VALUING DIVERSITY AND SPATIAL PATTERN OF OPEN SPACE PLOTS IN URBAN NEIGHBORHOODS

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Abstract

This study evaluates the diversity, spatial configuration, and pattern of open spaces in urban neighborhoods. Empirical evidence from hedonic modeling reveals that urban residents positively value the varieties of open space but negatively value the diversity within developed land uses. Square shaped plots of open spaces with smooth, as well straight edge are preferred to those of complex and convoluted shapes with irregular edges.

Keywords: Open space, Spatial configuration, Hedonic model, Roanoke, Virginia

Introduction

With increasing population density and congestion in U.S. cities, there is a rising demand for ecosystem services and overwhelming citizen support for open space protection. While federal, state, and local governments are currently planning to preserve more open space to ensure a sustainable supply of ecosystem services and environmental benefits (Kline 2006), our understanding of the economics of open space is inadequate to properly justify investments in open space. With some notable exceptions, most of the previous open space studies have focused on the amenity benefits from the quantity of open space only, while the amenity value of their spatial configuration and pattern effect has remained understudied (Cho et al. 2008).

Previous studies applied the hedonic method to estimate the dollar value of open space in the neighborhood as reflected by housing prices (Acharya and Bennett 2001; Irwin and Bockstael 2001; Irwin 2002; Anderson and West 2003; White and Leefers 2007). Other studies have focused on specific types of open spaces, such as wetlands (Mahan et al. 2000), farmland

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(Bowker and Didychuk 1994), and forest land (Tyrvainen and Miettinen 2000; Thorsnes 2002). McConnell and Walls (2005) reviewed an extensive list of recent open space research on various types such as forests, wetlands, parks, and farmland. One of the limitations of previous studies is that they focused only on the quantity of open space while failing to evaluate the quality, which can partly determine ecosystem services and aesthetic values. Nevertheless, research on valuing the quality of open spaces as measured by the spatial pattern and diversity of land use has been developed only recently. Bockstael (1996); Geoghegan et al. (1997); and Acharya and Bennett (2001) reported that the spatial pattern of land use affects nearby residential house prices. Geoghegan et al. (1997) found that value of landuse diversity depends on the location and level at which the landuse attribute is measured. Cho et al. (2008) analyzed the spatial variation in amenity value of some of the green open space amenities and concluded that composition and spatial pattern of open space greatly varies according the level of urbanization within the city.

The compositional variety in open space has not been the focus of previous studies, however. A recent study by Acharya and Bennett (2001) in an urban watershed revealed that both land use diversity and richness are not desirable factors in the neighborhood, regardless of location in the watershed. However, they measured land use diversity combining all types of land uses such as developed and undeveloped, making it difficult to interpret the diversity value of open space. Their findings do not answer questions such as whether the residents value a neighborhood with a mixture of low-density residential use and industrial use, a mixture of forests and high-density development, or a mosaic of grassland, hardwood forest, and pastureland. To better understand the benefits arising from the quality of open space, separate indices should be used to measure the diversity within the undeveloped land or open space (McConnell and Walls 2005).

This study measured the quality of open space with a more complete set of variables to capture the diversity, spatial configuration, and pattern of open space and to assess their effect on property price. The objectives were achieved by using separate indices of diversity within the natural or undeveloped open spaces as well as developed spaces. In addition, the spatial pattern and configuration of open space were measured using shape and plot density indices that were borrowed from landscape ecology literature.

Methods

We used a typical hedonic model, in which the equilibrium sales price of a house is explained as a function of structural attributes of the house, characteristics of the neighborhood where the house is located, and the landuse amenities in the neighborhood. Following Irwin and Bockstael (2001), endogeneity of open space variables were checked using a Durbin-Wu-Hausman test of endogeneity (Wooldridge 2003, pp. 483) and accordingly instrumented.

The structural variables included the size of living area, number of stories, age of house, number of bedrooms, and size of parcel on which the house was located. Dummy variables were used to capture the presence of exterior brick walls, central air conditioning (AC), masonry fireplace, and a garage. A seasonal dummy variable was included to control for seasonal difference in sales price. The neighborhood variables included the percentage of African-American population, percentage of residents with college degrees, and percentage of neighborhood residents below the poverty level. Distances from the house to public bus routes, nearby parks, regional airport, and railroad were also included. Size of the nearest park was also included to capture the size of publicly available open space in the neighborhood.

A set of open space and land use variables, the primary variables of interest in this study, were included in the model. Following Geoghegan et al. (1997), and Acharya and Bennett (2001), the diversity index originally proposed by Turner (1990) was used to two create separate indices of diversity for open space, or undeveloped land uses, and developed land use. The magnitude of this index represents the degree of dominance by few or many land use types in the neighborhood and depends not only on the diversity but also on the evenness of the land use type distribution. The interpretation of the index is that the larger the index value, greater the diversity (Geoghegan et al. 1997; Acharya and Bennett 2001). Eight land use types were identified within the open space or undeveloped category in the study area, and three within the developed land category.

