Park Proximity, Crime and Apartment Prices

ASIFA IQBAL*& MATS WILHELMSSON**

*Asifa Iqbal (Corresponding Author)
Department of Urban Planning and Environment
School of Architecture and the Built Environment
KTH Royal Institute of Technology, Stockholm, Sweden
Drottning Kristinas Väg 30, 100 44, Stockholm, Sweden
asifa.iqbal@abe.kth.se

**Mats Wilhelmsson
Department of Real Estate and Construction Management
School of Architecture and the Built Environment
KTH Royal Institute of Technology, Stockholm, Sweden
Drottning Kristinas Väg 30, 100 44, Stockholm, Sweden

Abstract

Parks and open green spaces are an important part of the city landscape. Although studies show that proximity to parks and open green spaces has a mostly positive impact on house prices, several studies also report that crime in parks can affect buyers' perceptions, making nearby properties less desirable. We examine the effects of park proximity and crime in parks on apartment prices by using geographic information systems and hedonic modelling. Our results indicate that grass parks and park blocks are more desirable than landscape parks and neighbourhood parks in Stockholm. Our findings also confirm that parks in Stockholm's city centre have a greater impact than parks on the periphery of Stockholm. Low-crime parks affect apartment prices positively.

KEY WORDS: Parks, crime, hedonic prices, distance to park

Introduction

During the past few decades, urbanization has posed some major challenges for cities around the world, with one challenge being a great demand for safe parks and open spaces. Although some studies have shown a positive effect of park proximity on house price values (Anderson and West 2006; Morancho 2003; Troy and Grove 2008), other studies have shown that parks can often depress property prices (Groff and McCord 2011; Jim and Chen 2010; Kou and Sullivan 2001). A small number of studies have also shown that house buyers avoid properties located near parks and open spaces with high crime rates (Troy and Grove 2008; Iqbal and Ceccato 2015). In addition, studies have been conducted on other factors (disamenities) such as air pollution (Harrison & Rubinfeld 1978), traffic noise (Wilhelmsson 2000) and traffic congestion (Li & Brown, 1980) that may contribute to pulling house prices down.

Although concern about safety issues in parks is growing, a gap remains in the literature on the effect of crime in parks on house prices. Instead, much of the attention has been recently devoted to questions concerning the impact of park proximity. The fact that these questions have been primarily raised by American researchers highlights a great gap in European and Scandinavian research (Iqbal and Ceccato 2015). To address this gap, Iqbal and Ceccato (2015) recently analysed all sales of apartments in Stockholm city for 2008 so as to assess whether the effect of proximity to park and open green spaces on apartment value is conditional upon neighbourhood crime level. They also discussed how different types of parks affect apartment prices differently.

The aim of this study is to contribute to the literature on the impact of crime on housing prices in the Scandinavian context. Specifically, this study investigates the effect of the amenity value of accessibility to parks and open green spaces on apartment prices with reference to crime rates. Whilst controlling for property and other location attributes, this study relies on geographic information systems (GIS) to measure accessibility in the form of the shortest distance from a park to apartments in Stockholm. This study adopts two innovative approaches. One approach involves employing the location attribute by using the shortest distance to a park as a main variable. The shortest distance to a park variable is considered a better choice than using park as an aggregate measure (Iqbal and Ceccato 2015). A second approach involves investigating the effect of park types on housing prices. Our main hypothesis suggests that parks as an environmental amenity have a substantial impact on apartment prices in close proximity, but this impact varies with specific park types, for instance, grass parks (GPs), neighbourhood parks (NPs), landscape parks (LPs) and park blocks (PBs). To the best of our knowledge, these specific park types have not been previously used for Stockholm.

The remainder of this article is organized as follows: a review of the recent literature is given in section Earlier studies. The methodology used is outlined in section Method. Descriptions of the area of study and the data are presented in section Area of Study and Data. The results of the study are presented in section Results and Discussion. The study concludes with some final thoughts about how our findings contribute to current research in section.

Earlier studies

Several empirical studies have sought to estimate the effects of proximity to neighbourhood parks and crime in parks on house prices. Table 1 summarizes the results of recent studies (selected between 2001 and 2015) that have considered the association between the location of parks and house prices (there are also a few examples in relation to crimes). A closer look at the previously published studies reveals that the effects of park proximity on house prices yield inconsistent results. In Table 1, most of the studies found a positive link between house price and accessibility to parks, but some reported mixed results.

Espey and Owusu-Edusei (2001) found that in Greenville, South Carolina, attractive small parks have a significant positive effect on house prices within a 600-foot radius of the related park but that “not particularly attractive parks” (with playgrounds and some grassy areas) affect house prices negatively within a 300-foot radius of the related park. Kong, Yin, and Nakagoshi (2007) pointed out that proximity to scenery has a positive amenity impact at the 5% significance level; however, the size–distance of the park and the size–distance of the plaza were not significant even at the 10% significance level.

In their investigation of the external effects of neighbourhood parks and landscape elements on the value of high-rise private residential units in Hong Kong, Jim and Chen (2010) found that neighbourhood parks are highly valued and that people are willing to pay more to have a harbour view than a mountain view. In addition, they found a street view to be negatively associated with sales price. A study by Anderson and West (2006) on the effect of proximity to open space on sales prices in the Minneapolis–St. Paul metropolitan area involved several types of open space, including golf courses, cemeteries and neighbourhood parks. Their findings suggested that house location and neighbourhood characteristics affect sales prices; for instance, the value of proximity to neighbourhood parks is higher in neighbourhoods with more children. Moreover, proximity to neighbourhood parks, special parks and golf courses increases the sales price of an average house. They also found that proximity to parks may buffer against the negative effects of high crime rates on sales prices.

