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December 19, 2014

Abstract

Urban Green Space (UGS) such as parks and forests provide a wide range of environmental and recreational benefits. One objective in the conservation efforts of UGS is to analyse the benefits associated with UGS in order to make them more visible and to provide support for landscape planning.

This paper examines the effects of UGS on house prices applying a Hedonic Pricing Method (HPM). The data set contains over 85,046 geo-coded apartment transactions for the years 1995-2012 and contains information on three intrinsic variables of the real estate (e.g. transaction price, floor area and age).

In order to examine the capitalization of UGS in real estate prices we further incorporate cross-section geo-coded data for the different types of UGS: forests, parks, farmland and fallow land drawn from the European Urban Atlas (EUA) of the European Environment Agency for the year 2006. In order to control for additional open space categories we further incorporated geo-coded data on water bodies and fallow land. Using a Geographical Information System (GIS) we calculated the coverage of UGS in pre-defined buffers around households as well as the distance in a continuous fashion (Euclidian distance) between UGS and the households.

Our results show a capitalization of UGS in real estate prices but the effect of the structural variables is higher. We found a positive price effect of parks, forests and water and an inverse relation between the price variable and the presence of fallow land and farmland.

Keywords: Urban Green Space (UGS), Open Space, Hedonic Pricing Method (HPM), GIS-Analysis

JEL Classification: R31, C14, Q50

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1. Introduction

Urban Green Space (UGS) such as parks and forests provide a wide range of benefits to the inhabitants of metropolitan areas. For example, UGS significantly affect air quality [Nowak et al. 2002; Nowak 1994: 63-81; McPherson et al. 1998: 215-223], provide recreational and aesthetic benefits [Elsasser 1999: 175-188; Tameko et al. 2011] and contributes to climate protection due to their ability to store carbon [Myeong et al. 2006: 277-282; Rowntree et al. 1991: 269-275; McPherson et al. 1998: 215-223]. Moreover, various studies show the contribution of UGS to mental and physical health by reducing stress and positively influencing mood change [e.g. Abkar et al. 2010; Marcus & Barnes 1999; Ulrich et al. 1991: 201-230]. The presence of UGS can also play a significant role for biodiversity protection by representing habitats for hundreds of species and several UGS are located within globally recognized "biodiversity hotspots" [Sukopp *et al.* 1993; Kuhn et al. 2004: 749-764; Cornelis & Hermy 2004: 385-401].

Since the development of cities puts increasingly pressure on green or open spaces, concerns over the preservation of UGS have been growing in recent years. However, from an economic point of view, most of the UGS are public goods, hence, the provision of UGS is often subject to market failures [Choumert 2010: 1123-1131]. As a consequence, the lack of market prices prevents UGS from being properly considered in policy and planning. One objective in the conservation efforts of UGS is to analyse the benefits associated with UGS in order to make them more visible and to provide support for urban planning and decision making.

There are two groups of methods applied in order to capture the value of UGS and associated benefits: Stated Preference Methods (SPM) and Revealed Preference Methods (RPM). In studies using SPMs, consumers state their preferences regarding, for example, environmental goods [Rambonilaza & Dachary-Bernard 2007: 318-326; Bateman 1993; Adamowicz et al. 1998: 64-75; Bennett and Blamey 2001]. RPMs, like the Travel Cost Method (TCM) or the Hedonic Pricing Method (HPM), try to infer the value of a non-market good by observing the actual behavior of individuals on related markets [Alriksson and Öberg 2008: 244-257; Alpizar et al. 2003: 83-110; Willis and Garrod 1993: 1-22; Melichar et al. 2009: 13-20; Mahan et al. 2000]. The overall assumption of the HPM concerning the real estate market is that house prices are affected by a bundle of variables and that the price of the dwelling is determined by the particular combination of characteristics [Melichar et al. 2009: 13-20]. Despite intrinsic factors, such as size and age of the house, also the location of the property itself can significantly affect the property price [Kolbe et al. 2012; Morancho 2003: 35-41; Melichar et al. 2009: 13-20; Bolitzer and Netusil 2000: 185-193]. In this regard, a broad literature analyses the effects of UGS and open space on property values by using the HPM [Kitchen and Hendon 1967: 357-360; Weigher and Zerbst 1973: 99-105; Shultz and King 2001: 239-252]. However, the growing availability of GIS-based data provides new opportunities to incorporate more accurate data on environmental qualities to a larger amount in studies using the HPM.