Similarly, the concept of habitat mean patch fractal dimension (MPFD) was borrowed from landscape ecology (McGarigal and Marks 1995) to compute the open space mean plot fractal dimension. A MPFD value of 1 indicates plots of square shapes with simple, smooth, and straight boundaries, whereas a value of 2 indicates more complex plot shapes with convoluted, rougher edges. In addition, a plot density measure was included to capture spatial pattern of open space distribution within neighborhood. Unlike the diversity index, open space plot density was measured by aggregating open space acres of all types in a single category. The plot or patch density represents the number of distinct open space patches per hectare of open space area (McGarigal and Marks 1995). This captures the extent to which a given amount of open space is scattered in numerous plots within a neighborhood.

This model was applied to a dataset of 11,125 houses that were sold between 1997 and 2006 within the city limits of Roanoke, Virginia. Data on structural attributes and sales price of house were obtained from the Geographic Information System (GIS) database of the city's real estate valuation department. The annual housing price index for Roanoke was used to convert the house sale prices to 2000-dollar values. Data on neighborhood variables were obtained from the U.S. Census Bureau's 2000 census block group database. Further, the distance variables were computed in ArcGIS 9.2 using the GIS shape file of park locations, regional airport, railways, and bus routes obtained from the city's real estate department. Data on landuse diversity and open space were obtained from the citywide Satellite Imagery of Landsat 7 classified and developed by National Land Cover Database 2001. The open space amenities were measured within the neighborhood, which are delineated by the local tax assessors. Bourossa et al. (2003) argued that small neighborhoods defined by the local tax assessor and real estate developers based on their experiences are appropriate measures of neighborhood, and are useful in hedonic modeling and prediction purpose.

Results and Discussion

The null hypothesis of the exogeneity for open space and landuse variables was rejected by Durbin Wu Hausman test at the 1% level, justifying the treatment of open space variables as endogenous regressors. Most of the structural and neighborhood variables were significant and had signs consistent with the literature. Importantly, all of the open space and landuse variables in the model were significant at the 5 % level or better (Table 1), suggesting that open space and landuse features are important predictors of housing price. The diversity index for open space type was positively and significantly related to housing price at the 1% level, suggesting urban residents prefer a neighborhood with more diverse and heterogeneously composed open spaces to a neighborhood with less diverse and homogenously composed open spaces.

Table 1. Regression estimates of open space variables from the hedonic model (dependent variable: natural log of real house sales price)

Variables	Definition	Coefficient	Standard error
Open space diversity	Diversity index of open space category in the neighborhood	0.537**	(0.180)
Developed land diversity	Diversity index of developed land category in the neighborhood	-0.508*	(0.249)
Open space MPFD	Mean Plot Fractal Dimension of Open spaces in the neighborhood	-31.705**	(6.813)
Opens space Plot Density	Number of plots in which per hectare of open space is distributed in the neighborhood	-0.033*	(0.014)
R2	0.50		
No. of observations	11,125		

Note: **, and * indicate the significance of parameters at 1%, and 5% respectively. Numbers in parenthesis are White's robust standard error.

Conversely, the diversity index for developed land was negatively and significantly related to housing price, suggesting that people do not prefer a neighborhood where residential landuse is mixed with industrial or commercial land uses. This result is also consistent with Stull (1975). Similarly, mean plot fractal dimension (MPFD) of open space was negatively and significantly related to housing price at the 1% level, suggesting that people prefer open spaces in more even and square/rectangular shape than those in crooked or convoluted shapes. This result agrees with findings of a similar study by Nelson et al. (2004) that the managed edges of forest landscape increase house price. The coefficient on spatial distribution of open space plots as measured by plot density was negative and significant at the 5% level, suggesting that an open space of a given amount increases house price in the neighborhood if it is aggregated into few larger assemblages and decreases house price if it is fragmented and spatially distributed in numerous plots throughout the neighborhood.

Conclusion

Findings from this study confirmed that urban residents value variety and spatial pattern of open space in their neighborhood. Preserving various types of open spaces might not only increase biodiversity and productivity of local ecosystems, but also raise the local tax base through increased house prices. In contrast, any growth policy that mixes different types of developed landuse in a residential neighborhood would be undesirable. Our analysis reveals that square shaped open space plots, with smooth and more managed boundaries are preferred to those with complex and convoluted shaped plots with unmanaged boundaries. Likewise, people prefer few larger plots of open space to numerous tiny plots those are spatially disaggregated around the neighborhood. This is consistent with the “bigger the better” principle, and reveals that smart open space protection polices should favor protecting fewer but sizable amounts of plots, rather than protecting numerous tiny plots randomly located around the neighborhood. Increasing urban population in U.S. cities will result in tremendous pressure on the remaining open spaces. Findings from this study would provide useful guidance for effective design and management of those spaces which will be crucial to derive the best human value from these amenities.

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