, on public space directly outside the unit. Items (1) and (2) were deemed reasonable proxies for rear and side access, which whilst prominent in offender-based literature, were problematic to measure reliably using Google Map tools. All items were coded so that a higher score indicated that the property would be deemed more accessible to burglars, and thus a more attractive target. The age of the building was calculated from the raw build year variable, with older properties being deemed more accessible. A higher score on the accessibility scale is indicative of a property that is easier to access.

*Wealth* was measured with three items, namely (1) whether the

[6] A theoretical maximum of the observed maximum plus 1 m was used for the reverse coding. The maximum observed value was inserted as the score for properties that had no unit opposite.

property had a garage, (2) the size of the property in square metres, and (3) the external condition of the property. The condition of the property was coded using the four ordinal categories 'Very good (no signs of disrepair)', 'Good (minimal signs of disrepair)', 'Sub-par (some signs of lack of upkeep e.g. flaking paint)', 'Poor condition (dilapidated e.g. broken windows, major wear)'. Despite findings to the contrary, previous quantitative research expected the presence of a garage to be indicative of higher perceived reward by burglars (see Vandeviver et al., 2015). We considered this expectation reasonable on the presumption that garages were more likely to contain valuable and vulnerable items, such as unlocked bicycles or cars. A higher score on the wealth scale is indicative of properties with more affluent residents.

*Ease of escape* was measured with three items, namely (1) the distance between the property and the nearest main road, (2) the distance between the property and the nearest street corner, and (3) the number of escape routes, including footpaths, leading off the street segment. The number of escape routes and distance to a main road have been mentioned in previous literature. The distance to a corner was commonly mentioned by burglars, but for varying reasons. We considered it most suitable as a feature for escape, given that corners inherently provide a number of escape options. Moreover, when fleeing the crime scene, the time it takes for an individual to disappear from sight is reduced the closer the burglarised property is to a corner. The distance from the nearest corner and main road were reverse coded using a theoretical maximum (maximum observed value plus 1 m) after dropping the outliers. A higher score on the escape scale is indicative of properties that were easier to escape from.

Three variables were used as *control variables*. One binary variable indicated whether there was a *business present* in the immediate surrounding area open during daylight hours: we aimed to control for the 'eyes on the street' that nearby businesses might generate. *Mixed land-use* was a binary variable indicating whether the immediate surrounding area had land usage beyond that of purely residential, such as a car park. *House type* was a categorical variable stating whether the house was terraced, semi-detached, or detached. The controls were selected based on previous research that has highlighted their importance in terms of criminal selection behaviour, but were not of interest given the aims of this study.

#### 3.3.3. Neighbourhood-level explanatory variables

As indicated earlier, the data used for the neighbourhood-level construct was retrieved courtesy of Bruinsma et al. (2013), gathered from the community survey which contained five questions on social trust and six questions on informal social control (see Bruinsma et al., 2013 for details). Two approaches were utilised to create measurements for *collective efficacy*. Firstly, the measure from Bruinsma et al. (2013) was replicated using the original data, by summing the scores of the two latent variables measuring social trust and informal social control. The second 'ecometric' approach constructs the measures by using a random effects model from which the neighbourhood-level residuals (the deviations from the grand mean of collective efficacy) are extracted. The measurements created by these two approaches correlated highly and we only report the results using the former approach. The final construct had a mean of 0.07 (min = −1.80, max = 2.28, SD = 1.05).