This paper takes advantage of these opportunities and examines the capitalization of UGS in house prices applying a HPM and using GIS-based distances and land cover information for different types of UGS. The data set contains over 85,046 geo-coded apartment transactions for the years 1995 to 2012. Our main data is provided by Colognes Committee of Valuation Experts (GAA, Gutachterausschuss für Grundstücksfragen) from their transaction database. The data set covers transactions of over 85,046 apartments for the years 1995-2012. The data contains information on three intrinsic variables describing the structural characteristics of the real estate (transaction price, floor area and age).

The cross-section geo-coded data on UGS are drawn from the European Urban Atlas (EUA) of the European Environment Agency for the year 2006. In order to analyse the capitalization of UGS we incorporated three different types of UGS in our analysis: parks, forests and farmland. To control for additional open space variables, we also consider the land use categories water and fallow land. Using a Geographical Information System (GIS) we calculated the coverage of UGS in pre-defined buffers around households as well as the Euclidean distance between UGS and the dwellings. In order to control for additional locational variables we further estimate the distance of the observations to the city centre. In this regard, our paper is one of the few applications trying to examine the value of UGS by applying the HPM using geo-referenced data.

This paper is structured as follows: Section 2 focuses on the valuation of UGS with HPM. Section 3 highlights our application of GIS-based data in HPM, explains the data set, the model application and the results. Section 4 discusses the main findings and provides some concluding remarks.

2. The valuation of Urban Green Space with HPM

The overall assumption of the HPM with respect to real estate is that house prices are affected by various variables and it is supposed that the price of the real estate is determined by the particular combination of characteristics it displays [Melichar et al. 2009: 13-20]. In contrast to SPM where the respondents are directly asked about their preferences for hypothetical transformation of the environmental good under valuation, the HPM allows inferring the value of a non-market good by observing the actual behaviour of individuals on related markets [Willis and Garrod 1993: 1-22; Melichar et al. 2009: 13-20; Mahan et al. 2000]. The HPM also holds some limitations relating to problems of information asymmetries, individual perception, subjectivity, continuity, aversion behaviour, market segmentation and the assumption of equilibrium [Vanslembrouck and Van Huylenbroeck 2006]. Taking into account these limitations, the HPM depends according to Bateman [1993] on several assumptions. First, individuals are able to perceive environmental quality changes and these changes affect future net benefit streams of a property and therefore they are willing to pay for environmental quality changes. Second, the entire study area is treated as one competitive market with perfect information regarding house prices and environmental characteristics and third, the housing market is in equilibrium i.e. individuals continually re-evaluate their location such that their purchased house constitutes their utility maximizing choice of property given their income constraint.

Within hedonic pricing models, the price of the real estate P is expressed as a function of the structural variables S (e.g. size of the house, age, number of rooms) and location variables N (e.g. schools, hospitals in the neighbourhood) and variables which describe the environmental quality Z (e.g. air quality, noise level, number of green space) [Bateman, 1993; Morancho 2003: 35-41, Kolbe et al. 2012; Melichar et al. 2009: 13-20; Bolitzer and Netusil 2000: 185-193]:

$$P=f\left(S_1\ldots S_k, N_1\ldots N_m, Z_1\ldots Z_n\right). \qquad (1)$$

Application of the hedonic technique to value environmental amenities has a long tradition [McConnell and Walls 2005]. In this regard a large literature analyses the effects of open space on property values by using the HPM [Lutzenhiser and Netusil 2001: 291-298; Acharya and Bennett 2001: 221-237; Irwin 2002: 465-480; Kitchen and Hendon 1967: 357-360; Weicher and Zerbst 1973: 99-105; Shultz and King 2001: 239-252, Morancho 2003: 35-41; Melichar et al. 2009: 13-20; Benson et al. 1998: 55-73; Bolitzer and Netusil 2000: 185-193].[1]). The capitalization of open space in house prices has been investigated by incorporating various variables. Many studies examine the influence of the size of the nearest open space area on housing prices [Morancho

1 For an overview of HPM studies on open space McConnell and Walls [2005)

2003: 35-41]. Others include the total quantity of surrounding open space areas [Acharya and Bennett 2001: 221-237] or the visibility of open space [Morancho 2003: 35-41; Luttik 2000: 161-167; Benson et al. 1998: 55-73]. Further popular approaches comprise the incorporation of different coverage variables [Cavailhès et al. 2009: 571-590, Mansfield et al. 2002]. In addition to coverage, a common approach is to include distance effects in hedonic studies analysing the impact of open space on house prices [Bolitzer and Netusil 2000: 185-193; Smith et al. 2002: 107-129; Morancho 2003: 35-41]. Many of the available studies prove a capitalization of open space in housing prices but the impact of intrinsic variables such as size and age of the real estate have often a far greater influence on the price function.

