CHAPTER 23

DOES CRIME IMPACT REAL ESTATE PRICES?

An Assessment of Accessibility and Location

VANIA CECCATO AND MATS WILHELMSSON

23.1 Introduction

Individuals regard safety as a key factor when looking for a home to buy or rent (Fransson, Rosenqvist, & Turner, 2002; Gibbons, 2004; Larsson, Landström, & Sandin, 2008). Although accessibility is also highly valued in the housing market, researchers and policymakers have acknowledged the negative aspects of transportation systems, such as crime, and their impact on housing markets (Boymal, Silva, & Liu, 2013; Ceccato, 2013; Ceccato, Cats, & Wang, 2015). Yet the interaction of accessibility and crime in determining housing preferences is still not well understood (Boymal et al., 2013; Ceccato & Wilhelmsson, 2011; Weisbrod, Ben-Akiva, & Lerman, 1980), because individuals make choices based on a series of housing characteristics, neighborhood features, job accessibility, and transportation trade-offs (Weisbrod et al., 1980).

In this study, we aim to contribute to this literature by assessing the impact of crime and accessibility on housing prices. Accessibility is expected to have a positive impact on housing prices, but good accessibility to a place may also mean more crime, because an accessible place allows more social interaction, more crime opportunities, and more crime, pulling housing prices down. Individuals make choices based on a trade-off between accessibility and criminality. Using hedonic modeling, we empirically assess this trade-off after controlling for other property and neighborhood characteristics.

In particular, we assess the effect of residential burglary on apartment prices in Stockholm, building on previous research (Ceccato & Wilhelmsson, 2011) that indicated residential burglary—not violence or vandalism—had the greatest effect on apartment prices in the Swedish capital. We assume that residential burglary has such an effect on housing prices because targets of this type of crime always include victims' most private property (their home and objects in it), so burglary can be perceived as more intrusive and more costly to victims than acts of property damage or violence that happen in their surroundings but often outside their private realm. We measured accessibility in two ways: a generalized monetary cost of travel to work (in Swedish crowns, SEK) and a centrality measure (distance to the city center). The analysis builds on previous research but is set apart by (1) extending the study area to all of Stockholm County (26 municipalities), encompassing 92,000 transactions of condominium apartments sold during 2012–2014, and (2) using an updated data set for police-recorded crime from 2013.

The chapter starts with a discussion in Section 23.1 of what influences buyers in their choice of home, especially in their attempt to avoid crime and fear of crime. We also discuss how the question has been addressed in previous research and summarize the results of earlier work. In Section 23.2, we present three hypotheses concerning the influence of burglary rates and accessibility on apartment prices. Section 23.3 describes the geographic area, data used, and the spatial hedonic models. This section includes a discussion of statistical problems and how they were solved. Section 23.4 presents the results from the models. Here we discuss the impact on apartment prices of a variety of factors, focusing on crime rates, accessibility, and distance from the central business district. Section 23.5 summarizes the study and discusses some of the limitations on using the results as a basis for general policymaking. Areas of future research are also suggested in this final section.

23.2 Theoretical Background

The decision to purchase a property is complex, because the price a person is willing to pay depends on the characteristics of the property as well as the surrounding neighborhood and how these characteristics relate to the city overall (Thaler, 1978). Hedonic regression is a preference method of estimating demand or value of an item, a product, or amenity. It decomposes the item into its constituent characteristics, and obtains estimates of the contributory value of each characteristic. Research in this area has long been applied to the concept of hedonic price to make inferences to a series of sales on the demand for certain housing characteristics (e.g., number of rooms) and characteristics of the location and neighborhood (e.g., accessibility to services). In reality, it is not easy to untangle these characteristics. Different land use and characteristics influence property values in different ways: some affect an area's attractiveness positively or negatively; some can have both effects simultaneously. What buyers pay for a property in a low-crime area is hypothetically more than in an area that is a crime hotspot, so safety (or the lack of it) is incorporated into different market prices.

More than three decades of research have been devoted to understanding the effects of crime and fear of crime on property prices (Table 23.1). Of the 31 studies written in English reviewed in Table 23.1, more than two-thirds show clear evidence that properties are discounted in areas with more crime or with poor perceived safety, while

Table 23.1 Crime, Accessibility Measures, and Real Estate Prices: A Review of the Literature

Author(s)	Study area	Method(s)	Safety indicators	Control for transport/ accessibility	Main results	Effect on prices
Vania Ceccato and Mats Wilhelmsson (2016)	Stockholm metropolitan area, Sweden	Hedonic price model	Residential burglary, car theft, vandalism, violence, and distance to a hotspot	Centrality measure, dummy for submarkets	Crime depresses property prices overall, but crime hotspots affect prices of single-family houses more than prices of apartments	Negative
Li et al. (2015)	Austin, Texas	Cliff-Ord spatial hedonic model	Violent crime rate within 1.6 km from the property	Network distance to nearest facilities, dummy for public transportation, walkability index	Violent crimes reduce property prices	Negative
Caudill, Affuso, and Yang (2015)	Memphis, Tennessee	Hedonic spatial error model	Locations of sex offenders	Distance to downtown, dummies for zip codes	Each additional sex offender in a one-mile radius results in a loss of about 2% of the property value	Negative
Iqbal and Ceccato (2015)	Stockholm municipality, Sweden	Hedonic quantile regression, spatial lag, spatial error	Rates of violence, property crime, and total crime in urban parks	Centrality measure, dummy based on distance to public transportation, main roads, submarkets	The price of apartments tends to be discounted in areas where parks have relatively high rates of violence and vandalism, but it depends on park type	Negative/No effect
Wilhelmsson and Ceccato (2015)	Middle-sized nonmetropolitan municipality, Sweden	Hedonic quantile regression, endogeneity dealt with two variables: young males and convenience stores	Residential burglary rates in 2005 and 2011	Centrality measure, dummy based on distance to main roads	Residential burglary reduced apartment prices in 2011 but not in 2005	Negative

Buonanno, Montolio, and Raya-Vílchez (2012)	City of Barcelona, Spain	Hedonic price model and quantile regressions, endogeneity dealt with past victimization index and percentage of youth	District-level data from Barcelona City Council victimization survey	Not declared	Homes in less safe districts have on average a valuation 1.27% lower than in the rest of the city	Negative
Congdon-Hohman (2013)	Summit County, Ohio, the city of Akron, Ohio,	Hedonic price model	Distance to methamphetamine laboratories	Zip code dummies, distance measures	Sale prices for houses decline 10%–19% in the year following discovery of a laboratory	Negative
D. G. Pope and Pope (2012)	3,000 urban zip codes in the United States	Hedonic model, endogeneity dealt with crime rate change that occurred over the same period for a "similar" zip code in a different area	Zip code's crime rate change, 1990–2000s, violent and property crimes	Distance measures, census tract dummies	Decreasing crime leads to increasing property values	Negative
Ceccato and Wilhelmsson (2012)	Stockholm municipality, Sweden	Hedonic model, spatial lag, and spatial error, endogeneity dealt with homicide rates	Rates of vandalism and/or fear of crime measures	Centrality measure, dummy based on distance to public transportation, main roads, submarkets	Fear of crime affects apartment prices even after signs of physical damage (vandalism) in an area are controlled for	Negative
Ceccato and Wilhelmsson (2011)	Stockholm municipality, Sweden	Hedonic model and spatial analysis, endogeneity dealt with homicide rates	Rates of total crime, robbery, vandalism, residential burglary, assault, theft	Centrality measure, dummy based on distance to public transportation, main roads, submarkets	Residential burglary shows a greater effect on prices, and the effect varies locally (neighborhoods) and regionally (submarkets)	Negative

(*continued*)

