The effect of open space on single-family, residential home property values.

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Assessors, planners, and local communities need quantitative information regarding residents' valuation of environmental amenities, including open space. In this paper, we determine the effect of open space on residential property values by fitting a standard hedonic pricing model to a sample of homes from within the Minneapolis suburban area. Based on our empirical results, we estimate that the externalities generated by adjacency to open space increase residential home property value by approximately $40,000 (or 20% for a mean-valued home of $188,000).

1. Introduction

What is the effect of open space on single-family, residential home property values? This question is relevant for several reasons. First, the answer will help assessors value homes and properties. Second, it will help developers and planners make decisions regarding future communities. Finally, it will help local governments make fiscal decisions regarding the provision of open space public goods.

While a number of studies have implicitly examined the effects of open space on home values, few have done so explicitly. Furthermore, relevant studies have had a narrow geographic focus, have relied on narrow definitions of open space, and have lacked, consequently, a generality by which to draw stronger conclusions. For example, Quang Do and Grudnitski (1995) study the effects of golf courses on residential home property values "entirely within [one] ZIP code."[1] Weicher and Zerbst (1973) examine the externalities of *three* neighborhood parks on adjacent property values. Finally, Correll et al. (1978) study the effects of *three* urban greenbelts on surrounding residential properties.

In this study, by contrast, we focus *explicitly* on the effect of open space on residential home property values, defining open space broadly as any type of open area, including golf courses, parks, and other undeveloped lands. Furthermore, we examine the effects of open space on properties *throughout* a metropolitan area, lending a higher degree of generality to our study.

Using hedonic regression, we estimate the effect of adjacency to open space on residential home property values, controlling for the homes' structural, neighborhood, accessibility, and amenity characteristics. Our data for home value, structural characteristics, and amenity characteristics come from an online listing site for homes throughout the Minneapolis suburban area. Our data for accessibility were also found online. Our neighborhood characteristics data come from a variety of government data sources.

Based on the results of our study, we estimate that adjacency to open space increases residential home property values in Minneapolis suburbs by approximately $40,000, or by 20% of our mean-valued home. These estimates are in accord with previous empirical findings.

The remainder of this paper presents the theoretical and empirical background literature, the conceptual model, the data, the results of our regressions, and our concluding remarks.

2. Theory and Previous Literature

The multiple benefits of open space fall into two categories. The "passive use" benefits of open space include, for instance, the pleasure derived from knowing that open land is being conserved (Breffle et al., 1998). The "active use" benefits include recreational use of the area, as well as scenic views, privacy, and a barrier to adjacent development provided by the area.

Based on these definitions, passive use benefits are non-rivalrous. That is, the passive use benefit one individual derives from open space preservation does not preclude another individual from enjoying the same benefit. By contrast, active use benefits *are* rivalrous. That is, when one individual chooses to reside near or adjacent to open space, he or she necessarily precludes someone else from enjoying the same benefits (convenient recreational opportunities, scenic views, privacy, and protection from adjacent development) derived from living near that particular space.

Because the active use benefits of open space are rivalrous, we expect that prospective homebuyers will bid up the prices of those homes near or adjacent to open space in order to

[1] Quang Do and Grudnitski argue that the benefits of proximity to a golf course include view, low population density, and a greater amount of privacy by virtue of *open space*.

gain these benefits. Therefore, the rivalrous, active use benefits of open space will be reflected in residential home values, while the non-rivalrous, passive use benefits will not.[2] Economic theory tells us, then, that the value of adjacent and non-adjacent sites will differ by the capitalized value of the active use externality generated by adjacency to open space (Weicher and Zerbst, 1973).

A common and well-established method for measuring the value of a residential amenity, such as adjacency to open space, is hedonic price regression. In hedonic price regression highly differentiable goods—like cars or homes, for instance—can be viewed as a bundle of characteristics, $\{Z_1, Z_2, Z_3...Z_n\}$, where the total price is a function of these characteristics, $P(Z) = P(Z_1, Z_2, Z_3...Z_n)$. Econometrically, we can estimate the prices of these individual characteristics using regression analysis (Rosen, 1974). In the context of the housing market, then, each coefficient estimate represents the marginal contribution of the corresponding housing characteristic to overall home value.