## 4. Results

Table 3 presents the conditional logistic regression models testing the four main effect hypotheses of H1, H2, H3 and H4, as well as the cross-level interaction to test H1a. Firstly, the main effect property-level hypotheses are simultaneously tested with the inclusion of controls (*Model 1*). The cross-level interaction to test H1a is then investigated with the same controls (*Model 2*). The results indicate that the more residential units are considered to be under surveillance, the less likely they are to be burglarised. Conversely, properties that are more accessible and are easier to escape from are more likely to be targeted by burglars. There is no evidence to suggest that indications of resident wealth have an effect on target selection. Emphasis is placed on the standardised coefficients of the constructs, rather than the odds ratios, in the interests of a meaningful comparison. Based on these standardised coefficients, the effect of surveillability appears to be strongest (B = −0.735, OR = 0.48, *p-2s* < 0.001), followed by the ease of escape (B = 0.477, OR = 1.61, *p-2s* < 0.01). The accessibility of properties appears to be the least important property-level feature to burglars (B = 0.380, OR = 1.46, *p-2s* < 0.05). The reasons behind burglars citing attributes relating to surveillability and escape were often driven by concerns of apprehension, or potential witnesses that may lead to apprehension. Our findings therefore suggest that burglars may be somewhat risk-averse in their behaviour. That is, one could propose that the rationale behind target selection is most dictated by the prospect of incurring the costs of being sanctioned. Given that the reasons behind citing accessibility attributes primarily relate to effort and difficulty, it is reasonable to propose that these kinds of attributes are deemed less costly than those that may lead to apprehension.

The findings lead us to reject the null hypotheses of no effect for hypotheses H1, H2 and H4. For H3, there is insufficient evidence to reject the null hypothesis that there is no relationship between indications of resident wealth and the risk of being burgled. The likelihood ratio test of Model 1 provides support for the assertion that the burglars do not randomly select their targets, given the statistically significant improvement over the baseline model (LR chi2(8) = 57.71; Prob > chi2 = < 0.001). Overall, we can conclude partial support for the findings in the offender-based literature.[7]

Model 2 mimics the initial model, but includes a cross-level interaction between surveillability on the property-level and

**Table 3**
Conditional logistic regression analysis on the risk of being burgled (including odds ratios) two-sided p < 0.05*, p < 0.01**, p < 0.001***.

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | B | SE | exp(B) | B | SE | exp(B) |
| Surveillability[a] | −0.735*** | 0.193 | 0.48 | −0.775*** | 0.197 | 0.46 |
| Accessibility[a] | 0.380* | 0.149 | 1.46 | 0.382* | 0.150 | 1.46 |
| Wealth[a] | 0.130 | 0.178 | 1.14 | 0.096 | 0.178 | 1.10 |
| Escape[a] | 0.477** | 0.165 | 1.61 | 0.475** | 0.165 | 1.61 |
| Surv. * CE | | | | 0.242 | 0.179 | 1.27 |
| *Controls* | | | | | | |
| Business | −0.523 | 0.369 | 0.59 | −0.509 | 0.371 | 0.60 |
| Mixed Land | 0.607 | 0.313 | 1.84 | 0.566 | 0.314 | 1.76 |
| House Type | | | | | | |
| Terraced (ref.) | – | – | – | – | – | – |
| Semi detached | 0.651 | 0.768 | 1.92 | 0.569 | 0.750 | 1.77 |
| Detached | 0.856 | 1.007 | 2.35 | 1.023 | 1.008 | 2.78 |
| R2 | 0.18 | | | 0.18 | | |
| LR Chi2(df) | 57.71(8) | | | 59.55(9) | | |
| Prob > Chi2 | *p < 0.001* | | | *p < 0.001* | | |
| N | 300 | | | 300 | | |

[a] Standardised.

[7] The method of creating the four main constructs assumes that each item is equally important. To assess this assumption, sensitivity analysis was carried out in order to explore the extent to which the items were constructed and weighted suitably. The results suggested that some items are 'unhappy' being weighted equally to other items within the constructs. Further research could use explorative analysis that improves model fit by altering the weighting of items.

collective efficacy on the neighbourhood-level (H1a).[8] The data offers no evidence to suggest that the effect of surveillability is greater in neighbourhoods with high collective efficacy (*p-2s* > 0.05). For this reason, we reject H1a. Since the sample size is rather low, we also tested the interaction hypothesis with a likelihood ratio test between Models 1 and 2, which provides a similar conclusion (LR chi2(1) = 1.85; Prob > chi2 = 0.1743).[9]

## 5. Discussion and conclusion

This study has sought to shed light on residential burglary target selection by explaining to what extent the selection process is dependent on the physical characteristics of residential dwellings, and their immediate surrounding area. To serve this purpose, fresh data was collected using Google Street View (GSV) as a tool of Systematic Social Observation (SSO). A case-control research design was implemented in order to isolate the effects of property-level explanatory variables from those on the neighbourhood-level.