Table 23.1 Continued

Author(s)	Study area	Method(s)	Safety indicators	Control for transport/ accessibility	Main results	Effect on prices
Ihlanfeldt and Mayock (2010)	Miami-Dade County, Florida	Hedonic model, endogeneity dealt with difference in housing price index, crime measures, and other factors	Nine-year crime panel data, changes in crime densities	Not declared	Changes in crime density explain the greatest variation in changes in the price index, a 1% increase in crime is found to reduce housing prices .1%–.3%	Negative
Hwang and Thill (2009)	Buffalo–Niagara Falls region, New York	Market-wide stepwise hedonic regression	Rates of violent and property crimes	Job accessibility, submarkets	Violent crime has a negative impact and property crime a positive impact, depending on type of submarket	Inconclusive
Troy and Grove (2008)	Baltimore, Maryland	Hedonic price model	Crime index and crime rates		0.017% decrease in the values of the homes associated with a park	Negative
J. C. Pope (2008)	Hillsborough County, Florida	Hedonic price model	Fear of crime, locations of sex offenders	Census tract dummies	Housing prices fall 2.3% after a sex offender moves into a neighborhood, when the offender moves out, prices rebound	Negative
Linden and Rockoff (2008)	Mecklenburg County, North Carolina	Hedonic model polynomial regressions	Locations of sex offenders	Neighborhood fixed effects	Prices of properties fell 4% following the arrival of an offender	Negative
Munroe (2007)	Mecklenburg County, North Carolina	Hedonic model and spatial analysis	Total crimes per census block	Distance measures, e.g., distance to uptown (km)	Crime has a negative impact on prices	Negative

Tita, Petras, and Greenbaum (2006)	Columbus, Ohio	Hedonic price model, endogeneity dealt with murder rates	Changes in rates of total crime, property crime, violent crimes	Centrality measure	Crime impacts differently in different types of neighborhood and violence had the most significant impact	Negative/ Inconclusive
Gibbons (2004)	London area, UK	Hedonic price model, endogeneity dealt with spatially lagged dependent variables	Rates of criminal damage (vandalism, graffiti, arson), residential burglary, theft from shops	Diverse set of distance measures to facilities, centrality measure, dummies for local authorities	Crime damage has a negative impact on prices (1%), but residential burglary does not	Negative/ No effect
Bowes and Ihlanfeldt (2001)	Atlanta region, Dekalb County, Georgia	Hedonic price model	Density of total crimes in tract	Distance to CBD, several distance measures	Negative crime effects are found mainly close to downtown, effects vary regionally	Negative
Lynch and Rasmussen (2001)	Jacksonville, Florida	Hedonic price model	Crimes and the estimated cost of reported crime in the relevant police "beat"	Not declared	The cost of crime has virtually no impact on house prices overall, but homes are discounted (39% less) in high-crime areas	No effect / negative
Case and Mayer (1996)	Boston metropolitan area, Massachusetts	Hedonic price model, change in price, endogeneity dealt with lagged permits and amount of vacant land	Rates of total crime	Distance to Boston, centrality measure	House prices in towns with high crime rates appreciated faster in the boom but remained similar to other towns in the bust	Positive/ negative
Buck, Hakim, and Spiegel (1993)	64 communities, including Atlantic City, New Jersey	Hedonic price model, endogeneity dealt with lags of explanatory variables	Frequency of larceny, auto theft, burglary; crime rate of community	Centrality measure, accessibility, travel time in minutes	Highly mixed, with no consistent finding across model specifications; in the majority of models, the effect of crime was negative	Inconclusive/ negative

(*continued*)

Table 23.1 Continued

Author(s)	Study area	Method(s)	Safety indicators	Control for transport/ accessibility	Main results	Effect on prices
Buck, Hakim, and Spiegel (1991)	64 communities, including Atlantic City, New Jersey	Hedonic price model	Frequency of violent crimes (murder, assault, etc.) and property crimes (burglary, car thefts, etc.)	Centrality measure, travel time in minutes	Casinos and crime affect property values inversely as a function of distance; the impact of a casino and crime varies by location: accessibility and other localities	Negative
Clark and Cosgrove (1990)	Sample of public use microdata urban areas, US	Two-stage intercity hedonic model	Police expenditures / crime rate, homicide rates, input price of public safety	Dummy for property located in city center, commuting distances in miles	Police expenditures / Crime rates have a negative impact but are insignificant; public safety expenditures increase rental prices;	Negative
Burnell (1988)	Chicago suburban communities, Illinois	Hedonic price model, endogeneity dealt with community fiscal and demographic characteristics	Property crime rate, full-time police officers per thousand population	Distance from community to CBD, distance from the Loop	Property crime rate has negative and significant effect on housing prices	Negative
Dubin and Goodman (1982)	Baltimore metropolitan area, Maryland	Hedonic price model	Principal component analyses on property and violent crimes	Centrality measure	Both violent and property crimes have a significant reducing impact on housing prices	Negative

Weisbrod et al. (1980)	Minneapolis–St. Paul metropolitan area, Minnesota	Logit estimation of location	Crime rates for assaults and robberies	Work-trip access	5% reduction in automobile commute time results in a 4.1% decrease in the rate of assaults and robberies for the current location, or a 28% increase in the same crime rate for other locational alternatives	Negative in relation to accessibility
Naroff, Hellman, and Skinner (1980)	Boston, Massachusetts	Hedonic price model, endogeneity dealt with population density of tract	Rates of total crime and property crime	Travel costs, centrality measure	All crime variables have a negative and significant effect on housing prices	Negative
Rizzo (1979)	Chicago, Illinois	Hedonic price model	Rates of total crime, property crime, and violence	Centrality measure	All crime variables have a negative and significant effect on housing prices	Negative
Thaler (1978)	Rochester, New York	Hedonic price model	Rates of property crime	Average driving time, dummy for zones	Crime reduces 3% of the average price per home	Negative
Kain and Quigley (1970)	City of St. Louis, Missouri	Regression models	Number of major crimes	Miles from CBD, dummy for zones	Crime reduces prices but the effect is not significant	No effect

one-fifth of these studies show mixed results, and only two show no indication. The effect of crime is also corroborated in studies of cities of the global South; for a review see Ceccato (2016). Ceccato and Wilhelmsson (2011, p. 83) have shown that even if all demand factors do not vary in space, the implicit price may fluctuate as the supply of attributes may vary in space; for example, "the relative scarcity of *no crime areas* in the inner city would suggest the implicit price of *no crime* is high compared to the suburbs, where the attribute *no crime* might be more abundant. But even within the suburbs the pattern of interaction between place attributes and safety may be different: If the average income among the households is higher in one area, it could be expected that the implicit price of the attribute *no crime* is higher than in an area where income average is lower."

How crime affects housing prices is also related to the nature of crime itself. Most crimes depend on social interactions and human activities in places. They can only happen if individuals move around, meet each other, or become acquainted with crime opportunities. Most of these interactions are pleasant, but some turn into a fight, a theft, or an act of vandalism. Thus, accessibility to places is fundamental for crime, because crime occurs only when a potential victim (or target) and a motivated offender converge in place when there is nobody watching (Cohen & Felson, 1979). Modern public transportation systems not only *allow* people to meet one another; these systems themselves *generate* areas of social convergence that are more prone to crime. Moving between places also means that people are being exposed to unfamiliar environments where they may be at a higher risk of victimization by crime (Ceccato & Newton, 2015; Loukaitou-Sideris, 2012; Newton, Johnson, & Bowers, 2004). Even if transport systems may not generate more crime (e.g., Bowes & Ihlanfeldt, 2001), they make it possible for crime to occur in other places, as they shift people around and make places accessible.

Good accessibility often affects prices positively, but its impact depends on the types of transportation system (buses, subways, roads, railways) and what they represent in terms of urban landscape and their effects (noise, architectural disruptions). For instance, Ceccato and Wilhelmsson (2011) found that if apartments are within 300 meters of a subway station, the effect on prices is positive. It is clear that the negative externalities, for example noise and vibrations, do not outweigh the positive. In contrast, proximity to commuter train stations has a negative effect on apartment prices for the same distance range, while being located close to main streets seems to have a positive effect on price of the apartments.

One of the most interesting studies in this area *from a buyer's perspective* is from the early 1980s and assessed the trade-offs between accessibility and crime. Weisbrod et al. (1980, p. 7) found that the negative attributes of where people currently reside are at least as important as the positive attributes of locational alternatives in encouraging a decision to move. For example, for those using public transportation, "a 5% reduction in commute travel time was estimated to have an effect on locational attractiveness for the surveyed movers that is equivalent to 3.8% decrease in the rate of assaults and robberies per population." Their results suggest that households make significant trade-offs between transportation services and other factors, but that the role of both in determining where people choose to live is small compared with socioeconomic and demographic factors.