Specification of the full housing price model varies from study to study. In general, however, residential home value can be seen as a function of *housing structure* characteristics, *neighborhood* characteristics, *accessibility* factors, and *amenities.* Structural characteristics often include home size, number of bedrooms and bathrooms, lot size, construction quality and other characteristics. Neighborhood characteristics include ethnic and racial composition, income levels, school quality, housing density, and other variables. Accessibility variables include distance to employment, shopping, recreational and entertainment opportunities.[3] Finally, amenity characteristics vary greatly from study to study, but could include such variables as adjacency to a body of water, adjacency to a toxic waste dump, or degree of local air quality.

Previous studies have used such methods to examine the effects of open space directly or to control for the effects of open space while examining some other variable. Their formulations of the open space variable vary. Quang Do and Grudnitski (1995) use a dummy variable to measure the effects of adjacency to a golf course on residential home values. Weicher and Zerbst (1973) use a dummy variable to measure the effects of adjacency to city parks on home values. Palmquist (1980) controls for proximity to open space with straight line distance to the nearest park. Finally, Correll et al. (1978), in their study of the effects of urban greenbelts, employ walking distance to the greenbelt as their variable of study.

In most studies house price data and structural characteristics data are obtained via local government assessors' records and/or multiple listing services. Because sale price data (obtained from assessors) represent actual market transactions, they are generally preferred over listing price data (obtained from multiple listing services). Neighborhood characteristics data are obtained from a variety of sources, including U.S. Census tract data and various other government sources. Finally, amenity characteristics data are collected on site or obtained from various other sources.

In general, these studies have implicitly shown that the externalities generated by open space have a positive impact on residential home values. Quang Do and Grudnitski find that adjacency to a golf course increases residential home value by approximately 7.6%. Weicher and Zerbst find that adjacency to neighborhood parks may increase home values by as much as 23%.[4] Finally, Correll et al. (1978) find that property values decrease by approximately 8.5% per 1000 feet in walking distance from the urban greenbelt.[5] These empirical results support the hypothesis that adjacency to open space will increase residential home property values.

3. Conceptual Model

As discussed, we can characterize housing value as a function of its structural characteristics, neighborhood characteristics, accessibility factors, and amenities. Furthermore, we can estimate the marginal contribution of each individual characteristic to overall home value using regression analysis.

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[2] Breffle et al. (1998) examine a community's "willingness to pay to preserve undeveloped land" in Boulder, CO. Employing a contingent valuation method (survey), they measure both active and passive use benefits.

[3] This section refers to independent variables used by Palmquist (1984), Brookshire et al. (1982), and Gillard (1981).

[4] Weicher and Zerbst (1973) find that values increase by 23% for homes facing open space, while values decrease by 7% for homes facing recreational facilities (baseball diamond, field house, etc).

[5] Correll et al. (1978) find that home values decrease by $4.20 per foot as one moves away from the greenbelt. As a percentage of mean home value ($49,172), that is 8.5% per every 1000 feet.

Price = f(housing structure, neighborhood, accessibility, amenities)

Table 1—Variables, expected signs, and definitions

Variable	Definition
AGE (-)	Age of home
FLOOR (+)	Total square feet of finished floor space
BED (+)	Number of bedrooms
BATH (+)	Number of bathrooms
WOOD (+)	Equals 1 if home has hardwood floors
GAR (+)	Number of garage spaces
DECK (+)	Equals 1 if home has deck or patio
FIRE (+)	Number of fireplaces
ACRE (+)	Size of lot
DENSITY (+/-)	Housing density in neighborhood
RACE (-)	Percent minority population in neighborhood
INCOME (+)	Median household income in neighborhood
SCHOOL (+)	Measure of quality of neighborhood school district
TIME (-)	Total driving time to Central Business District
VIEW (+)	Equals 1 if home has a view
WATER (+)	Equals 1 if lot is adjacent to waterfront
SPACE (+)	Equals 1 if home is adjacent to open space (park, undeveloped area, golf course)
NATURE (+)	Equals 1 if VIEW or WATER or SPACE equals 1