Since the effects of environmental variables on housing prices in contrast to intrinsic variables are often very small, the accuracy of the environmental variables used in the hedonic price function plays an important role. In this regard, the growing availability of GIS-based data on environmental quality provides new opportunities to use environmental data in a large amount for HPM-studies. As a result an increasing number of HPM applications using GIS-based data for the valuation of UGS have been recently carried out [e.g. Kong et al. 2007: 240-252; Cavailhès et al. 2009: 571-590; Melichar et al. 2009: 13-20; Choumert 2010: 1123-1131].

3. Application of GIS-based data for HPM

3.1 The data set

Our main data is provided by Colognes Committee of Valuation Experts (GAA, Gutachterausschuss für Grundstücksfragen) from their transaction database. The data set covers transactions of over 85,046 apartments for the years 1995-2012. The data contains information on three intrinsic variables describing the structural characteristics of the real estate (e.g. transaction price, floor area and age). The reported transaction prices are adjusted for the general price trend of apartments within Cologne[2]. As most of the observations lie within large apartment complexes and therefore have the same address and geographical position, the intrinsic variables for these observations are averaged and appear only once in the regression. Averaging over the observations by location yields 9,737 observations in the final data set. Descriptive statistics for the intrinsic variables can be found in the appendix in table 1.

2 The prices are converted into year 2000 Euros using hedonic indices described in Schulz & Werwatz [2011)

In order to investigate the capitalization of UGS in the real estate prices we used the European Urban Atlas (EUA) of the European Environment Agency (EEA) which provides land use and land cover data for European major cities with more than 100.000 inhabitants. For the GIS-analysis we used data on UGS from the EUA including information on the land use classes green urban areas, forest and agricultural land.[3] According to the EUA the class green urban areas contains public green areas for predominantly recreational use such as gardens and parks. Not included in the green urban areas are private gardens within housing areas and cemeteries.[4] The forest-class contains land that has ground coverage of tree canopy of more than 30%, tree height of more than 5 m including bushes and shrubs at the fringe of the forest. Forests within urban areas and/or subject to human pressure are included in class urban green areas. The land use class agricultural land includes all land under agricultural use (e.g. arable land, permanent crops) and semi natural areas and wetlands. In order to control for other land use categories we incorporated geo-coded data from the EUA for the classes' water and fallow land. The land use class water contains among others lakes, rivers and canals. The category "fallow land" contains all land in a transitional position with no actual agricultural or recreational use.

The accuracy of the mapping data differ between the land use categories where the minimum mapping unit of parks (green urban areas) is 0.25ha and 1ha for forest and water. The total amount of land coverage in the city district of Cologne is 40695.05ha including 3197ha of green urban areas, 4860ha of forest, 1834ha of water, 8709ha of agricultural land and 213ha of fallow land.

In order to control for UGS-data in the hedonic price function, we included proximity or the share of green spaces around an observation in our regressions. First we used the distance from the real estate to UGS in a continuous fashion [see Thorsnes 2002: 426-441; Thibodeau and Ostro 1981: 19-30; Weigher and Zerbst 1973: 99-105]. For the estimation of the share of UGS, we defined buffer zones of 500m, 1,000m and 2,000m around the real estate and measured the share of the land use classes urban green areas, forest and water by Geographical Information System (GIS) and ArcGIS (10.2) respectively.

In order to control for other location variables, we also included an additional variable in our analysis which measures the proximity to the city centre of Cologne. The descriptive statistics of

3 For a detailed description of the land use data see the mapping guide of the European Urban Atlas.

4 In the following we refer to green urban areas as parks.

all location variables used in the regression analysis is summarized in table 2. Figure 1 shows the boxplots of prices per square meter for the nine districts of the city of Cologne. There are apparently huge deviations in prices per square meter between all districts. This clearly indicates a huge variation in the other explaining variables. In table 1 the descriptive statistics for the transaction prices and the intrinsic variables (age and floor size) are reported. The average price for an apartment in Cologne is 156,401.1 Euros. A negative age indicates a transactions that occurred before the dwelling was constructed.