From a criminal's perspective, good accessibility means potential opportunities, such as for residential burglary. Yet any type of movement imposes travel costs. The farther criminals have to travel, the greater the travel costs (for the effect of street networks on crime and offenders' decision-making, see Beavon 1994; Johnson and Bowers 2010; Johnson and Summers 2015). As Burnell (1988, p. 187) suggested, if criminals are more likely to come from certain areas, the distance from these areas to the wealthier areas represents a cost to the criminal that must be weighed against the "potentially expected higher payoffs in these wealthier areas, [and] therefore a negative relationship between distance and crime is expected." Offenders' decision-making seems to be more complex than a cost-benefit analysis of distance and payoffs. Johnson and Summers (2015) examined how the characteristics of neighborhoods and their proximity to offender home locations affect offender spatial decision-making. Findings for adult offenders indicated that offenders' choices appear to be influenced by how accessible a neighborhood is via the street network. For younger offenders, results indicated that they favor areas that are low in social cohesion and closer to their home, or other age-related activity nodes.

How accessibility affects prices may also be a function of the way accessibility measures are incorporated into hedonic price models. Table 23.1 indicates at least three ways:

(a) A global measure of centrality (e.g., distance decay from city center, Von Thunen model): The closer a property is to the inner city, the higher its price. This measure is often represented by a continuous variable from a central point in the city center.

(b) A local measure of accessibility (e.g., transport nodes, such as a station, distance to roads or schools, commuting time, travel costs): The closer to the transport node, the higher the property prices, though it may also be noisier, more polluted, and with a poorer quality of life with mixed land use. This measure is normally represented by dummy variables for locations, buffer distances to stations, or distance measures from properties to accessibility points.

(c) A measure of spatial arrangement of the data (e.g., boundary sharing with a zone with higher accessibility means that individuals living in these neighboring zones are more likely to experience higher accessibility). Despite not being completely homogeneous, housing submarkets[1] share a number of characteristics, including accessibility. These measures can vary, from simple dummy variables that flag differences between zones or neighborhoods, to measures of spatial autocorrelation for travel time or accessibility variables within a housing submarket.

However, it is remarkable that although both crime and accessibility normally are correlated with other neighborhood characteristics, such as deprivation, more than half of the studies summarized in Table 23.1 regard crime or accessibility as an *exogenous* variable. To find out "what causes what," instrumental variables are often used in these models. An appropriate instrumental variable must be highly correlated with the endogenous measure but, at the same time, be uncorrelated with the error term and correctly excluded from the estimated housing price equation. Of the 12 studies that do instrument crime, only a few tested the validity of the instruments. As suggested by Ihlanfeldt and Mayock (2010, p. 161), the endogeneity of crime has been overlooked because "it is extremely difficult to identify variables that satisfy the conditions required of a valid instrument." In this study, a set of instrumental variables is used (see 23.4.2, "Data and Methods)".

23.3 Hypotheses of the Study

This study builds on previous research in Stockholm (Ceccato & Wilhelmsson, 2011; Wilhelmsson & Ceccato, 2015) but represents a departure by testing the hypotheses articulated below.

First, we will test if *burglary rates have a negative impact on housing prices* (H1). We also test whether *accessibility increases property prices* (H2). At the same time, there is an expected link between crime and accessibility. Good accessibility is often positively related to higher crime rates and vice versa. Hence, a location further away from the city is often associated with lower housing prices because of poorer accessibility but higher prices because of lower criminality. Moreover, the distance to the central business district (CBD) and accessibility is positively related, of course, but not perfect, especially in a place like Stockholm that is an archipelago, which means that people live and routinely commute to and from the islands in a well-connected transportation network (for the effect of street network on crime, see Beavon 1994; Johnson and Bowers 2010). However, this also implies that any measure based on Euclidian distance is problematic in this context, as one cannot easily walk or drive from each location to every other even if they are physically close (therefore in this study two measures of accessibility are employed). Even in a more or less monocentric city such as Stockholm, smaller subcenters with shopping and good public transportation may increase the accessibility but not the distance to the CBD. Thus, we test *whether the impact of burglaries on apartment prices differ with accessibility and distance to the CBD* (H3).

23.4 Components of the Study

23.4.1 The Study Area

Stockholm County was chosen for the case study because it is one of the most accessible cities in Europe. This Scandinavian capital received the 2013 Access City award for disabled-friendly cities, in third place after Berlin and Nantes, France (European Commission, 2010). The area is served by an extensive public transportation system (three subway lines with more than 100 stations, 2,000 buses, 5,000 taxis, dozens of ferryboats, and several tram routes) as well as roads, so the islands that constitute the metropolitan area are well connected. However, the region is characterized by urban sprawl. It extends to a large area (6,519 square kilometers) with a relatively low population density (3.6 inhabitants/square kilometer, compared to 6.9 for Copenhagen, Denmark (Statistics Denmark, 2016). Moreover, accessibility is limited by the fact that the region is an archipelago, located on Sweden's south-central east coast, where Lake Mälaren, Sweden's third largest lake, flows into the Baltic Sea.

Stockholm's metropolitan area, or Stockholm County, is composed of the municipality of Stockholm and 25 other surrounding municipalities (Figure 23.1). It is the largest of the three metropolitan areas in Sweden, with about 2.2 million inhabitants in 2014, half of them residing in Stockholm municipality. Although other types of housing tenure can also be found, privately or cooperatively owned apartment buildings dominate the most central parts of the metropolitan area. Large sections of Stockholm's inner city have residential land use, where citizens enjoy a good quality of life with high housing standards. However, there are flats built in the 1960s and 1970s throughout the Stockholm region that do not command high prices in the housing market. Some more peripheral municipalities have areas associated with poor architecture, lack of amenities, and social problems, including crime.

The Swedish housing market has ~~three~~ different forms of tenure: single-family, owner-occupied housing; cooperative multifamily housing; and multifamily rental housing. The multifamily rental housing market is subject to rent control, resulting, among other things, in a housing shortage in attractive locations. In the case of cooperative housing, the property is owned by a cooperative association. Each resident owns a share of the cooperative and occupies an apartment with tenancy rights nearly as strong as those of full ownership. Cooperatives are traded on an ordinary free housing market. Residents of cooperative apartments pay a monthly fee to the cooperative covering communal property expenses, such as maintenance, taxes, and other fees.

The geography of residential burglary has been changing since the early 1990s. Wikström (1991) showed that residential burglaries in Stockholm tend to occur mostly in outer-city wards with high socioeconomic status and especially in districts where there are high offender-rate areas nearby. For the latter, travel costs to targets are not too high because criminals do not need to travel long distances. Using data from the late 1990s, Ceccato, Haining, and Signoretta (2002) showed that high relative risks of residential burglary tended to occur both in the more affluent areas and in the more deprived areas. On the one hand, the higher the income, the higher the relative risk of residential burglary. Ten years later, Uittenbogaard and Ceccato (2012) found a similar geography for property crimes. What was striking at this time was that the geography of crime varied over space and time. This is because the risk of crime in a place varies as a function of the place's location, the characteristics of its built environment, and, most importantly, the human activities that the place generates at a particular time. These factors together determine different opportunities for burglary, even in areas with extensive use of housing safety measures (da Costa & Ceccato, 2015).