The results from this study indicate that the behaviour of burglars out on the street does, on the whole, concur with the claims by participants in experimental scenarios or interviews in previous research. There is evidence to suggest that the extent of potential surveillability, ease of escape and accessibility of residential units dictates the cost-benefit analysis of burglars when foraging for a suitable target to victimise. Properties with potential for tight surveillance appear less attractive to burglars, whilst residential units with greater prospects for a successful escape are more at risk of being targeted. Those properties that have straightforward access offer little in terms of a deterrent, and consequently are more likely to be targeted. Contrary to expectations, there is no evidence to suggest that external indications of wealth make such units more attractive for burglary, or that surveillability acts as a greater deterrence in neighbourhoods characterised by strong social cohesion and a willingness to intervene on behalf of the common good.

Whilst one must not confuse main effects with cross-level interactions, our findings do seem to align with previous research in The Hague that failed to find a main effect between collective efficacy and criminal activity (see Bruinsma et al., 2013). We have no clear-cut explanation for the absence of statistical evidence regarding the indications of wealth. It is worthwhile noting that of the three items measuring wealth, only one was specifically mentioned by interviewed burglars, namely the condition of the residential unit. Even with the tailor-made dataset, the items can still be considered proxies for a concept that is largely subjective. A number of interviewed burglars actually explicitly stated that they do not consider external indications of wealth on the basis that all homes contain at least something of value (Cromwell et al., 1991). Although the findings here support this notion, it remained a rare comment to make during interviews. Future studies could consider using different measures of wealth, such as the value of the residential property or residents' income details from tax records.

Though collecting small-scale bespoke data runs against the grain, this study has shown that by collecting such tailored information, one can shed a different light on a phenomenon than by using readily available, generic data. This opens up new avenues for future research involving other crime types. Moreover, when augmented with information regarding the home location of criminals, one could even mimic the journey-to-crime route taken using a virtual GSV walk-through. This could establish whether criminals react to environmental cues in a way that guides their trajectory through the urban space towards the eventual crime location.

The data collection technique is not without its drawbacks. The inability of the Google Car to capture isolated properties inevitably leads to a bias sample, as these cannot be coded. Given that some interviewed offenders even stated that they preferred isolated properties, this is a particularly problematic shortcoming. A resolvable issue for future research would be an exploration into whether behaviour varies depending on the time of day (e.g. Montoya, Junger, & Ongena, 2016). One would expect that burglars place less importance on attributes relating to surveillability during hours of darkness.

It is worthwhile noting that this study cannot claim to have infallibly replicated the experience of a burglar selecting a suitable target. The measurements and statistical analyses employed cannot necessarily capture all of the nuances glimpsed from one-on-one interviews in previous research. Nonetheless, we believe to have made a contribution to the field of residential burglary target selection by using an innovative data collection technique that has made it possible to collect bespoke information on the physical features of residential homes before the crime event occurred. As such, a new path has been forged that challenges more fashionable 'big data' approaches to data-driven crime science. In the age of Big Data, it sometimes pays to think small.


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## Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.apgeog.2017.06.014.

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[8] Based on comments by an anonymous reviewer, additional models were ran that investigated a cross-level interaction between *escape* and *collective efficacy*. The reviewer proposed that the ease of escape might matter less in neighbourhoods characterised by low collective efficacy, because irrespective of the escape options residents would not be expected to intervene. This was not a priori hypotheses because we deemed collective efficacy to primarily deal with preventative forms of intervention before or upon witnessing a criminal act, and therefore independent of post-crime behaviour (i.e. escape). The additional analysis offered no evidence to suggest that the effect of escape was moderated by the collective efficacy in a neighbourhood.

[9] Robustness checks were carried out using alternative neighbourhood boundaries to explore whether the reported results were a statistical artefact caused by a poorly defined neighbourhood unit. Results of these additional analyse are similar to the ones reported here. Details regarding these analyses can be found in the online supplementary materials.

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