The association between parks, open spaces and crime has been discussed by many researchers. Groff and McCord (2011) found that urban parks are strongly associated with an increase in crime in parks and adjacent communities. However, research has also revealed the presence of accessible, safe parks to be an essential ingredient to a healthy community life (Hillborn 2009). One challenging aspect of public open spaces and parks as a public good is that nobody is in charge of these publically owned spaces (Groff and McCord 2011; Iqbal and Ceccato 2016). Based on their examination of neighbourhood parks in urban areas, Groff and McCord (2011) suggested that crime is not distributed evenly across parks within an urban area and that neighbourhood park “environs” (an area within 50 feet of the park) play an important role in whether a certain park is considered a crime generator. In addition, they observed that some park environs have many crimes, whereas others have few or none. They also found that where parks are concerned, mixed land use reduces crime. Larger parks that generate more activities in parks have lower crime levels, which in turn are connected to greater numbers of people using these parks (Groff and McCord 2011).

Poorly designed places can create opportunities for criminal activity or criminal behaviour. Parks showing signs of physical deterioration – for instance, unmaintained places, graffiti and litter – might be considered a type of disamenity by nearby residents (Wilson and Kelling 1982). The absence of capable guardians might result in a situational opportunity for motivated offenders (Cohen and Felson 1979). Michael, Hull, and Zahm (2001) reported that offenders can use parks as sites for selecting targets and for disposing stolen goods. In their direct examination of the relationship between crime in parks and property values in the Baltimore housing market, Troy and Grove (2008) found that neighbourhood crime levels affect housing prices negatively. Their findings suggest that park proximity is positively valued in the Baltimore housing market, whereas robbery and rape rates influence house prices negatively. They also found that a 1% increase in distance from a park decreases house prices in Baltimore by 2.2%. In the Swedish context, Iqbal and Ceccato (2015) found a positive relationship between apartment prices and parks and a negative relationship between

Table 1. A summary of location of parks, crime and house price value

Reference	Study area	Dependent Variable	Independent Variable	Method/scale	Result +/−	Selected Results
Espey and Owusu-Edusei (2001)	USA	House price value	Proximity to park, house structure	Hedonic modelling/24 parks in a city	+	Evidence of positive effect on apartment prices.
Morancho (2003)	Spain	House price value	Proximity to green urban area, house structure	Hedonic modelling	+	Inverse relationship between the selling price and distance from an urban green area. Park size is the most important variable.
Dehring and Dunse (2006)	Scotland	House price value	Proximity to park, house structure, neighbourhood data	Hedonic modelling/5 city parks within 800 m	+	Apartment prices increase near a park; no evidence of lower density housing.
Anderson and West (2006)	USA	House price value	Home structure, amenity size/distance, neighbourhood data, crime data	Hedonic modelling/parks in twin cities of Minneapolis and St. Paul	+/−	Positive evidence in dense neighbourhoods, near central business district, high income or home to many children. Proximity to parks buffers against the negative effects of high crime rates on sales prices.
Kong, Yin, and Nakagoshi (2007)	China	House price value	Proximity, neighbourhood data, house structure, landscape metrics	Hedonic price model/city level	+	Positive evidence at 5% significance level; 1.9% increase in house price was measured at 1% increase in the education environment.
Cho, Poudyal, and Roberts (2008)	USA	House price value	House structure data, accessibility and neighbourhood data	Two-stage model/city level	+/−	Positive evidence from larger forest blocks in the city centre.
Troy and Grove (2008)	USA	House price value	House structure, park proximity and crime rates	Hedonic modelling, Box–Cox method/city level	+/−	Negative evidence of park proximity; if crime levels in parks are above the national average, park proximity is positively valued.
Jim and Chen (2010)	Hong Kong	House price value	House structure, location and neighbourhood data	Hedonic modelling/18 private districts	+	Neighbourhood parks increase house prices by 16.88%: 14.93% for availability and 1.95% for view of a park.
Saphores and Li (2012)	USA	House price value	House structure, crime data, value of urban trees, irrigated grass and non-irrigated grass	Geographically weighted model and Cliff–Ord model	+/−	Lawns are more in demand: 88% properties gain more value with additional grass, whereas non-irrigated parcels and additional trees decrease property values. Trees are more valuable in higher crime areas.
Iqbal and Ceccato (2015)	Sweden	House price value	House structure, location and neighbourhood data, park data and crime data	Hedonic modelling, buffer analysis/city level	+/−	10% decrease within 100 m of a neighbourhood park and 18% decrease within 150 m. Impact of parks varies with park characteristics. High rates of violence and vandalism tend to decrease apartment prices.

apartment prices and crime in parks and crimes in adjacent areas. Their initial results from a buffer analysis of around 40 parks in Stockholm suggested that apartments near parks are highly valued by people in Stockholm. They detected a 10% decrease in the average price within 100 metres of a neighbourhood park and an 18% decrease within 150 metres. They also pointed out that types of parks do affect apartment prices differently. Playgrounds and schoolyards are considered a valuable amenity by residents; however, a lack of maintenance makes large natural area parks a disamenity. When it comes to crimes, parks with high violence and vandalism rates tend to decrease apartment prices – especially on the periphery of Stockholm, whereas apartments in the centre of Stockholm tend to have higher prices (Iqbal and Ceccato 2015).

Method

Hedonic modelling is the most common method used for evaluating house prices in this study. Hedonic modelling can be explained as a relationship between dependent and independent variables (Rosen 1974). No strong agreement exists as to the correct number of independent variables to include in a hedonic regression analysis (Malpezzi 2002). There is large number of potential housing characteristics available that could be included as independent variables. Researchers have suggested that a homeowner not only buys a property but also considers its locational characteristics, such as housing structure, neighbourhood and environmental characteristics (Wilhelmsson, 2000, Kong, Yin, and Nakagoshi, 2007, Wilhelmsson, 2008 and Ceccato and Wilhelmsson, 2011). A number of statistical models were run to test the relationship between apartment prices, parks and crime rates in parks. The modelling strategy is composed of four steps.