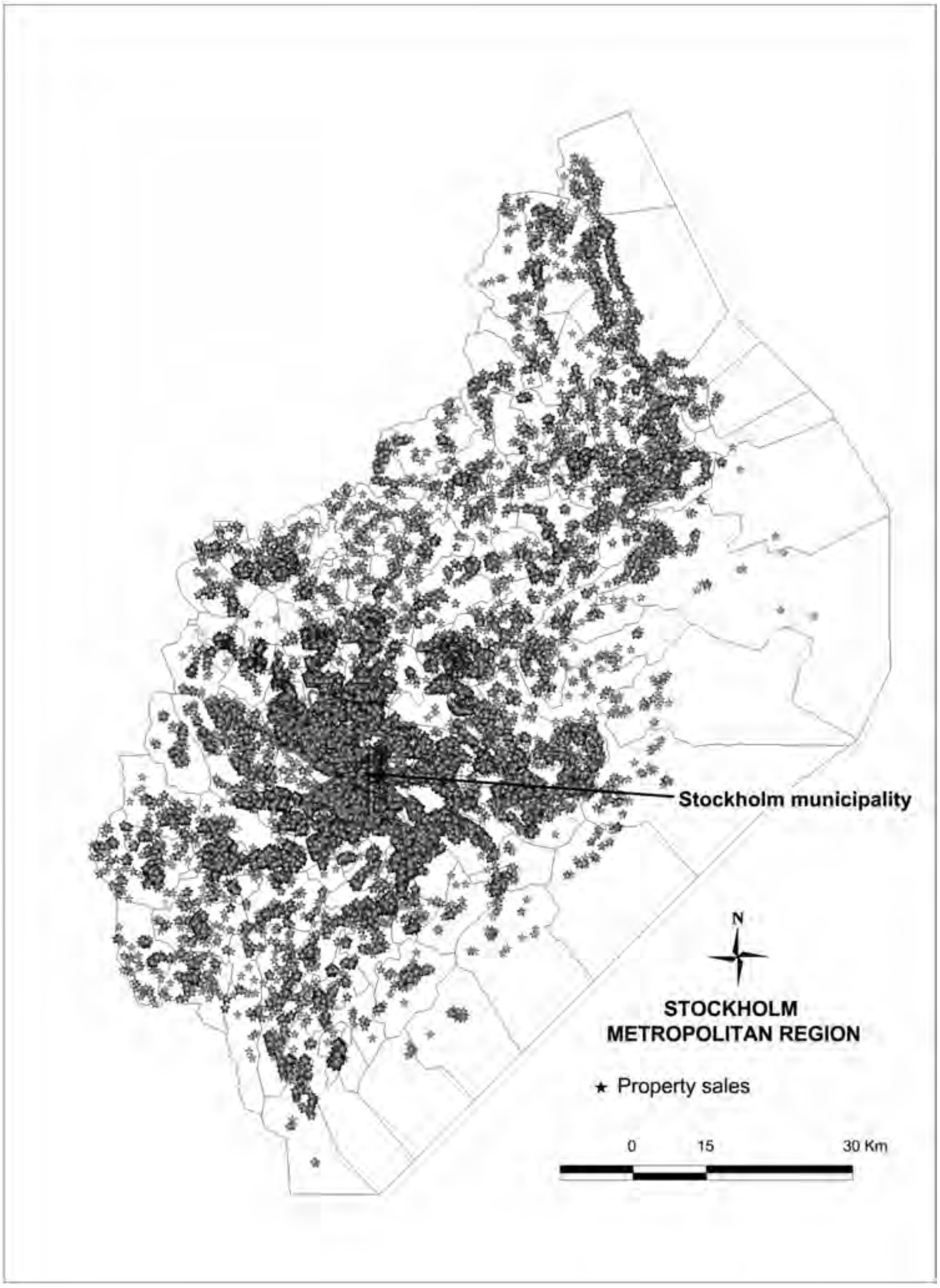

FIGURE 23.1 Stockholm metropolitan area: Study area

23.4.2. Data and Methods

23.4.2.1 *The Data Sets*

The data used comes from three sources. First, we used transactions of condominium apartments sold during 2012–2014 in Stockholm County (Figure 23.1), approximately 92,000 observations. Although the data covers three years, the x,y coordinates of each transaction are considered a cross-sectional database since a property cannot be sold every year, or multiple times (or rarely it is) in a short span of time. Each x,y coordinate is unique and illustrates a more robust picture of the housing market that would not be shown if only a year of data were used in the analysis.

The data comes from the company Valueguard, which gathers data on prices and property attributes. Only arm's-lengths transactions are included in the data set. The database contains property address, area code, parish code, selling price, living area, year of construction, presence of balcony and elevator, price per square meter, date of contract, monthly fee to the condominium association, number of rooms, date of disposal, number of the floor of the specific flat, total number of floors in building, postal code, and x,y coordinates. This vector of attributes at the x,y coordinate level of every single apartment sold was mapped using geographical information systems (GIS). There is also a second vector of attributes associated with the neighborhood context of the apartments (e.g., distance to CBD, crime rates, accessibility). Thus, if an apartment *i* is located in an area *j*, then all *i* are automatically associated in GIS with the attributes of *j*. Using GIS, area-level data was combined with x,y data using standard matching table procedures. Note that these areas, *basområde*, are the smallest geographical unit for which statistical data is available in Sweden, in a total of 1298 units. They vary in shape, size, and total population (mean population of 1,521 inhabitants with standard deviation of 1,508). The coverage of the data collected by Valueguard varies from 85% to 90% of all sales. Sales not included are transactions sold without a real estate broker.

The cross-sectional data was merged with land use data from the Stockholm metropolitan area's database and with police records from Stockholm Police headquarters. Police records were mapped using x,y coordinates for each offense in 2013. The data for accessibility and some of the control variables (e.g., indicators of urbanization) come from the company WSP (William Sale Partnership). The variable accessibility is measured as "generalized travel cost," the total cost a traveler experiences when taking a trip from one location to another relative to the location's attractiveness (here, number of jobs at the location). The costs include indirect costs for time and direct costs, such as for tickets. Here, travel cost is measured for public transportation (Ben-Akiva & Steven, 1985). The travel cost is not based on the distance between the transacted apartment and Stockholm CBD; instead it is the "average" travel cost to all other locations in the study area, weighted by number of jobs in that location. On the other hand, the variable distance to the CBD is the Euclidean distance between property addresses and the Stockholm CBD and has been estimated in GIS. Figure 23.2 exemplifies the accessibility measure and cases of residential burglary in Stockholm.