Table 2 shows the summary statistics for the locational variables. From all open space categories, the distance to the next park is the shortest, at least on average. Noteworthy is that the average distance for any other category is at least three times bigger. This is in line with the summary statistics for the certain land use categories within a buffer. The share of urban green spaces (e.g. parks) is on average 7.13 percent for the 500 m buffer, the next category is farmland with 4.18 percent.

3.2 The model

Functional forms that have been applied in the literature include among others linear, quadratic, semi-log, log-log and Box-Cox transformation [Appelbaum 1979: 449-458]. The theory underlying the HPM approach does not provide much guidance about which of these functional forms is the most appropriate [McConnell and Walls 2005, Melichar et al. 2009: 13-20]. The functional form is mostly determined empirically by testing different functional forms whereas the model evaluation is mainly based on overall goodness-of-fit [Vanslembrouck and Van Huylenbroeck 2006]. Many researchers prefer to use the so-called semi-log model for various reasons [Malpezzi, 2003]. One reason is that the coefficients of a semi-log model can be interpreted as a percentage change in prices. This serves, of course, the purpose at hand when trying to quantify the monetary effects of our hedonic regression coefficients. Next to these reasons, the semi-log model proved to have a considerable goodness-of-fit in our empirical analysis. According to McConnel and Walls [2005], the omitted variables lead to bias in more coefficients in the more complicated version of the model than they do in the simpler model [McConnel and Walls 2005]. Against this background, we decided to apply the following semi-log model to estimate the implicit prices:

$$p=\beta_0+z'\beta+\varepsilon, \qquad (2)$$

where p is the log transaction price, z is the matrix of independent variables and β and ε are the hedonic regression coefficients and the stochastic error term. In the end, we estimate four regression models, which differ only in the type of variables of interest. First, a model is estimated using the absolute distances to UGS and open space. Second, we run three regressions including the relative shares of all types of UGS or open space, respectively, within a certain buffer (500, 1000, 2000 meters). The intrinsic variables used in this model are the living area (size) and the age of the dwellings. In addition to that, we include district dummies for the city districts of Cologne to have at least a control for locational characteristics other than environmental aspects.

4. Results

Parameter estimations of all the specified models are illustrated in table 3 (see appendix). The implicit prices of the structural and the location variables are illustrated in table 4. The estimations of all structural variables across the models are highly significant and the direction of the influence is in line with our expectations. The signs of the coefficients of the controls are reasonable. We found a positive correlation between the apartment size and the price. Here a one square meter increase of the size of the apartment would lead to an increase in the price variable of 2.51% or 3925.67 €. The age of the apartment has a negative impact on apartment prices. For every year an observation loses -0.22% or -328.44 € of its value.

Among the open space variables the coverage of parks, forests and water positively influences the price variable. For example, a 1% increase of urban parks in a 500m buffer around accommodation would lead to an increase in apartment prices of 0.1% (156.40 €). The presence of water has the highest impact on the price variable and a 1% increase of water would result in positive price changes of 0.16% or 250.24 €. The coverage of fallow land and agricultural land negatively influences the price of the accommodations. According to our findings, a 1% increase of fallow land would result in a 1.46% (2283.46 €) and for farmland in a 0.18% (281.52 €) decrease in apartment prices.

The findings also show a significant price effect of the distance variables. The coefficients (and so the implicit prices) of the intrinsic variables change only slightly, compared to the buffer models. We found an inverse relation between the distance to the nearest water site and park and the location of the apartment, meaning the further away an apartment is situated to water and urban parks the lower the price of the apartment. For example, a one unit (meter) increase in distance to water leads to a decrease in apartment prices of 0.0022% or 3.44 €. The distance to urban parks has the highest impact on the price variable. An increase in distance to the nearest urban park would lead to a fall in apartment prices of 0.0038% or 5.94 €. The distance model also indicates negative preferences of residents for brownfields and farmland. An increase in distance to farmland would result in 0.0062% (9.70 €) and to brownfields in 0.0043% (6.72 €) price change.