First, by using a non-spatial instrument variable (IV) regression method, accessibility to parks is estimated by calculating the shortest distance to all parks in Stockholm. The shortest distance was calculated with MapInfo Professional 11.0. The distance calculator tool in MapInfo performed this analysis and returned with a list of dummy variables with the distance to parks from the apartments: (1) shortest distance to all parks and open green spaces, (2) distance to the nearest GPs, (3) distance to the nearest NPs, (4) distance to the nearest LPs and (5) distance to the nearest PBs. This procedure is entirely different from that used in a previous study by Iqbal and Ceccato (2015), which focused on all park attributes and all types of parks. In the hedonic price equation distance included as distance and square of distance, that is, a non-linear relationship. Crime rates in parks are estimated using statistics on crime rates in areas where the park is located as a proxy for crime rates in the park. We have defined a binary variable indicating if the park has a crime rate below the average (variable name: low-crime park). The instrument variable approach is used in order to control for endogeneity of crime rates (see Gibbons, 2004, Tita et al, 2006, and Ceccato and Wilhelmsson, 2011). To address the endogeneity bias we have instrumented crime rates with homicide and spatial lagged independent variables because they are highly correlated with crime rate, but not with apartment prices. Homicide rates have earlier been used in Ceccato and Wilhelmsson (2011) and spatial lagged variables have earlier been used in Mandell and Wilhelmsson (2015). First we have regressed crime against all instrument variables and all independent variables in the hedonic model and, later, we have regressed apartment prices against all independent variables and the expected crime rates. The functional form of the hedonic price equation is using a flexible multi-parameter Box-Cox model (see Halvorsen and Pollakowski, 1981) in order to find the best-fitting transformation. It has for example earlier been used in Wilhelmsson (2000). All variance estimates are based on White heteroscedasticity-corrected standard errors.

Second, as the spatial dimension is always present in real estate data, spatial econometric modelling approach is employed because it may create biased and inefficient estimates for the implicit prices. However, uncritical use of spatial econometric may cause problems in the interpretation of individual implicit prices (see Wilhelmsson, 2002) as the imposed spatial structure may be correlated to the included independent variables. A specific-to-general test procedure proposed by Elhorst (2010) and used in Berggren et al (2017) is used. The first step, as discussed, is the estimation of the IV-model. For spatial dependency LM-tests (Anselin, 1988, and Anselin et al, 1996) and Moran’s I. If the LM-tests are significant we estimate a Spatial Durbin Model (SDM). If the LM-tests suggest Spatial Error Model (SEM) as the best spatial model, log likelihood ratio test and AIC/BIC will be used in order to test SDM against SEM. Moreover, AIC/BIC is used in order to select spatial weight matrix (see Elhorst 2010). The choice of spatial weight matrix is somewhat arbitrary. Four different spatial weight matrixes namely inverse distance, inverse square distance, binary with a cut-off of 2000 meters and five nearest neighbours will be used.

Third step is to test for spatial parameter heterogeneity. The existence of park in the neighbourhood is hypothesized to be different in the inner-city and in the suburbs. In the city centre open spaces are rare and in the suburbs open spaces are more frequent. It is reasonable to assume that the implicit price concerning accessibility to parks and accessibility to low-crime parks are different in the inner-city and in the suburbs. This hypothesis is tested by estimating a spatial IV-model by including interaction variables between accessibility to parks and crime rates to a binary variable indicating if the apartment is located in the inner-city or in the suburbs. Inner-city is defined as within 4600 meters from CBD.

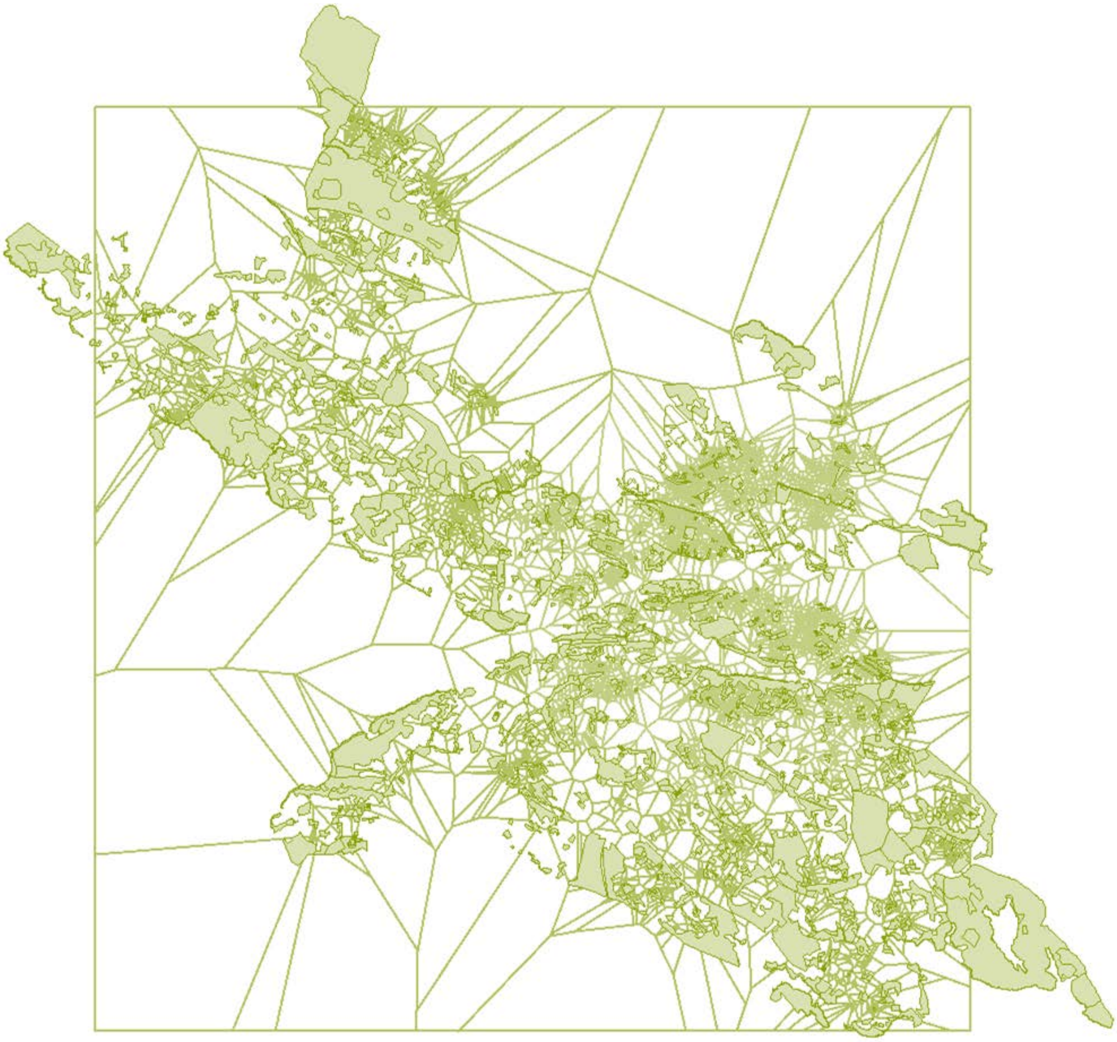
Fourth Step, accessibility to four specific park types (GPs, NPs, LPs and PBs) was modelled through the shortest distance to these four types of parks. The shortest distance to the nearest park allows the calculation of the distance between points in two different data sets.