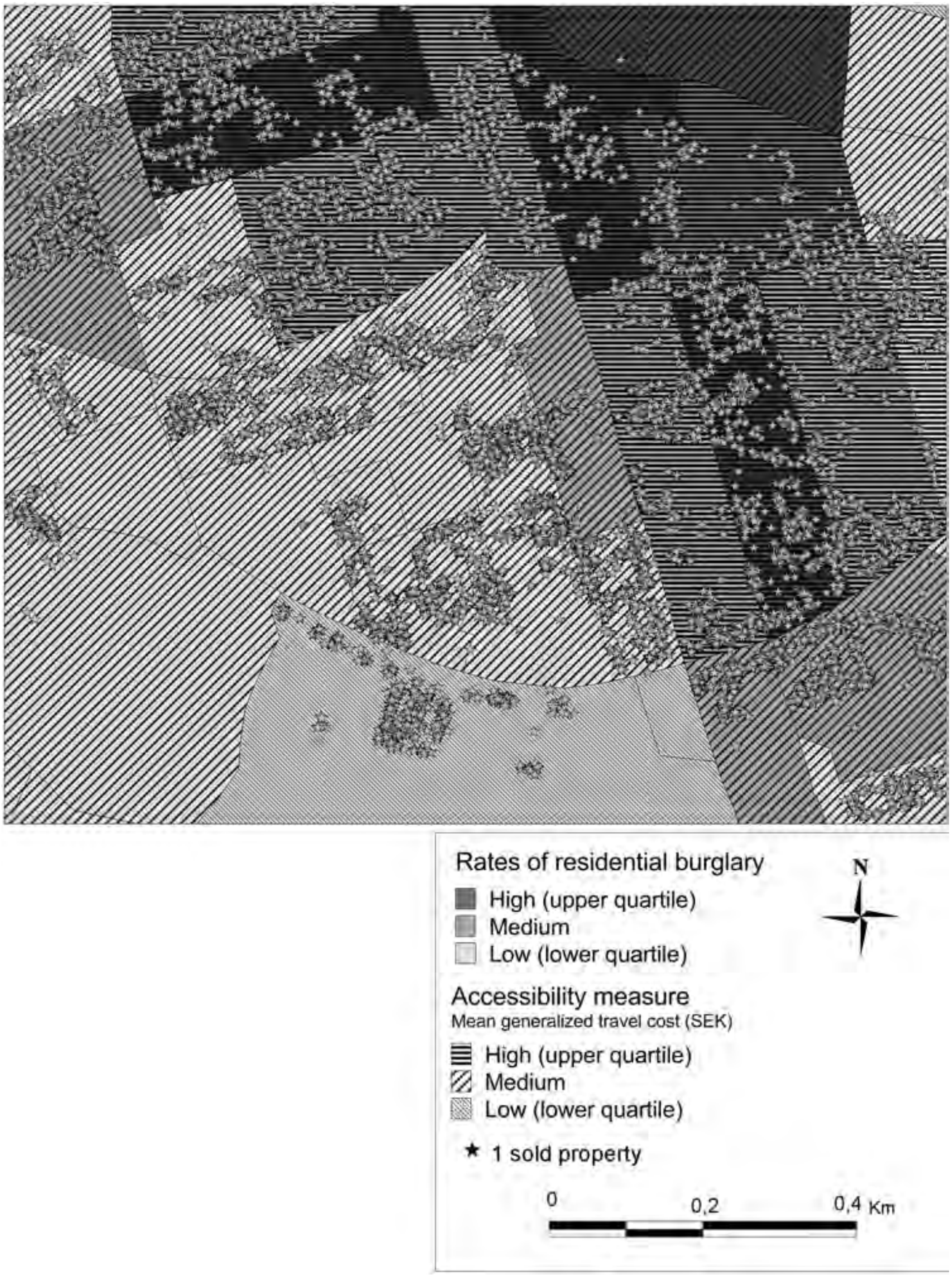

FIGURE 23.2 Overlaps in space of covariates "Accessibility" and "Residential burglary" in a snapshot of central Stockholm (Sweden)

Data source: Police headquarters, 2013 and WSP (William Sale Partnership).

Crime rates for residential burglary were calculated by using data for small unit areas (*basområde*). To link crime rates to the x,y coordinates of each property sale, the Stockholm metropolitan map with 1,298 units was layered over the properties' x,y coordinates. All sales within the boundaries of a small unit area would get that small unit area's crime rates. This procedure was performed using the standard table join function in GIS. For more details, see Ceccato and Wilhelmsson (2011). Note that these zones vary greatly in the total number of crimes, from no crime to 5,564 offences, with a standard deviation of 436,065 and a mean of 319,943 offences. For residential burglary, the mean was 7.6 per small unit areas, with a standard deviation of 11.14.

23.4.2.2 *The Models*

To test our hypotheses, we used spatial hedonic models (Wilhelmsson, 2002; but see also Ceccato & Wilhelmsson, 2011, 2012, 2016; Wilhelmsson & Ceccato, 2015). In spatial hedonic models, a commonly used model especially in real estate economics, the dependent variable equals price, and the independent variables are housing attributes, neighborhood characteristics, and time indicators if the sample is a combination of cross-section and time series (as in our case). The hedonic model is based upon the assumption that the value of a house or apartment is a function of its characteristics and that there exists an implicit price (or hedonic price or willingness to pay) for each characteristic. The characteristics could be attributes of the house or apartment (such as size, quality, and age), and/or the characteristics of the neighborhood (such as closeness to parks, sea view, and access to public transportation, as well as absence of traffic noise and crimes). Hedonic models are used in property valuation, estimation of willingness to pay, and construction of house price indexes. The term "hedonic" was introduced in an article by Court (1939). By estimating the so-called hedonic price equation, the implicit prices can be revealed. The stochastic version of the hedonic price equation takes the form

$$Y = X\beta + \varepsilon \qquad (23.1),$$

where Y is a $1 \times n$ vector of observations of the dependent variable, and β is a $k \times 1$ vector of parameters associated with exogenous explanatory variables (X); X is an $n \times k$ matrix. The number of observations is equal to the number of transacted individual sales, that is, a cross-sectional data set. The stochastic term ε is assumed to have a constant variance and normal distribution. Usually the functional form is nonlinear but linear in parameters. The estimated parameters (a vector of β) can be interpreted as willingness to pay for the housing and neighborhood attributes (Rosen, 1974). In order to be able to interpret the coefficients as causal relationships, the explanatory variables must be exogenous. If the independent explanatory variable is endogenous, we need to utilize other methods such as the instrument variable approach discussed below.

The explanatory variables X can be divided into a number of different types of attributes. Here we used attributes controlling for structural differences such as size of apartment, age of property, and maintenance fees to the cooperative. But we also used neighborhood characteristics such as crime rate (here, burglary rates), distance to CBD, and accessibility via public transportation, as well as indicators of urbanization such as housing density.

A major concern in estimating Equation 23.1 is the problem of simultaneous causality (endogeneity); that is, we do not know whether it is burglaries that explain house prices or whether it is house prices that explain burglaries. Hence, the causality may go in both directions. If that is the case, the error and the independent variable "burglary" are correlated and the OLS estimates will be biased.

In addition to the simultaneity problem discussed above, there may also be a problem of spatial dependency, which is often the case in real estate models such as this (see, for example, Wilhelmsson, 2002). If spatial autocorrelation is not included when building the real estate model, OLS will be biased, and furthermore the estimated variance will be biased; that is, it will be difficult to make an inference (Anselin, 1988). To mitigate this problem, we estimated a spatial lag model, that is, spatial lagged house prices are included as an additional independent variable in the hedonic price equation. The spatial weight matrix that we are using is defined by the inverse distance between observations and is row-standardized. To reduce the problems of simultaneity and spatial dependency and to estimate unbiased, consistent, and efficient parameters, we adopted an instrument variable (IV) approach proposed by Kelejian and Prucha (1998) and refined in Drukker, Egger, and Prucha (2013). The instrument two-stage technique assumes the instrument to be uncorrelated with the error term but a good proxy for the endogenous variables. We use as instrument variables spatial lagged neighboring characteristics such as housing density and proportion of high-rise buildings as well as spatial lagged aggregated housing attributes such as size, maintenance fee, and number of rooms. Hence, the instrument variables are assumed to be correlated to our independent spatial and crime variables, but not correlated to our dependent variable housing price. This method, with the same type of instrument variables, has been used in previous research (Basile, 2008; Brasington, Flores-Lagunes, & Guci, 2016; Buettner, 2001; Buonanno, Prarolo, & Vanin, 2016; Gómez-Antonio, Hortas-Rico, & Li, 2016; Kügler & Weiss, 2016; Mandell & Wilhelmsson, 2015; Solé Ollé, 2003; Usai & Paci, 2003). The instrumental variables that we are using address the problem of endogenous independent variables (burglary and spatial lagged house prices) and were included in all five estimated models. If the instruments variables are good, it is possible to interpret the estimated parameters as causal relationships and not just correlations.

23.5 Results

23.5.1 Descriptive Analysis

Descriptive statistics for the variables used are shown in Table 23.2. Our dependent variable was transaction price, covering more than 90,000 apartment sales in Stockholm

Table 23.2 Descriptive Statistics

Variable	Definition	Mean	Standard deviation
Apartment data			
Price	Transaction price of apartments, SEK	2,756,114	1,833,382
Living area	Square meters	64.89	27.08
Fee	Maintenance fee to the cooperative, SEK	3,476.39	1,450.39
Rooms	Number of rooms	2.42	1.13
Year	Year of construction	1962.55	35.58
Neighborhood data			
Accessibility	Generalized travel cost to work, SEK	113.43	7.66
Distance to CBD	Distance to central business district, meters	9,701.13	10,190.25
Built area	Proportion of built area in the neighborhood	0.56	0.24
High-rise buildings	Proportion of high-rise buildings	0.48	0.40
Low buildings	Proportion of low-rise buildings	0.21	0.32
Single-family	Proportion of single-family houses	0.15	0.28
Criminality data			
Burglary rate		0.6089	1.49

County. Most of the sales were within the municipality of Stockholm. The apartments resemble condominiums in cooperative property associations. We used sales during the period 2012–2014. The average price was SEK 2.7 million, but the variation around the mean was large: SEK 1.8 million.

In our hedonic model, the variation in prices is modeled using our four independent variables (see above) after controlling for differences in the apartment (living area, maintenance fee, and number of rooms) and the year of construction of the property. On average, each apartment sold had an area of almost 65 square meters, allocated to 2.4 rooms. The standard deviation was around 27 square meters, that is, a slightly lower variation around the mean than for price. The maintenance fee was on average SEK 3,500, with a standard deviation of SEK 1,400. The typical apartment was located in a building built in 1962. Apartments in older buildings often command a higher price than apartments in newer buildings. The size of the fee has an impact on the user cost that is typically inversely correlated to price.