Therefore, the implicit prices for most of the other open space variables are in line with the buffer models. The exceptions are the distance to the next forest and the distance to the central business district (CBD). Here, we observe a change in the sign of the coefficients. We found a positive relation between distance to the CBD and the price variable and an inverse relationship between the CBD and the apartment prices in the distance model. The distance to forests is in a positive relation to the price variable meaning the further away an apartment is located to forests the higher is the price of the accommodation. However, the coverage models indicate positive preferences of residents for forests.

5. Concluding Discussion

The HPM analysis shows significant price effects of both structural and open space variables. The influence of the structural variables (age, size) on prices is significantly higher than the influence of open space variables on apartment prices. Taken the age of the apartment and the distance to the nearest water expanse as examples, the influence of the structural variable (344 €) on the price is a hundred times higher than the influence of the open space variable (3.44 €). Among the open space variables, the presence of water and parks positively influence apartment prices. The distance and the coverage models indicate strong preferences of residents for these land use categories. Based on these findings one could conclude that residents not only prefer accommodations which are located close to parks and water but which are surrounded by large amounts of these land use categories. The appreciation for water and parks in our analysis is in line with the findings by other studies [e.g. Morancho 2003: 35-41, Bolitzer and Netusil 2000: 185-193, Lansford and Jones 1995: 341-355]. According to Wu et al. [2004: 19-32] open space is among others associated with recreational opportunities and visual amenities. Therefore, it would be interesting to separate the impact of recreational benefits from visual amenities in the hedonic price function. Since our data set doesn’t contain any information concerning visual relation between the apartment and the nearest open space we couldn’t control for price effects of visual amenities in the price function.

The HPM analysis also proofs negative preferences for brownfields (fallow land) and farmland. Brownfields refer to all land in a transitional position with no actual agricultural or recreational use. As mentioned above we couldn’t control for additional open space amenities (e.g. visual amenities) in the price function. However, the negative impact of brownfields on the price variable in all models also indicates that residents don’t associate brownfields with visual amenities. According to previous studies the impact of farmland on real estate prices depends on the way the land is management. For example, Ready and Abdalla [2005: 314-326] found a negative impact on property values of animal agriculture and Vanslembrouck et al. [2006] shows positive effects of permanent grassland on rental prices. The surrounding areas of Cologne are covered by high shares of fodder crops. According to Vanslembrouck et al. [2005: 17-30] the presence of fodder crops implies the use of farming practices (application of fertilizer and pesticides) that are assumed to negatively influence the environment. Therefore, one explanation for the negative preferences for farmland might result from negative preferences of residents for fodder crops and associated management practices. However, since no geo-coded data are available for different land use practices we couldn’t control for the impact of agricultural management on apartment prices in the hedonic price function.

The results indicate that the impact of parks and water on transaction prices grows with the buffer size. However, the variables of interest are ratios, meaning that the absolute amount of open space also grows with the buffer size. A one percent change of a certain land use type yields around 7854 square meters for a 500 meter buffer respectively 31,416 (1,000 meter buffer) and 125,664 (2,000 meter buffer). Looking at these large absolute numbers reveals that the estimated effects are rather small. The implicit prices for all other open space categories are in line with the buffer models. Against these findings, the buffer model seems to be the more robust model, in terms of possible correlations between other independent variables. Distances to certain land use patterns may inherit some other locational information that does not necessarily correspondent to the characteristics of that land use type. Table 5 shows the correlations between the distance variable for forests and the according ratios. Distances and ratios are negatively correlated but the level of the correlation points out that they are no surrogates (e.g. a relatively short way to the next forest does not invariably mean that the dwelling has a lot of forests within a certain buffer). Here we further observe a change in the sign of the coefficients for the distance to the next forest and the distance to the Central Business District (CBD). An explanation for this change might be the high negative correlation of -0.82 between both variables.

Considering the implicit prices of all open space variables the differences between the distance and the coverage models are relatively high. For example, a one unite increase (meter) in distance to the nearest park would result in a 0.0038% fall in apartment prices. Increasing the coverage of parks by one unit (1%) within a 500m buffer around the accommodation would result in a rise in apartment prices of 0.1% or 156.40 €. Comparing these findings the influence of open space coverage seems to be considerably high.