Before moving on, we discuss the expected signs in Table 1, beginning with the structural variables. Over time a home will tend to deteriorate structurally, so the expected sign on AGE is negative. The rest of the structural variables all follow the logic that "more is better" (i.e. more expensive).[6]

Since prospective home buyers will bid up the prices of homes with greater accessibility, the expected sign on TIME is negative. There are both advantages (closer neighbors, friends, etc.) and disadvantages (lack of privacy, traffic, etc.) to greater housing density, so the expected sign on DENSITY is ambiguous. Assuming that neighborhoods tend to stratify by income and that higher income represents a greater ability to bid for choice homes and properties, the expected sign on INCOME is positive. Previous empirical results indicate that the expected sign on the RACE variable is negative (Palmquist, 1974; Gillard, 1981; Brookshire et al., 1982).[7] Finally, as prospective homeowners seek quality education for their offspring, they will bid up the prices of homes in better school districts, so the expected sign on SCHOOL is positive.[8]

Since we believe that a view, adjacency to waterfront, and adjacency to open space are all desirable amenities, we expect that prospective homeowners will bid up the prices of properties with these characteristics. Therefore, the expected signs for the VIEW, WATER, and SPACE variables are all positive.

4. Data

We collected home listing price,[9] structural characteristics, and amenity characteristics data from an online home listing site[10] for properties within Hennepin County, MN,[11] initially listed between January 1, 1999 and December 1, 1999.[12]

We collected data for structural and amenity characteristics from this same online information. In general, the online information consistently noted the square feet of floor space, the age, the number of garages, the presence of hardwood floors, the number of bedrooms, the number of bathrooms, the presence of a deck or patio, and the lot dimensions for listed homes. For lots of irregular shape, we estimated the

[6] With the exception of the WOOD variable, which may also be seen as a proxy for quality of construction.

[7] These studies do not explain the expected sign for this variable.

[8] The preceding sections rely heavily upon Brookshire (1982). As he discusses, full specification of the model leads to multicollinearity, especially among structural and neighborhood characteristics. For this reason, we limit our array of neighborhood and accessibility factors to a set which closely resembles his. We replace his "Distance to Employment" with a comparable accessibility proxy, "driving time to CBD" (TIME). "Crime" and "public safety expenditures" were replaced with "income" (INC).

[9] As discussed, while listings price data likely reflect true market value, sales price data are ideal. Determining the direction of the bias, if any, in listing price as opposed to sales price is not easy. It is likely that homes sell both above and below listing price. For instance, sellers of homes may list their homes above true market value, expecting that the price will be "bargained down." Or, buyers may bid up the prices of homes and buy them above listing price.

[10] Online realty site was *Edina Realty, http://www.edina.com*

[11] For the purpose of limiting the scale of data collection, homes in the city of Minneapolis were excluded.

[12] This window of time allows for bias due to fluctuations in housing market supply and demand. Data regarding time on market were not available.

ACRE variable using the given lot dimensions.[13] For each property, we included the VIEW dummy variable if the online information explicitly mentioned a "view". We included the WATER dummy variable if the online information explicitly mentioned adjacency to any body of water (river, lake, or pond). For the purposes of our study, we defined "open space" as any type of open land area, including "parks," "undeveloped land," and "golf courses." We included the SPACE dummy variable if the online information explicitly mentioned adjacency to open space.[14]

TIME, our proxy for overall accessibility, measures the driving time from each property to downtown Minneapolis as determined by an online driving directions site.[15] Our INCOME data come from 1990 U.S. Census Bureau data for median household income, which we used to calculate an income index (median household income by census tract as compared to the metro-wide median). Our RACE data also come from 1990 U.S. Census Bureau data and measure the percent minority population by census tract.[16] Our DENSITY data come from Metropolitan Council data for single family housing density by township.[17] The SCHOOL variable measures the combined average score on the mathematics and reading basic skills tests by 8th grade students in each school district.[18]