Besides apartment and property characteristics, neighborhood characteristics explain the value of an apartment. We used six different neighborhood variables to control for location. The first two measured how good the accessibility was and how far from the CBD the apartment was located. The accessibility measurement combined the cost of travel measured in SEK, such as direct cost of the trip and indirect cost of time, referred to as the generalized travel cost, relative to the attractiveness of the location. Here we used the generalized travel cost to work using public transportation; that is, we measured accessibility to work by public transportation, and we did that in more than 800 spatial units in Stockholm County. The accessibility was SEK 113, and the variation around this mean was low. Distance to CBD was measured by the Euclidian distance from each sold apartment to the CBD. On average, the apartments were located 9,700 meters from the CBD, and the variation was large. Besides the measurement of accessibility and distance, we used four different variables to measure the degree of urbanization: the proportion of built area in the neighborhood (that is, the inverse of the proportion of green area), the proportion of high-rise buildings and low-rise buildings, and the proportion of single-family houses. The expected impact on apartment prices was that accessibility and degree of urbanization increase the expected price.

Finally, we used burglary rates as one of the independent variables in the hedonic price equation. The average burglary rate was equal to.6, and the variation was very big, as the standard deviation was almost 1.5.

Table 23.3 shows the correlations between our main variables. Despite the fact that bivariate correlations can be misleading, as they ignore spatial structure and the influence of the other variables, some interesting results can be observed. Covariates "accessibility," "distance to CBD," and "burglary rate" are all only modestly correlated to price. The expectation is that location is very important, but the correlation between price and accessibility is only .48, and in absolute values the correlation is even lower between price and distance. However, what stands out is the very low correlation between burglary rates and apartment prices, only .03. Even more interesting is that the correlation is positive, which comes from the fact that burglary rates are often higher in locations with good accessibility. But again, burglary rates are not highly correlated with accessibility and distance, though the correlation coefficients may differ statistically from zero. Finally, it is interesting to observe that accessibility and distance to CBD are highly correlated but not perfectly correlated. Hence, there exist locations far from the CBD that have good accessibility, such as locations close to public transportation, and locations close to the CBD with bad accessibility, for instance, because they are disrupted by water between the islands.

Table 23.3 Selected Correlation Coefficients

	Price	Accessibility	Distance to CBD	Burglary rate
Price	1.00			
Accessibility	.48	1.00		
Distance to CBD	−.41	−.86	1.00	
Burglary rate	.03	.08	−.07	1.00

23.5.2 Modeling Results

Table 23.4 shows the results from the hedonic price equation. The model controls for spatial dependency and endogeneity by the instrument variable approach (a two-stage regression).

The overall effect using all data is presented in Model 1. Variables included in the hedonic price equation can explain about 70% of the variation in price. All apartment- and property-related attributes are statistically significant and have the expected sign and magnitude. The results also seem to suggest that spatial lagged apartment prices have a positive impact on apartment prices. Increased accessibility is expected to raise apartment prices, and distance from the CBD to decrease apartment prices. More urbanized areas are expected to increase house prices, while too many high-rise buildings lower apartment prices on average. Our results suggest that if the proportion of single-family houses increases, apartment prices increase. Hence, the conclusion that can be drawn is that urbanization has a positive effect on prices, but this effect only holds when there is a diversified supply of housing types in the neighborhood.

What about burglary and its effect on apartment prices? Here we can observe that higher burglary rates are associated with lower home prices. If burglary rates increase

Table 23.4 Two-Stage Least Square Regression Results (IV approach), Y = Log of Apartment Prices

	Hedonic price equation	
	Coefficient	*t*-value
Wprice[a]	.4971*	(28.14)
Burglary rate	–.0864*	(–7.40)
Living area	.0121*	(139.97)
Fee (10^2)	–.0081*	(–68.71)
Rooms	.0444*	(24.29)
Year (10^2)	–.0199*	(–6.35)
Accessibility	.0280*	(86.31)
Distance to CBD (10^2)	–.0011*	(–51.47)
Built area	.0812*	(17.17)
High-rise buildings	–.2188*	(–68.67)
Low buildings	–.2321*	(–42.06)
Single-family	.0728*	(11.02)
Constant	4.3079	(16.09)
R^2	0.7224	
No. of observations	88,979	

Note: Dependent variable: natural logarithm of transaction price.

[a] Wprice is equal to spatial lagged transaction prices.

* Statistically significant estimates on a 5% significance level.

by one unit, apartment prices are expected to fall by almost 0.09%. We have checked for multicollinearity by variance-of-inflation (VIF). The result indicates that we have no problem with multicollinearity. The VIF-value concerning variable "burglary" is below 2, that is, far from a rule-of-thumb value of 5. We have also corrected for the potential problem of heteroscedasticity. Hence, our interpretation is that our results indicate that there is a negative causal relationship between burglary rates and apartment prices.

To summarize, we can accept hypothesis 1, that burglaries have a negative impact on apartment prices. Moreover, there seems to be a variation in impact depending on where the apartment is located in respect of accessibility and distance from the CBD. The impact is higher in areas far away from the CBD or with poor accessibility to public transportation (or both), a finding that corroborates hypothesis 3. The impact is measured as a percentage of apartment prices. Of course, measured in absolute Swedish crowns, the impact can be higher because of higher prices.

What can we expect if the location has relatively good accessibility but is located far from the CBD, that is, if the apartment is located close to a public transportation hub? Table 23.5 presents the results from an analysis in which we split the data set into four subsamples: good accessibility close to CBD, good accessibility far from CBD, poor accessibility close to CBD, and bad accessibility far from CBD. Note that the regression model in Table 23.5 includes all of the other variables, but for simplicity here only the results of interest are presented.

For apartments located in areas with good accessibility near the CBD, burglaries have no statistically significant effect on prices. It appears that burglaries in the inner city are, in some sense, expected and therefore discounted less in the price (see also Ceccato & Wilhelmsson, 2011). However, in locations with poor accessibility, burglaries impact apartment prices negatively, pulling the prices down—and this effect is statistically significant. In locations far from the CBD, regardless of levels of accessibility, burglaries have a negative impact on apartment prices. However, the effect is much higher in locations with poor accessibility. Overall, the effect of burglaries on apartment prices seems to be of more importance far from the CBD than in the inner city.

In Stockholm County, if burglary rates increase 1%, apartment prices are expected to fall by almost 0.09%. For apartments in Stockholm municipality (note, not the County),

Table 23.5 The Impact of Burglaries on Apartment Prices

	Near CBD	Far from CBD
Good accessibility	.0121 (1.61)	–.1237* (–11.41)
Poor accessibility	–.0654* (–5.37)	–.4451* (–9.50)

Note: t-values within brackets. Dependent variable: natural logarithm of transaction price. Only coefficients concerning burglary rates are presented in the table.

Ceccato and Wilhelmsson (2011) found that the discounts were greater: If residential burglary increased by 1%, apartment prices were expected to fall by 0.21%, perhaps because apartments located in areas with lower burglary rates are more scarce the closer one gets to the central areas of the county. The impact of crime on housing prices in North American cities seems to be slightly greater than the impact found in Stockholm County or municipality (see, e.g., Lynch and Rasmussen, 2001 or Hellman and Naroff, 1979). For a discussion of potential reasons for this difference in prices see Ceccato and Wilhelmsson (2011). However, it is important to note that these results are not completely comparable because of differences in crime type and the methodology of these studies.

23.6 Conclusions and Implications of Results

This chapter sets out to assess the impact on apartment prices of residential burglary mediated by accessibility. A review of the literature on hedonic modeling covering more than three decades shows that, despite different modeling strategies, these studies consistently find evidence that crime affects housing prices. Two measures of accessibility are used: a "global" distance decay from Stockholm city center and a "local" measure of accessibility to work expressed as travel costs. Results for all of Stockholm County confirm previous findings once limited to Stockholm municipality only (Ceccato & Wilhelmsson, 2011), that residential burglary reduces apartment prices. However, such an effect varies across space and levels of accessibility. For instance, for apartments located in areas with relatively good accessibility near the CBD, burglary has no effect on prices; while for apartments in areas with poor accessibility, burglaries help reduce prices. In locations far from the CBD, regardless of levels of accessibility, residential burglary has a negative impact on apartment prices.