Our investigation shows the capitalization of UGS variables in housing prices. However, the analysis might also hold some limitations. The house price sample covers transaction for the time 1995-2012 whereas the EUA contains cross section data on land use for the year 2006. The time gap between the house price data and the land use data might lead to measurement errors. Moreover, the EUA contains only spatial objects which exceed a minimum size of 0.25 hectare. Therefore smaller objectives could not be considered in our analysis and also might bias the results of our analysis. We know from stated preference studies that the quality of parks (e.g. infrastructure, path network) has an influence on the way people use UGS and therefore to the attractiveness of the sites. Against this background it is very likely that the incorporation of such data on UGS qualities would improve the explanatory power of our models. Since no additional geo-coded data on UGS quality are available for the city of Cologne we could not control for these data.

The presence of UGS such as parks and forests are often connected with additional environmental qualities. For example, urban parks and forests are often associated with higher air quality and lower noise levels and the presence of water can positively influence the climate of the surrounding areas. Therefore, our estimation of the capitalization of parks and water in house prices might be biased by price effects of additional environmental qualities.

However, by estimating the hedonic pricing model for the housing market of the city of Cologne, we could show that apartment prices are significantly affected by the amount of surrounding open spaces. The presence of parks and water positively influences the price variable and increasing amounts of brownfields and agricultural land has a negative impact on apartment prices. The effect is smaller than for the intrinsic and the control variables, especially, when looking at the district dummies, one has to conclude that other locational characteristics have a far greater effect on the apartment price. Nevertheless, urban planners have to consider urban green spaces, besides their ecological benefits, as a source of utility for the inhabitants of cities. Future research should incorporate further geo-coded data on open space quality in order to provide more specific information on the economic value of urban green for planning and administration.

Acknowledgment

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6. Appendix

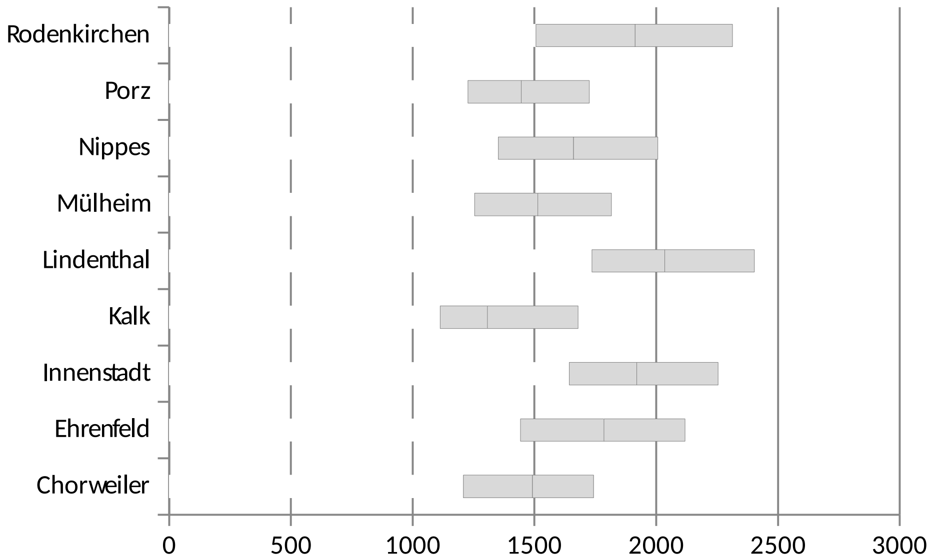

Figure 1: Square meter prices by city districts of Cologne (GAA Cologne 2013; own calculations)

Table 1: Descriptive Statistics for the intrinsic variables and the prices

Variable	Mean	Std. Deviation	Minimum	Maximum
Price (in €)	156,401.1	101026.4	14452.69	1435000
Size (in m²)	81.29	30.53	17.42	490
Age (in years)	41.88	35.14	-2	984

(GAA Cologne 2013; own calculations)

