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Classification and valuation of urban green spaces—A hedonic house price valuation

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HIGHLIGHTS

- We categorize green space into eight different types based on aerial photos and GIS data.
- We find that it is important to distinguish between different types of green space.
- We find that green buffer areas are unattractive in their own right.
- We find a quadratic relationship between implicit prices and green space proximity.

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ABSTRACT

In this paper we propose a categorization of green space into eight different types and quantify their impact on housing prices in the city of Aalborg using the hedonic house price method. The categorization was made manually according to an idealized description of the eight types of green space and a rating system in which each green space was rated according to accessibility, maintenance levels and neighboring negative land-use. The hedonic house price schedule for each of the green spaces was estimated using a generalized additive model, which allows for a data driven adjustment of underlying omitted spatial processes. To our knowledge the use of a spatial generalized additive model is novel to the hedonic valuation literature. We find that types of green space, which are rated highly in terms of accessibility and maintenance level, have high implicit prices whereas types with low ratings are not identified or provide ambiguous results. Green space buffering unattractive land-use such as infrastructure and industry is found to provide negative implicit prices despite controlling for the negative neighboring land-use. Our results clearly indicate that green space is not a uniform environmental amenity but rather a set of distinct goods with very different impacts on the housing price.

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1. Introduction

Provision of green space in a dense urban environment is costly. The rent from alternative land-use for areas allocated to green space is high. At the same time, green space provides a number of valuable direct and indirect services to surrounding parcels. These services span from provision of recreational opportunities to floodways and improved air quality as well as benefits associated with reduced housing density (e.g. more light and reduced noise levels). Green space in cities exists in a broad variety of types spanning from the high maintenance urban park to natural areas and buffer space between noisy infrastructure and other land uses. From such a degree of heterogeneity in the type of green space it follows that the benefits (and costs) generated by different green space provision vary greatly.

The value of green space has been the subject of a good deal of research using the hedonic method and stated preference methods as surveyed in, e.g. McConnells & Walls (2005) and Waltert & Schläpfer (2010). The results are generally mixed with both positive, negative and insignificant effects found for the same types of green space. With the notable exceptions of Anderson & West (2006) and Irwin (2002) much of the existing literature primarily deals with either a few specific types of green space such as nature preserves or agricultural fields (Morancho, 2003; Towe, 2009; Tyrväinen & Miettinen, 2000) or with categorization of green space by size and/or proximity (Abbott & Klaiber, 2010; Jim & Chen, 2006a; Kong, Yin, & Nakagoshi, 2007; Morancho, 2003).

Green space is often treated as a homogeneous good with distinctions in some cases being made with regard to ownership (Cheshire & Sheppard, 1995) or conservation status (Irwin & Bockstael, 2001). As stressed in the survey by Waltert and Schläpfer

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(2010), the measurement and definition of green space in the literature varies substantially, making it difficult to compare results across studies and to use studies for benefit transfers. Different definitions and aggregations of types of green space may be one explanation for the large variation in results discussed in both surveys.

Evidence outside the field of valuation suggests that people perceive and value green space according to the services provided by the green space. Schipperijn et al. (2010) and Kienast, Degenhardt, Weilenmann, Wäger, and Buchecker (2012) find that the frequency of visits varies with the type of green space and landscape characteristics. In general, people seem to be able to appreciate both naturalistic and designed landscapes and find recreational benefits in both kinds (Jim & Chen, 2006b; Özgüner & Kendle, 2006). It is evident that people distinguish between different types of green space; obviously valuation studies should do the same.

We take the heterogeneity of green space in an urban environment as our point of departure. Our hedonic analysis is based on a careful classification of urban green space into eight categories identified through aerial photos and information from the local municipality. These categories reflect a hierarchy of recreational and amenity services provided by urban green space. The aim of our analysis is to examine the differences in capitalized value related to these different types of green space.

The hedonic house price model is estimated using the generalized additive model (GAM). This allows us to control for omitted spatial processes in a flexible way. Omitted spatial processes and temporal price variations are handled using smoothing splines. In light of recent critique of the standard spatial econometric approach using a spatial weight matrix, i.e. Gibbons and Overman (2012) and McMillen (2012), the GAM model is an attractive alternative as it imposes less restrictive assumptions on the unobserved spatial processes omitted from the hedonic model. We find that access to green space can be associated with both significantly higher and lower housing prices depending on the type of green space. In addition we find differences in the capitalization of different types of green space between apartments and houses.