Area of Study and Data

Stockholm is experiencing a dramatic population growth, and the population is predicted to be about 933,961 inhabitants by the year 2016, an increase of 69,637 inhabitants from 864,324 inhabitants in year 2011 (SCB 2013). Growth in the city of Stockholm is always challenging because of the resulting increased demand for housing/apartments; a national objective is to build 250,000 new homes by the year 2020 (Kaplan 2015). Apartments in Stockholm typically refer to rented and owned units within a multi-unit building. A large part of Stockholm’s inner city area is composed of blocks of apartments, mostly private or cooperative housing flats, facing the water or parks (Ceccato and Wilhelmsson 2011).

The city of Stockholm consists of a total of 1046 green spaces and parks, which are classified into three major categories (City of Stockholm 2006). A majority of the parks are mainly categorized into one of three groups: local parks (0.5–5 hectares; 19% of neighbourhood parks and 18% of playgrounds), city district parks (5–50 hectares; 4% of square parks, beach parks and allotment gardens; 1% of harbour parks, hilly parks, inner-city parks and cemeteries) and natural area parks and recreation areas (>50 hectares; 19% of large natural area parks and forests). (For more information, see City of Stockholm [2006]). Four specific park types – GPs, NPs, LPs and PBs – were considered as they are the most commonly distributed park types in Stockholm (for more information, see City of Stockholm [2006]). The park and open spaces in Stockholm are shown in Figure 1. In accordance with previous research by Iqbal and Ceccato (2015), several house structure and neighbourhood locational attributes were used for the year 2008. Most of the neighbourhood-level data, including park and neighbourhood locational attributes, were provided by the Stockholm City Planning Administration; the sales transaction data were provided by Valueguard Technology AB. Crime data in this study were collected from Stockholm Police Department (Police Statistics 2008). The unit of analysis is 8,305 apartment sales (x and y coordinates), and parks and crime rates are considered part of the area context (polygons). Stockholm Police provided data for crimes that occurred in small unit areas known as basområde (the smallest geographical unit for statistical data in Sweden). The municipality of Stockholm is divided into 408 units (for more detail, see Ceccato & Wilhelmsson, 2011).

Figure 1. Parks and open spaces in Stockholm in relation with the polygons



We encountered some challenges and limitations whilst conducting research for this article. First, only those crime incidents that happen in parks were used. This means that it is difficult to determine the location of a crime that happened in a large park covering several square kilometres. This problem has been previously mentioned by many researchers (see Chainey and Ratcliffe 2005). In this situation, it is better to relate certain localities or points of reference (e.g. playground, football field in the park). Second, crime rates were calculated by selecting the total resident population as a denominator, which is, unfortunately, not an appropriate indicator and may cause bias (Wikström 1991). Researchers have also suggested that the lack of demographic data and land use data used to create the ratios often limits crime analysis over time (Ceccato & Wilhelmsson, 2011). The total number of users in each park might be considered a good indicator (Iqbal and Ceccato 2015), but such data were not available.

Appendix 1, presents the descriptive statistics concerning apartment price, apartment attributes, neighbourhood characteristics and measures of parks and crime. On average, an apartment in Stockholm was sold for SEK 2.4 million. The standard deviation from the mean is relatively high. The mean size of living area is as small as 63 square meters, the standard deviation was about 26 square meters and the average number of rooms was about 2.4. The average age is about 53 years old, that the houses were built in the 1950's. The monthly fee that the owner has to pay to the co-operative is about SEK 3200 with a standard deviation of SEK 1300. Around 20 percent of the apartments were located on the ground floor and the average floor level was about 2.5. Almost 60 % of the apartments have access to elevator and around 10 percent have a balcony. The neighbourhood characteristics consists of a number of binary variables indicating if the apartment is located in a buffer zone from subway stations, train station, motor way, main street and water. Almost 10 percent of the apartments are located with 10 meters from a subway station and almost 70 percent are located with 50 meters from a subway station. Only 1 percent of the apartments are with 100 meters from a train station or a motorway. On the other hand, more than half of the apartments are within 300 meters from a main street. Approximately 10 percent have access to water within 100 meters. As a complement to the binary variables we are also using distance to central business district (CBD). The average distance to CBD is 4600 meters with a standard deviation of 3200 meters.

Results and Discussion

In all statistical models, apartment price was used as the dependent variable that is influenced by the independent variables – that is, attributes related to the apartment structure, neighbourhood characteristics, different types of parks and crimes in parks. All these variables are tested in separate models. The results presented in Table 2 demonstrate the non-spatial instrument variable regression model. Two different models have been estimated. The first model relates apartment prices with apartment attributes, neighbourhood characterises and shortest distance to a park and burglary rates. In the second model another variable low-crime rates also included. The *t* statistics and the coefficients of each significant variable are included in Table 2. The *R*-squared value indicates 80% of the variation in apartment prices in the whole of Stockholm.