Table 2: Descriptive Statistics for location variables

Variable	Mean	Std. Deviation	Minimum	Maximum
Distances (in meters)				
Parks	300.87	286.05	0	1516.83
Water	988.5	630.86	17.51	3739.8
Forest	1878.86	1185.54	0	4569.95
Farmland	921.17	659.03	0	2680.56
Brownfields	1084.39	636.4	0	2949.21
500 meter Buffer (in percent of buffersize)				
Parks	7.13	8.23	0	61.94
Water	2.71	7.65	0	43.86
Forest	1.57	6.25	0	88.1
Farmland	4.18	9.83	0	99.97
Brownfields	0.004	0.014	0	0.23
1000 meter Buffer (in percent of buffersize)				
Parks	9.23	7.75	0	57.56
Water	4.15	7.06	0	26.24
Forest	2.52	7.31	0	76.9
Farmland	7.23	12.62	0	
Brownfields	0.004	0.009	0	0.17
2000 meter Buffer (in percent of buffersize)				
Parks	10.8	7.6	0	20.2
Water	4.65	4.85	0	
Forest	3.71	8.46	0	66.01
Farmland	9.89	13.77	0	78.02
Brownfields	0.005	0.007	0	0.07

(Urban Atlas 2010; own calculations)

Table 3: Regression results.

	Model			
Variable	Distances	Ratio 500	Ratio 1k	Ratio 2k
Size	0.025***	0.025***	0.024***	0.024***
Size squared	-0.000051***	-0.000051***	-0.000051***	-0.00005***

Age	-0.0022***	-0.0021***	-0.0021***	-0.0021***
Age squared	0.0000031***	0.000003***	0.0000029***	0.0000029***
Innenstadt	0.12***	0.14***	0.13***	0.14***
Rodenkirchen	0.046***	0.0518***	0.048***	0.034**
Lindenthal	0.12***	0.16***	0.17***	0.18***
Ehrenfeld	0.022	0.0464***	0.0556***	0.089***
Chorweiler	-0.19***	-0.11***	-0.11***	-0.11***
Porz	-0.16***	-0.12***	-0.093***	-0.076***
Kalk	-0.17***	-0.17***	-0.14***	-0.064***
Mühlheim	-0.1***	-0.097***	-0.095***	-0.089***
Parks	-0.000043***	0.001***	0.0019***	0.0035***
Brownfields	0.000043***	-0.015***	-0.036***	-0.067***
Forests	0.000021***	0.0014**	0.0028***	0.00344***
Water	-0.000022***	0.0016***	0.0018***	0.0041***
Farmland	0.000062***	-0.0018***	-0.0013***	-0.0014***
Distance CBD	0.000012***	-0.0000055**	-0.000007***	-0.0000062*
Constant	10.04***	10.21***	10.22***	10.19***
N	9737	9737	9737	9737
R^2	0.79	0.78	0.79	0.79

(GAA Cologne 2013; Urban Atlas 2010; own calculations)

Table 4: Implicit prices (given a one unit increase)

	Distances		Ratio 500m	
	% change	Implicit price	% change	Implicit price
Size	2.52	3941.31	2.51	3925.67
Age	-0.22	-344.08	-0.21	-328.44
Parks	-0.0038	-5.94	0.1	156.4
Brownfields	0.0043	6.72	-1.46	-2283.46
Forest	0.0021	3.28	0.14	218.96
Water	-0.0022	-3.44	0.16	250.24
Farmland	0.0062	9.7	-0.18	-281.52
Distance CBD	0.0012	1.88	-0.00055	-0.86

(GAA Cologne 2013; Urban Atlas 2010; own calculations)

Table 4: Implicit prices cont'd

	Ratio 1000m		Ratio 2000m	
	% change	Implicit price	% change	Implicit price
Size	2.4	3753.63	2.4	3753.63
Age	-0.21	-328.44	-0.21	-328.44
Parks	0.19	297.16	0.35	547.4
Brownfields	-3.6	-5630.44	-6.7	-10478.87
Forest	0.28	437.92	0.34	531.76
Water	0.18	281.52	0.41	641.24
Farmland	-0.13	203.32	-0.14	218.96
Distance CBD	-0.0007	1.095	-0.00062	-0.97

(GAA Cologne 2013; Urban Atlas 2010; own calculations)

Table 5: Correlations between location variables for forests

	Distance forest	Distance CBD	Ratio 500m forest	Ratio 1k forest	Ratio 2k forest
Distance forest	1.0				
Distance CBD	-0.82	1.0			
Ratio 500m forest	-0.37	0.37	1.0		
Ratio 1k forest	-0.47	0.46	0.84	1.0	
Ratio 2k forest	-0.52	0.55	0.62	0.87	1.0

(Urban Atlas 2010; own calculations)

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