Results represented here estimate the trade-offs that buyers make in a single Swedish county at a single point in time when buying apartments. Therefore, there are obvious limitations to the policy-related conclusions that should be drawn or generalized for other urban centers, at any other moment in time, or for other types of housing. Note that despite being well connected by public transportation, the Stockholm region is an archipelago. New measures of accessibility as well as indications of safety should be tested in the future (for alternatives, see Table 23.1) Moreover, housing prices might be affected by regional factors, which suggests the existence of housing submarkets. Future research should test the effect of submarkets in Stockholm County, in other words, to check whether and how the implicit prices and/or the quantity of different housing attributes differ from one area to another within the same area of study.

Despite limitations, some issues can be highlighted on the basis of these findings. First, price-related policies (rent control, tax advantages, and mortgage ceilings) can potentially offset the impact of transportation on property prices. We agree with Weisbrod et al. (1980, pp. 7–8) that "a small change in housing costs may have an effect on residential location decisions equivalent to the effect of a larger proportional change in travel time." Thus, as far as the Swedish context is concerned, future research should also consider assessing differences in municipal taxes and other price-related policies that potentially make an area more (or less) attractive in the market. Second, investments to improve safety (in this case reduce burglary) and reduce travel time can contribute to increasing the attractiveness of some locations, especially in the more peripheral areas of Stockholm County, where both crime and poor accessibility decrease property prices.

Research of this kind also makes a direct contribution to environmental criminology. First, knowing how crime affects people's willing to pay for housing can help prevent its occurrence, as environmental criminology is about the study of crime and places (and the way crime reflects space-time activities of individuals and organizations). Areas that are highly discounted in the market are often associated with other environmental characteristics that pull prices down, including those that generate crime (e.g., "no-go areas"). These areas may decay even more if no intervention is made. Therefore, people's willing to pay for housing can be used as an indicator of an area's well-being. Second, crime can be place and time dependent, highly determined by the types of land uses (e.g., residential versus mixed land use) and activities that these areas may attract. This research can therefore be indicative to help criminologists to understand the nature of environments where crime takes place, but, more importantly, understand that crime opportunities are affected by a complex system of agents that go much beyond particular locations.

Note

1. Submarkets are typically defined as areas in which the implicit prices and/or the quantity of different housing attributes differ from those of another area. The challenge of dividing a large housing market into submarkets has been addressed in a number of papers, such as Goodman and Thibodeau (2003).

References

Anselin, L. (1988). *Spatial Econometrics: Method and Models*. Dordrecht: Kluwer Academic.

Basile, R. (2008). Regional economic growth in Europe: A semiparametric spatial dependence approach. *Papers in Regional Science*, *87*(4), 527–544. doi:10.1111/j.1435-5957.2008.00175.x.

Beavon, D. J. K., Brantingham, P. L. & Brantingham, P. J. (1994). "The influence of street networks on the patterning of property offences." In R. Clarke (Ed.), *Crime Prevention Studies* (Vol. 2, pp. 115–48). Monsey, NY: Criminal Justice Press.

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

Bowes, D. R., & Ihlanfeldt, K. R. (2001). Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics*, *50*(1), 1–25. doi:http://dx.doi.org/10.1006/juec.2001.2214.

Boymal, J., Silva, A., & Liu, S. (2013). Measuring the preference for dwelling characteristics of Melbourne: Railway stations and house prices. Paper presented at the 19th Annual Pacific Rim Real Estate Society Conference, Melbourne, Australia,

Brasington, D., Flores-Lagunes, A., & Guci, L. (2016). A spatial model of school district open enrollment choice. *Regional Science and Urban Economics*, *56*, 1–18. doi:http://dx.doi.org/10.1016/j.regsciurbeco.2015.10.005.

Buck, A. J., Hakim, S., & Spiegel, U. (1991). Casinos, Crime, and Real Estate Values: Do They Relate? *Journal of Research in Crime and Delinquency*, *28*(3), 288–303. doi:10.1177/0022427891028003003

Buck, A. J., Hakim, S., & Spiegel, U. (1993). Endogenous crime victimization, taxes, and property values. *Social Science Quarterly*, *74*(2), 334–348.

Buettner, T. (2001). Local business taxation and competition for capital: the choice of the tax rate. *Regional Science and Urban Economics*, *31*(2–3), 215–245. doi:http://dx.doi.org/10.1016/S0166-0462(00)00041-7

Buonanno, P., Montolio, D., & Raya-Vílchez, J. M. (2012). Housing prices and crime perception. *Empirical Economics*, *45*(1), 305–321. doi:10.1007/s00181-012-0624-y

Buonanno, P., Prarolo, G., & Vanin, P. (2016). Organized crime and electoral outcomes. Evidence from Sicily at the turn of the XXI century. *European Journal of Political Economy*, *41*, 61–74. doi:http://dx.doi.org/10.1016/j.ejpoleco.2015.11.002

Burnell, J. D. (1988). Crime and Racial Composition in Contiguous Communities as Negative Externalities: Prejudiced Households' Evaluation of Crime Rate and Segregation Nearby Reduces Housing Values and Tax Revenues. *The American Journal of Economics and Sociology*, *47*(2), 177–193.

Case, K. E., & Mayer, C. J. (1996). Housing price dynamics within a metropolitan area. *Regional Science and Urban Economics*, *26*(3–4), 387–407. doi:http://dx.doi.org/10.1016/0166-0462(95)02121-3

Caudill, S. B., Affuso, E., & Yang, M. (2015). Registered sex offenders and house prices: An hedonic analysis. *Urban Studies*, *52*(13), 2425–2440.

Ceccato, V. (2013). *Moving safely: crime and perceived safety in Stockholm's subway stations*. Plymouth: Lexington.

Ceccato, V. (2016). Segurança e mercado imobiliário urbano (Security and the housing market). In A. Vitte (Ed.), *Novas perspectivas analiticas e interprepativas da Ciencia geografica no atual contexto do sistema mundo* (p. 16). Sao Paulo, Brazil: Paco editorial.

Ceccato, V., Cats, O., & Wang, Q. (Eds.). (2015). The geography of pickpocketing at bus stops: An analysis of grid cells. In V. Ceccato & A. Newton (Eds.), *Safety and Security in Transit Environments: An Interdisciplinary Approach*, Basingstoke: Palgrave.

Ceccato, V., Haining, R., & Signoretta, P. (2002). Exploring crime statistics in Stockholm using spatial analysis tools. *Annals of the Association of American Geographers*, *22*, 29–51.

Ceccato, V., & Newton, A. (Eds.). (2015). *Safety and Security in Transit Environments: An Interdisciplinary Approach.* London: Palgrave.

Ceccato, V., & Wilhelmsson, M. (2016). Do crime hot spots affect housing prices? ERSA-conference, 2017, Groningen, Holland

Ceccato, V., & Wilhelmsson, M. (2011). The impact of crime on apartment prices: Evidence from Stockholm, Sweden. *Geografiska Annaler: Series B, Human Geography*, *93*(1), 81–103. doi:10.1111/j.1468-0467.2011.00362.x.

Ceccato, V., & Wilhelmsson, M. (2012). Acts of vandalism and fear in neighbourhoods: Do they affect housing prices? In V. Ceccato (Ed.), *The Urban Fabric of Crime and Fear* (pp. 191–213). New York: Springer.

Clark, D. E., & Cosgrove, J. C. (1990). Hedonic prices, identification and the demand for public safety. *Journal of Regional Science*, *30*(1), 105–121. doi:10.1111/j.1467-9787.1990.tb00083.x.

Cohen, L. E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review*, *44*. doi:10.2307/2094589.

Congdon-Hohman, J. M. (2013). The lasting effects of crime: The relationship of discovered methamphetamine laboratories and home values. *Regional Science and Urban Economics*, *43*(1), 31–41. doi:http://dx.doi.org/10.1016/j.regsciurbeco.2012.11.005.

da Costa, B., & Ceccato, V. (2015). Assessing the adoption of household safety protection (HSP) in Stockholm, Sweden. *Crime Science*, *4*(1), 1–12. doi:10.1186/s40163-015-0027-4.