Table 2—Summary characteristics of homes, 65 observations[19]

Variable	Mean	Std. Dev.
Listing price	$ 188142.7	79051.1
Total floor space (square feet)	2206.5	802.5
Age of Home	33.3	19.1
# of bedrooms	3.5	1.0
# of bathrooms	2.4	0.9
# of car spaces in garage(s)	2.0	0.7
# of fireplaces	1.1	0.8
Acreage of lot	0.3	0.2
Housing density (by township)	3.6	3.8
% minority population (by census tract)	5.7	2.9
Income index (median income/metro median; by census tract)	116.1	19.7
Average combined score on state math/reading test (by school district)	88.6	5.5
Driving time to CBD (minutes)	20.2	5.0

Characteristic	# of homes with characteristic
Hardwood floors	31
Deck or patio	43
Nice view	3
Adjacency to waterfront	2
Adjacency to open space	14
Has view, or waterfront, or open space	17

n = 65

5. Results

The results of three regressions are presented in Table 3A, Table 3B, and Table 3C [20] on the following page.

[13] This estimation may allow for inaccuracy, albeit random, in the lot size data.

[14] These amenity data are less than ideal. First, the online information did not systematically include amenity characteristics. Second, the definition of some characteristics like "a good view" are open to interpretation. Finally, our data fail to account for different types of views, waterfront, or open space. We were compelled to aggregate these data due to relatively few observations in any one category.

[15] TIME variable data were obtained from *Yahoo! Maps driving directions, http://www.yahoo.com.* It is unlikely that these data fully capture overall accessibility to employment, shopping, and entertainment.

[16] Aggregated by census tract, INCOME and RACE data may fail to represent levels of income and percent minority population in particular neighborhoods.

[17] Aggregated by township, these data may fail to measure housing density in particular neighborhoods.

[18] Minnesota Dept of Children, Families, and Learning data on state education standards. Standardized test data is for the 1998/99 academic year. Performance on standardized tests is related to many factors other than school quality, so this proxy is also less than ideal.

[19] We first performed our OLS estimates on our original sample of 74 observations with poor results as compared to previous studies. Our original sample, however, had a very high mean home value (nearly $250,000) and standard deviation (181459.36) relative to these studies, leading us to hypothesize that there may be something *fundamentally different* about homes of such high value—a difference not captured in our model. For these reasons, we sampled out homes valued above $500,000, leaving a total of 65 observations.

[20] Severe problems with multicollinearity forced us to drop the BED and BATH variables under the assumption that FLOOR would proxy for both. We calculated Variance Inflation Factors (VIF) greater than 5 when either the BED or BATH variables (which were correlated with FLOOR) were inluded. VIF factors are found by running OLS on each of the k explanatory variables as a function of the other k – 1 explanatory variables. VIF = 1/(1 - R-squared). If VIF exceeds 5 for any of these regressions, significant multicollinearity exists.

Table 3A—Regression 1; Explaining variations in single family home prices; n = 65

Variable	Coefficient	t-stat
CONSTANT	-4581.9	-0.04
FLOOR	53.6	5.80***
AGE	-318.8	-0.96
WOOD	13461.8	1.33*
GAR	3373.0	0.44
DECK	7329.3	0.71
FIRE	-2897.9	-0.41
ACRE	53538.9	1.40*
TIME	833.7	0.65
DENSITY	942.5	0.70
RACE	-5326.8	-2.64**
INCOME	203.2	0.60
SCHOOL	313.0	0.27
VIEW	42871.8	1.73**
WATER	63127.4	2.08**
SPACE	39076.9	2.76***
NATURE	NA	NA
Adjusted r-squared 0.80		
SSR 6.05E+10		

***significant at 99% level
**significant at 95% level
*significant at 90% level

Table 3B—Regression 2; Explaining variations in single family home prices; n = 65