Table 2. Non-spatial Instrument Variable Regression (IV)

	Model 1 Coefficient	t-value	Model 2 coefficient	t-value
Apartment attributes				
Living area	5877.369	58.62	5869.019	58.93
Monthly fee	-4911.012	-24.12	-4891.927	-24.18
Rooms	-253.561	-2.71	-353.080	-2.75
Floor	651.069	9.14	651.308	9.14
Ground floor	1019.861	4.20	-293.153	-3.20
Elevator	22.116	0.26	49.229	0.59
Balcony	-373.004	-3.80	-365.93	-3.73
Age group:				
Before 1900	1711.418	6.91	1660.005	6.66
1900-1930	1388.762	10.71	1332.362	10.32
1930-1945	-422.466	-3.29	-407.221	-3.18
1945-1965	-2596.035	-14.60	-2589.219	-14.58
1965-1993	-1980.011	-11.38	-1984.603	-11.44
New	1019.861	4.20	1006.727	4.20
Neighbourhood attributes				
Subway 10 meter	-329.937	-2.35	-288.330	-2.05
Subway 30 meter	-59.130	-0.64	1.823	0.02
Subway 50 meter	597.152	5.68	615.585	5.89
Train 100 meter	-1641.429	-4.73	-1503.274	-4.25
Motorway 100 meter	-837.786	-3.14	-912.193	-3.44
Main street 100 meter	213.088	2.14	224.132	2.25
Main street 200 meter	231.474	2.59	244.713	2.75
Water 100 meter	1485.461	11.51	1425.38	11.10
Distance CBD	231596.2	10.66	234377.7	10.91
Distance CBD Square	-111126.7	-10.89	-112452.5	-11.14
Park and crime				
Distance Park	12345.420	3.79	19773.06	5.58
Distance Park Square	-6297.318	-3.78	-10001.89	-5.53
Low-crime park	-	-	774.883	7.15
Burglary rate	-666.114	-11.16	-660.980	-11.10
Constant	-2835.472	-0.52	-4236.146	0.79
No. of observations		8 305		8 305
Breusch-Pagan test (p-value)		0.000		0.000
R^2		0.8079		0.8091
AIC		158 067		158 305
BIC		157 989		158 263

Note: White heteroscedasticity robust variance estimates. Fixed time effects are included in the hedonic price model. Box-Cox transformation of all continuous variables.

All estimated parameters regarding apartment attributes are statically significant except for elevator. It is only the coefficient concerning balcony that have an unexpected sign. As expected, apartment price is directly associated with the year of construction, the number of rooms and the living area, and is inversely related to the age of the building. The proximity to water has a positive and highly significant effect on apartment prices. These results are consistent with a previous study by Jim and Chen (2010) where waterfront view is valued more than Mountain View. Moreover, the proximity to commuting subway stations has no significant effect on apartment prices in the 30-metre range. However in the 50 meter range it has a positive effect on apartment prices. The distance to the city centre seems to have a negative effect on apartment prices, which was expected according to the theory and previous empirical studies (Iqbal and Ceccato, 2015; Ceccato and Whilhelmsson, 2011). In corroboration with some of the findings of a previous study by Iqbal and Ceccato (2015), the present analysis indicates that the impact of proximity to a park on apartment prices is positive. Park proximity variables (shortest distance to all parks and open green spaces) have a positive relationship with apartment prices (at a 5% significance level) for the whole of Stockholm. These findings are consistent with earlier conclusions that residents prefer living near to parks and open green space (Iqbal and Ceccato, 2015; Ceccato and Whilhelmsson, 2011; Saphores and Li, 2012; Jim and Chen, 2010, Troy & Grove, 2008). The overall burglary rates have a negative impact on apartment prices. The results presented in model 2 suggest that low-crime park has a positive effect on apartment prices. That is, the households have a willingness to pay for the proximity of a park or open space but even more if it is a low crime rate park. These findings are consistent with the previous findings by Troy and Grove (2008) where crime is considered as an important factor when differentiating parks as amenities or disamenities.

Table 3. Spatial Diagnostic (p-value)

Test	Weight matrix: Inverse distance	Inverse square distance	Binary	Five nearest neighbours
Spatial error				
Moran's I	0.000	0.000	0.000	0.000
Lagrange multiplier	0.000	0.000	0.000	0.000
Robust Lagrange Multiplier	0.000	0.000	0.000	0.000
Spatial lag				
Lagrange multiplier	0.000	0.000	0.000	0.000
Robust Lagrange Multiplier	0.419	0.004	0.000	0.000
AIC	147079	153566	155134	155035
BIC	147634	154106	155682	150590

Table 3 shows the results of the diagnostic tests for spatial dependency in IV-regression. All-LM-tests are significant which suggest the presence of spatial dependence. Moreover, the diagnostic tests are in favour of the spatial error model as the LM-tests concerning the spatial error model have a higher value than the value concerning the spatial lag model. Finally, the results indicate (lowest AIC/BIC value) that the inverse distance describes the spatial structure best and hence that is the spatial weight matrix we are going to use.

Table 4 Spatial Durbin Model and Spatial Error Model (spatial weight matrix: inverse distance)