Drukker, D. M., Egger, P., & Prucha, I. R. (2013). On two-step estimation of a spatial autoregressive model with autoregressive disturbances and endogenous regressors. *Econometric Reviews*, *32*(5–6), 686–733. doi:10.1080/07474938.2013.741020

Dubin, R. A., & Goodman, A. C. (1982). Valuation of education and crime neighborhood characteristics through hedonic housing prices. *Population and Environment*, *5*(3), 166–181.

European Commission (2010). Stockholm—European green capital. Retrieved from http://ec.europa.eu/environment/europeangreencapital/winning-cities/2010-stockholm/index.html.

Fransson, U., Rosenqvist, G., & Turner, B. (2002). Hushållens värdering av egenskaper i bostäder och bostadsområden. Research report, Uppsala University.

Gibbons, S. (2004). The costs of urban property crime. *Economic Journal*, *114*(499), F441–F463. doi:10.1111/j.1468-0297.2004.00254.x.

Gómez-Antonio, M., Hortas-Rico, M., & Li, L. (2016). The causes of urban sprawl in Spanish urban areas: A spatial approach. *Spatial Economic Analysis, 11*(2), 1–28. doi:10.1080/17421772.2016.1126674.

Goodman, A. C., & Thibodeau, T. G. (2003). Housing market segmentation and hedonic prediction accuracy. *Journal of Housing Economics*, *12*, 181–201.

Hellman, D.A. & Naroff, J.L. (1979). The impact of crime on urban residential property values. *Urban Studies*, *16*, 105–112.

Hwang, S., & Thill, J.-C. (2009). Delineating urban housing submarkets with fuzzy clustering. *Environment and Planning B: Planning and Design*, *36*(5), 865–882.

Ihlanfeldt, K., & Mayock, T. (2010). Panel data estimates of the effects of different types of crime on housing prices. *Regional Science and Urban Economics*, *40*(2–3), 161–172. doi:http://dx.doi.org/10.1016/j.regsciurbeco.2010.02.005.

Iqbal, A., & Ceccato, V. (2015). Does crime in parks affect apartment prices? *Journal of Scandinavian Studies in Criminology and Crime Prevention*, *16*(1), 97–121. doi:10.1080/14043858.2015.1009674.

Johnson, S. D., & Bowers, K. J. (2010). Permeability and burglary risk: Are cul-de-sacs safer? *Journal of Quantitative Criminology*, *26*(1), 89–111. doi:10.1007/s10940-009-9084-8.

Johnson, S. D., & Summers, L. (2015). Testing ecological theories of offender spatial decision making using a discrete choice model. *Crime and Delinquency*, *61*(3), 454–480. doi:10.1177/0011128714540276.

Kain, J. F., & Quigley, J. M. (1970). Measuring the value of housing quality. *Journal of the American Statistical Association*, *65*(330), 532–548. doi:10.1080/01621459.1970.10481102.

Kelejian, H. H., & Prucha, I. R. (1998). A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. *Journal of Real Estate Finance and Economics*, *17*(1), 99–121. doi:10.1023/a:1007707430416.

Kügler, A., & Weiss, C. (2016). Time as a strategic variable: Business hours in the gasoline market. *Applied Economics Letters,* 23(15), 1051–1056. doi:10.1080/13504851.2015.1133888.

Larsson, J., Landström, M., & Sandin, M. (2008). *Ombildning av hyresrätt: en studie av två fastigheter*. Mälardalens Högskola, Master thesis.

Li, W., Joh, K., Lee, C., Kim, J.-H., Park, H., & Woo, A. (2015). Assessing benefits of neighborhood walkability to single-family property values: A spatial hedonic study in Austin, Texas. *Journal of Planning Education and Research*, *35*(4), 471–488. doi:10.1177/0739456x15591055.

Linden, L., & Rockoff, J. E. (2008). Estimates of the impact of crime risk on property values from Megan's laws. *American Economic Review*, *98*(3), 1103–1127.

Loukaitou-Sideris, A. (2012). Safe on the move: The importance of the built environment. In V. Ceccato (Ed.), *The Urban Fabric of Crime and Fear* (pp. 85–110). New York: Springer.

Lynch, A. K., & Rasmussen, D. W. (2001). Measuring the impact of crime on house prices. *Applied Economics*, *33*(15), 1981–1989. doi:10.1080/00036840110021735.

Mandell, S., & Wilhelmsson, M. (2015). Financial infrastructure and house prices. *Applied Economics*, *47*(30), 3175–3188. doi:10.1080/00036846.2015.1013608.

Munroe, D. K. (2007). Exploring the determinants of spatial pattern in residential land markets: Amenities and disamenities in Charlotte, NC, USA. *Environment and Planning B: Planning and Design*, *34*(2), 336–354. doi:10.1068/b32065.

Naroff, J. L., Hellman, D., & Skinner, D. (1980). Estimates of the impact of crime on property values. *Growth and Change*, *11*(4), 24–30. doi:10.1111/j.1468-2257.1980.tb00878.x.

Newton, A. D., Johnson, S. D., & Bowers, K. J. (2004). Crime on bus routes: An evaluation of a safer travel initiative. *Policing*, *27*(3), 302–319. doi:10.1108/13639510410553086.

Pope, D. G., & Pope, J. C. (2012). Crime and property values: Evidence from the 1990s crime drop. *Regional Science and Urban Economics*, *42*(1–2), 177–188. doi:http://dx.doi.org/10.1016/j.regsciurbeco.2011.08.008.

Pope, J. C. (2008). Fear of crime and housing prices: Household reactions to sex offender registries. *Journal of Urban Economics*, *64*(3), 601–614. doi:http://dx.doi.org/10.1016/j.jue.2008.07.001.

Rizzo, M. J. (1979). The effect of crime on residential rents and property values. *American Economist*, *23*(1), 16–21.

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, *82*(1), 34–55.

Solé Ollé, A. (2003). Electoral accountability and tax mimicking: The effects of electoral margins, coalition government, and ideology. *European Journal of Political Economy*, *19*(4), 685–713. doi:http://dx.doi.org/10.1016/S0176-2680(03)00023-5.

Statistics Denmark (2016) *Statistical Yearbook*. Copenhagen. Retrieved September 21, 2017, from http://www.dst.dk/en/Statistik/Publikationer/VisPub?cid=22256

Thaler, R. (1978). A note on the value of crime control: Evidence from the property market. *Journal of Urban Economics*, *5*(1), 137–145. doi:http://dx.doi.org/10.1016/0094-1190(78)90042-6.

Tita, G., Petras, T., & Greenbaum, R. (2006). Crime and residential choice: A neighborhood level analysis of the impact of crime on housing prices. *Journal of Quantitative Criminology*, *22*(4), 299–317. doi:10.1007/s10940-006-9013-z.

Troy, A., & Grove, J. M. (2008). Property values, parks, and crime: A hedonic analysis in Baltimore, MD. *Landscape and Urban Planning*, *87*(3), 233–245. doi:http://dx.doi.org/10.1016/j.landurbplan.2008.06.005.

Uittenbogaard, A. C., & Ceccato, V. (2012). Space-time clusters of crime in Stockholm. *Review of European Studies*, *4*, 148–156.

Usai, S., & Paci, R. (2003). Externalities and local economic growth in manufacturing industries. In B. Fingleton (Ed.), *European Regional Growth* (pp. 293–321). New York: Springer.

Weisbrod, G., Ben-Akiva, M., & Lerman, S. (1980). Tradeoffs in residential location decisions: Transportation versus other factors. *Transportation Policy and Decision-Making*, *1*(1), 13–26

Wikström, P.-O. H. (1991). *Urban Crime, Criminals, and Victims: The Swedish Experience in an Anglo-American Comparative Perspective*. Stockholm: Springer.

Wilhelmsson, M. (2002). Spatial models in real estate economics. *Housing, Theory and Society*, *19*(2), 92–101. doi:10.1080/140360902760385646.

Wilhelmsson, M., & Ceccato, V. (2015). Does burglary affect property prices in a nonmetropolitan municipality? *Journal of Rural Studies*, *39*, 210–218. doi:http://dx.doi.org/10.1016/j.jrurstud.2015.03.014