2. Modeling the value of a residence

Housing is a composite good which provides a wide range of services including access to green space. We distinguish between houses (single family and terraced housing) and apartments. We model these housing types separately assuming that they are separate markets. This approach allows for differences in the hedonic price schedule between the two types of homes. In particular, the capitalization of green space may differ between the two. Residents of houses have private gardens which may substitute for other green space. Furthermore, the density of development in a neighborhood where residences consist of houses is lower than in most areas where the prevalent type of dwelling is an apartment. This implies that apartments may get a higher price premium from the reduced development density provided by green space than houses.

Although we have ample data on the characteristics of a dwelling and its surroundings, it is close to impossible to measure every characteristic of a home and a neighborhood. Similarly, it may be difficult to accurately model the functional form of individual components such as distance to the city center. Omitted variables or misspecification can result in spatial autocorrelation in the residuals (Anselin, 2010). Such concerns motivate a modeling approach which takes account of spatial variation at different scales.

We model the spatial context of the individual dwelling on two scales: On a large spatial scale, our approach is based on the recognition that we do not know a priori how the land rent gradient declines as distance from the center increases. For this reason, we model the location of the property through a smooth function of the spatial coordinates, which allows us to capture the shape of the land rent gradient. This geo-additive component accounts for the spatial structure of the housing market at an aggregate level. To capture the finer structure at a neighborhood level we include a vector of variables Z_i which describes the average visible characteristics of homes in the neighborhood of dwelling i. For houses these characteristics are calculated based on all houses on the same street as house i—including those not traded within our time frame. For apartments, measures are constructed on the outwardly visible characteristics of apartment buildings within 200 m of the building in which apartment i is located. These measures are intended to proxy for unobservable neighborhood characteristics in close proximity to the individual dwelling and capture externalities derived from neighboring properties.

Table 1
Control variables describing housing characteristics.

Structural variables	Locational variables
Size of living area (log)	Highway
Room (log)	Large road (wider than 6 m)
Garden area	Railway track
Basement	Industrial area
Number of floors	Coastline
Number of apartments	Hasseris—high income area
Low basement	Geographical coordinates
Renovation 1970s	
Renovation 1980s	**Neighborhood variables**
Renovation 1990s	Spatial lag: garden
Renovation 2000s	Spatial lag: brick
Built before 1927	Spatial lag: age
Built between 1927 and 1939	Spatial lag: tile roof
Built between 1939 and 1955	Spatial lag: renovation in 1970s
Built between 1955 and 1975	Spatial lag: renovation in 1980s
Built between 1975 and 1999	Spatial lag: renovation in 1990s
Brick	Spatial lag: renovation in 2000s
Tile roof	
Fiber board roof	

We modeled the hedonic price function using the semi-logarithmic functional form which is widely used in the hedonic literature (Palmquist, 2005). We estimated the model as a GAM using a logarithmic link function, which transforms the dependent variable:

$$E(P|X, G, Z, x, y, t) = \exp(X_X + G_G + Z_Z^{lag} + f_1(x_{lon}, y_{lat}; k_1) + f_2(t; k_2)) \quad (1)$$

We distinguish between green space, G, and other characteristics, X. The matrix X contains numerous characteristics describing the dwelling and its location. A full list is given in Table 1. The term $f_1(x_{lon}, y_{lat}; k_1)$ is a smooth function over the spatial coordinates of each dwelling and $f_2(t; k_2)$ is a smooth function over the time of sale for the properties. The smooth functions: $f_1(x_{lon}, y_{lat}; k_1)$ and $f_2(t;k_2)$ are fitted using thin plate regression splines with a penalty on "wiggliness", which is found through generalized cross validation (GCV). This approach determines the appropriate level of smoothing by repeated estimations, leaving out one observation and predicting its value based on the estimated model. This generates a prediction error. The penalty terms are found by minimizing this mean squared prediction error. The model coefficients, β, are estimated with a penalized likelihood, i.e.:

$$1_p(\hat{\beta}) = 1(\hat{\beta}) - \frac{1}{2}\sum_j \lambda_j \beta^T S_j \beta \quad (2)$$

where, $1(\beta)$ is the value of a standard likelihood function and describes the model's fit to the data. The second term contains the

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