	SDM				SEM	
	Coeff.	t-value	WXcoeff.	t-value	Coeff.	t-value
Apartment attributes						
Living area	5411.451	67.80	-5153.129	-43.95	5511.081	81.87
Monthly fee	-3790.289	-18.81	3486.135	11.75	-4006.966	-22.74
Rooms	-377.087	-2.72	389.177	2.03	-381.768	-3.40
Floor	541.991	9.36	-466.226	-5.34	574.594	10.96
Ground floor	-249.500	-2.88	280.783		-240.039	-3.20
Balcony	-26.511	-0.23	-65.286	-0.23	-122.150	-1.18
Elevator	-164.362	-1.78	220.582	-1.78	-89.392	-1.08
Age group:						
Before 1900	924.686	4.25	-691.965	-1.94	1173.635	6.41
1900-1930	712.861	5.90	-631.399	-3.53	867.424	8.19
1930-1945	-91.409	-0.72	22.182	0.12	-138.126	-1.22
1945-1965	-1493.591	-9.02	1269.771	5.50	-1648.229	-11.10
1965-1993	-1782.638	-9.04	1590.014	6.16	-1841.367	-10.20
New	1772.488	5.08	-2083.355	-4.17	1513.781	5.05
Neighbourhood attributes						
Subway 10 meter	236.208	-2.35	-369.590	-1.67	145.406	1.13
Subway 30 meter	331.991	-0.64	-384.797	-2.44	270.220	2.91
Subway 50 meter	-339.896	5.68	664.887	3.91	-89.828	-0.85
Train 100 meter	572.832	-4.73	-1130.496	-1.49	116.444	0.28
Motorway 100 meter	-969.662	-3.14	917.709	1.14	-977.756	-2.19
Main street 100 meter	-153.970	2.14	204.695	1.29	-121.367	-1.32
Main street 200 meter	-290.596	2.59	442.751	3.02	-132.866	-1.42
Water 100 meter	800.814	11.51	-591.702	-2.85	967.953	8.24
Distance CBD	177732.100	10.66	-180176.80	-5.68	192071.1	10.87
Distance CBD Square	-85338.020	-10.89	86463.24	5.79	-92228.9	-11.04
Park and crime						
Distance Park	-65.176	-0.19	5862.674	1.12	4183.427	1.34
Distance Park Square	39.057	-0.02	-2976.575	-1.11	-2117.161	-1.32
Low-crime park	-19.57	-0.19	255.06	1.62	164.951	1.77
Burglary rate	-43.023	-0.68	-115.858	-1.29	-178.798	-3.19
rho	0.973	229.04			-	
lambda	-				0.982	261.75
Constant	2033.685	0.72			-6911.62	-1.84
No. of observations	8305				8305	
AIC	147079.3				147161.7	
BIC	147634.2				147449.7	
Likelihood-ratio test	-				0.000	

The next step is to estimate the SDM model with inverse distance as spatial weight matrix. The SDM will be compared to the SEM model. Both models are presented in Table 4. What conclusions can be drawn from the SDM and SEM estimations? First, spatial dependence is present as both rho and lambda are highly significant different from zero. Second, all estimated parameters concerning apartment attributes and neighbourhood characteristics have the same sign and magnitude as in the IV-model. Third, the SDM model estimate both direct effects and indirect effects which make it harder to interpret the results.

Figure 2 Park effect on apartment prices

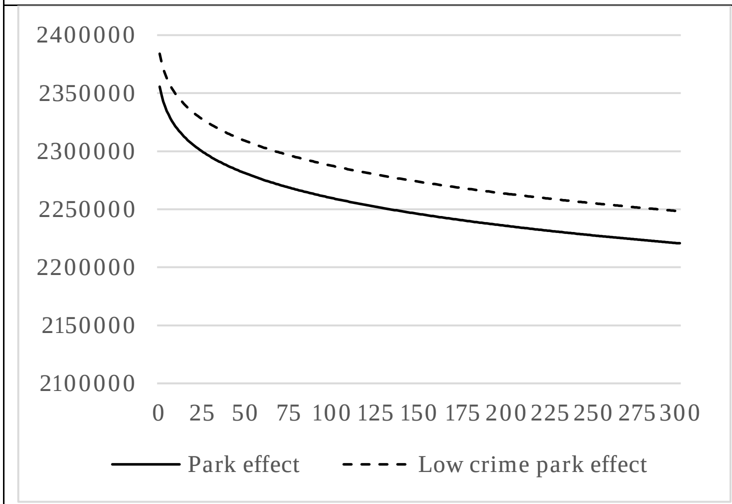
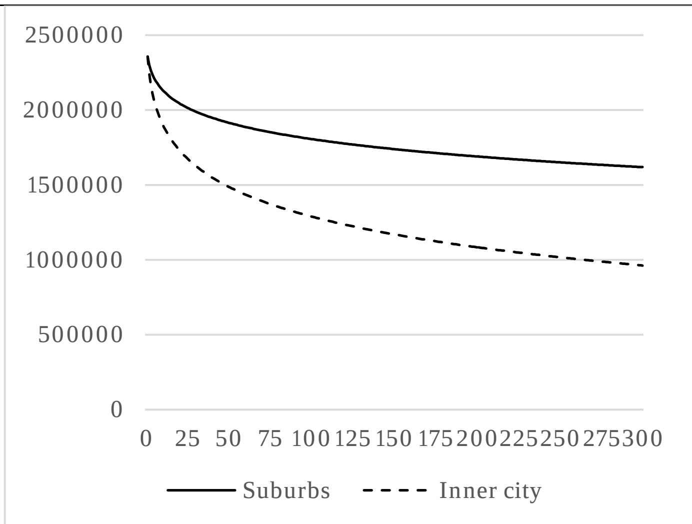


Figure 3 Park effect on apartment prices in inner city versus suburbs



However, the results suggest that the effects of parks seem to be smaller than in the IV-model and corresponding t-values are lower. An F-test concerning if all estimated parameters concerning parks and low-crime parks shows that they are jointly significant different from zero. Fourth, the tests concerning if SEM can be used instead of SDM is inconclusive. The likelihood ratio test and AIC suggest that SDM is preferred but then the BIC suggest that SEM can be used. As the interpretation is easier in the SEM specification than in the SDM-specification, SEM is going to be used in the rest of the paper.

As all variables have been Box-Cox transformed it is not obvious how to interpret the coefficients. Therefore, the park effect on apartment prices has been calculated (see Figure 2). On the vertical axis is apartment price presented and on the horizontal axis is distance to CBD presented. As shown, the expected price of the standardized apartment declines with the distance from the park. The effect is larger for low-crime parks. The spill over effect from parks is narrow as the price effect declines rapidly in the range 0-50 meters. After 50 meters the decline is much slower. These findings are in line with those reported in a study by Troy and Grove (2008) and Anderson and West (2001). They found out that value of open space varied with the distance increase from the house. Open spaces in relatively low crime areas considered as amenity. As discussed earlier, there is no reason why the implicit price of parks and low-crime parks are the same in inner-city and in the suburbs. As a test of this hypothesis, we have estimated a SEM including interaction variables between parks and crime with binary variable indicating inner-city locations. The result from estimation is shown in table 5 and in figure 3.

Table 5. Parameter heterogeneity (inner-city and suburbs)

	SEM Coeff.	t-value
Park and crime		
Distance Park	18396.760	2.87
Distance Park Square	-9405.459	-2.86
Low-crime park	513.443	3.11
Burglary rate	-130.140	-1.69
Inner-Distance Park	-17896.300	-2.43
Inner-Distance Park Square	9175.665	2.44
Inner-Low-crime park	-496.908	-2.52
Inner-Burglary rate	-82.808	-1.07
lambda	0.982	261.77
Constant	-7028.814	-1.72
No. of observations	8305	
AIC	148072.3	
BIC	148388.5	

Note: t-values within brackets. Fixed time effects and apartment and neighbourhood attributes are included in the hedonic price model. Box-Cox transformation of all continuous variables.

Our findings show that the effect of park proximity on apartment prices is strongly related to the distance of parks. The impact of parks on apartment prices is different in the different segments of the apartment market in Stockholm. These findings support with previously published results (Iqbal and Ceccato 2015). They found that apartments located close to parks near/within the city centre have a higher selling price than apartments located close to parks on the periphery of Stockholm. They also point out that high crime rates lead to decreased apartment prices, thus attracting people with weak resources. The result seems to suggest that the impact of parks is higher in the inner-city but the impact of low-crime parks seems to be lower in the inner-city. One reason could be that many of the parks in the inner-city have a higher crime rates than the parks in the suburbs, that is, it could be difficult to distinguish the effect of inner-city versus low-crime parks. Moreover, the results suggest that the effect of burglaries is higher in the inner-city than in the suburbs. However the estimate is not statistically significant. Visualized, the park effect on apartment prices in inner-city and suburbs are presented in Figure 3. It is clear that the impact of parks in the suburbs is much narrower than in the inner-city. The decline in price is very steep in the range 0-25 meters in the suburbs while in the inner-city the decline is steeper in the range 0-50 meters. The magnitude in the decline is also more evident in the inner-city. In order to test the effect of different park types effects on apartment prices four different models were tested, one for each type of parks. The results are presented in table 6 and figure 4.

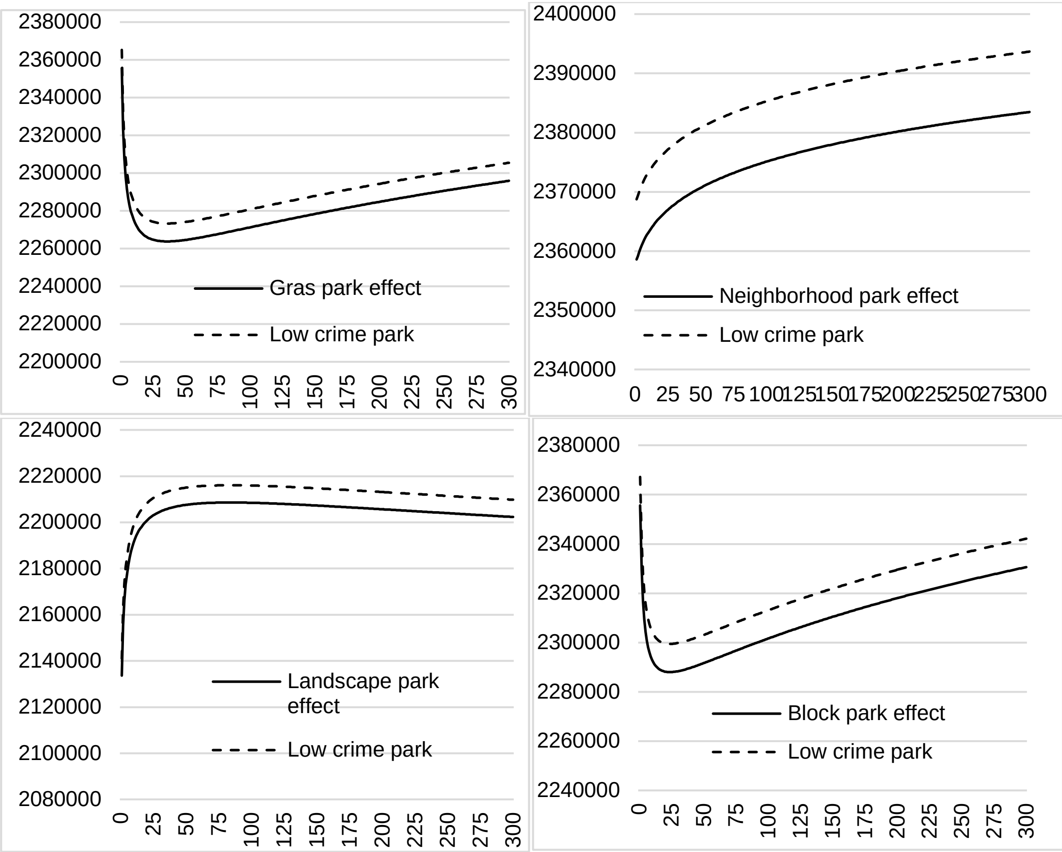
Table 6. Spatial Error Model (different types of parks)

	SEM Coeff.	t-value
Grass park		
Distance Park	-132165.1	-2.33
Distance Park Square	65939.3	2.33
Low-crime park	53.5	0.79
Burglary rate	-192.2	-3.41
Neighbourhood park		
Distance Park	7816.6	0.38
Distance Park Square	-3907.2	-0.37
Low-crime park	65.9	0.83
Burglary rate	-228.8	-3.44
Landscape park		
Distance Park	31727.9	1.68
Distance Park Square	-15754.1	-1.68
Low-crime park	48.0	0.62
Burglary rate	-229.1	-3.58
Block park		
Distance Park	-20027.7	-3.07
Distance Park Square	9907.1	3.06
Low-crime park	57.5	0.95
Burglary rate	-152.1	-3.04

Note: t-values within brackets. Fixed time effects and apartment and neighbourhood attributes are included in the hedonic price model. Box-Cox transformation of all continuous variables.

Our results also confirm that specific types of parks have varied effects on apartment prices in Stockholm. The results of this study indicate support for the claim that GPs and PBs may be thought of as places that can improve the quality of life and overall well-being (figure 4). Some possible reasons could be that these types of parks consist mainly of green space and have no major activities as they are not in extensive use and may be considered an amenity by inhabitants of Stockholm. The results for LPs and NPs can be associated with the large area size and the issue of poor maintenance (Iqbal and Ceccato 2016) and extensive use of parks (Schroeder 1982). In other words, extensive use of parks may decrease the amenity value of being closer to such types of parks. Schroeder (1982) indicated that naturalness, upkeep and absence of crowds are important features associated with high-quality parks and recreation sites.

Figure 4. Park effect of apartments prices (different types of parks)



Conclusions

In this paper, we used the hedonic modelling approach to analyse the amenity value of proximity to parks and open green spaces so as to test the relationship between apartment prices and the proximity to parks and green spaces in Stockholm, Sweden. Spatial data analysis was used as an input into the hedonic models. Although the methodology used in this work is different, the results are in line with some of the previously reported empirical results and confirm that the proximity of parks as an environmental amenity has an effect on apartment prices (Iqbal and Ceccato 2015). Our results also demonstrate that the impact of parks on apartment prices is different in the different segments of the apartment market in

Stockholm. Moreover, various types of parks may differ in their impact, for instance, GPs and PBs are more desirable in Stockholm than LPs and NPs. The effects of crimes in parks influence apartment prices negatively. Thus, parks with crimes are not attractive to future buyers (McCormack et al. 2010).

Our findings suggest that buyers in Stockholm may be willing to pay an extra amount of money for an apartment that is near a park, but there might be some other issues related to poor maintenance or criminogenic conditions of the park. Based on the existing literature, this study proposes that not all parks have equal amenity value: some may be negatively valued, and crime in parks as a source of environmental stigma is one of the most likely factors explaining this variability, which is also linked to the distance to the city centre. It is also worth mentioning that crimes in parks have a considerable influence on apartment prices and that the distance from a park to apartments is used to calculate this effect. This study also concludes that crime in parks must be considered in perspective with crimes in the neighbouring areas because any park with high crime rates is usually associated with high crime rates in the surrounding area.

We believe that the results of this study can contribute to current research and provide a comprehensive picture of crime conditions in parks and their impact on housing in Stockholm. We also believe that several attributes including proximity, amenities, maintenance and safety are important for encouraging park use and can help in community organization campaigns. The findings of this study may also be of help to the retail market in Stockholm and to Swedish planning officials by revealing possible ways to improve the conditions in parks for urban safety and for crime prevention. The results of this study can be of interest for homeowners and potential buyers to use this research to decide whether to invest when buying a property near a park. These results may also support police and other expertise in the field and be helpful in deterring crime by engaging people of the area to improve overall urban safety and well-being in Stockholm.

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APPENDIX

Appendix 1	Descriptive statistics		
	Unit	Average	Standard deviation
Apartment price	SEK	2 355 677	1 412 246
Apartment attributes			
Living area	Square meter	63.04	26.49
Monthly fee	SEK	3176.03	1308.30
Rooms	Number	2.37	1.04
Floor	Number	2.45	1.99
Ground floor	Binary	0.20	0.40
Elevator	Binary	0.59	0.49
Balcony	Binary	0.11	0.31
Age	Year	53.15	34.54
New	Binary	0.01	0.11
Neighbourhood attributes			
Subway 10 meter	Binary	0.09	0.29
Subway 30 meter	Binary	0.42	0.49
Subway 50 meter	Binary	0.69	0.46
Train 100 meter	Binary	0.01	0.08
Motorway 100 meter	Binary	0.01	0.09
Main street 100 meter	Binary	0.24	0.43
Main street 300 meter	Binary	0.62	0.48
Water 100 meter	Binary	0.11	0.31
Distance CBD	Meter	4655.45	3238.69
Park and crime			
Distance Park	Meter	81.10	70.00
Distance grass park	Meter	242.76	669.35
Distance neighbourhood park	Meter	329.27	977.75
Distance landscape park	Meter	205.04	456.84
Distance block park	Meter	97.08	180.99
Low-crime park	Binary	0.36	0.48
Burglary rate	Ratio	49.47	29.52
No. of observations		8 305	

Notes

Grass parks are lawn areas that are good for walking, running and sitting. They do not contain anything more than grass and (unfortunately) dog excrement. Grass parks are mostly categorized under city district parks. Their area size varies between 5 and 50 hectares, and they are mostly available within 500 meters (City of Stockholm 2006).

Park blocks are semi-open parks with green oases of lawns and seating places for relaxation. They are sometimes dominated by playgrounds and flowerbeds. They are categorized under local parks. Their area size varies between 0.5 and 5 hectares, and these parks are mostly available within 200 meters (City of Stockholm 2006).

Landscape parks are mostly located in the valleys between the districts in the suburbs. Their intensively farmed landscapes include meadows and pastures, plantations, peaceful grass fields, streams and other bodies of water. These parks are also teeming with playgrounds and sports fields. They are categorized under city district parks. Their area size varies between 5 and 50 hectares, and they are mostly available within 500 meters (City of Stockholm 2006).

Neighborhood parks are smaller parks and are often interspersed throughout the settlement. They often have a single function because of their small size. They also complement the bigger parks, recreation sites, wild nature trails and flower plots. Neighborhood parks are categorized under local parks. Their area size varies between 0.5 and 5 hectares, and they are mostly available within 200 meters (City of Stockholm 2006).