Variable	Coefficient	t-stat
CONSTANT	4957.1	0.04
FLOOR	60.3	6.59***
AGE	-372.5	-1.09
WOOD	14658.1	1.40*
GAR	1732.4	0.22
DECK	10035.9	0.95
FIRE	-2910.2	-0.39
ACRE	36080.7	0.94
TIME	751.6	0.56
DENSITY	826.9	0.60
RACE	-5859.8	-2.86**
INCOME	71.9	0.21
SCHOOL	380.0	0.31
VIEW	NA	NA
WATER	NA	NA
SPACE	NA	NA
NATURE	41783.5	3.13***
Adjusted r-squared 0.79		
SSR 6.81E+10		

***significant at 99% level
**significant at 95% level
*significant at 90% level

Table 3C—Regression 3; Explaining variations in single family home prices; n = 65

Variable	Coefficient	t-stat
CONSTANT	-36519.4	-0.32
FLOOR	55.9	5.99***
AGE	-357.7	-1.06
WOOD	13539.7	1.32*
GAR	3906.4	0.49
DECK	7426.5	0.71
FIRE	-3250.3	-0.45
ACRE	38812.0	1.02
TIME	793.6	0.61
DENSITY	1060.1	0.77
RACE	-4910.3	-2.40**
INCOME	302.3	0.88
SCHOOL	536.6	0.45
VIEW	NA	NA
WATER	83135.5	2.90***
SPACE	39343.7	2.72***
NATURE	NA	NA
Adjusted r-squared 0.79		
SSR 6.42E+10		

***significant at 99% level
**significant at 95% level
*significant at 90% level

Regression 1 includes all three amenity dummy variables, VIEW, WATER, and SPACE. Regression 2 lumps these three variables into a single dummy variable, NATURE, which measures adjacency to waterfront *or* a view *or* adjacency to open space. Regression 3 drops the VIEW dummy variable.[21]

In general, these results are consistent with our prior expectations. Most of the coefficients have the expected signs. The incorrect signs on FIRE and TIME may be explained by problems with multicollinearity,[22] though neither of these coefficients is statistically significant. While possessing an ambiguous expected sign, the DENSITY variable may also be a source of multicollinearity. [23] This coefficient is statistically insignificant, as well.[24]

[21] Due to problems defining the view variable. That is, what qualifies as a good view? Do waterfront properties have a view factor, even if it is not mentioned? Do properties bordering open space?

[22] The correlation coefficient between FLOOR and FIRE is 0.57. The correlation coefficients between TIME and the AGE and RACE variables are –0.46 and –0.46, respectively.

[23] The correlation coefficient between DENSITY and INCOME is –0.34. DENSITY is correlated with several other variables (absolute values of correlation coefficients between 0.2 and 0.3).

[24] It should be noted that, although no problematic multicollinearity was found, there might be theoretical reason to suggest interaction between the amenity characteristics and the structural characteristics, particularly FLOOR. For

In general, the coefficient estimates seem plausible. Of particular interest are the FLOOR, AGE, WOOD, and ACRE variables, which seem to dominate among the structural variables in terms of explanatory power and significance. In particular, every additional square foot of floor space adds approximately $55 to the value of a home ($121,000 for a home with the mean 2200 square feet of floor space). Every additional year of age takes approximately $350 from the value of a home. The presence of hardwood floors adds approximately $13,800. An acre of land adds approximately $45,000. Though not as statistically significant, each additional car space and the presence of a deck or patio add approximately $3500 and $7500, respectively.

Among the accessibility and neighborhood factors, the RACE variable seems to dominate in terms of explanatory power and significance. Explicitly, for every 1% increase in the minority population, home value decreases by approximately $5000.[25] The SCHOOL and INCOME variables, while statistically insignificant, also have the expected signs. Every one point increase in the school district's 8th grade combined average reading and mathematics standardized test scores increases home property value by approximately $400. The coefficient on INCOME is less stable, but for every one point increase in income (on an index of median income of census tract versus the metro-wide median) there is a $70-300 increase in home value.

Now we turn our focus to the amenity variables. Again, these coefficient estimates all have the expected signs, are statistically significant, and seem plausible. A view adds approximately $43,000; waterfront adjacency adds approximately $75,000; and adjacency to open space adds approximately $40,000 to the value of a home. The presence of any one or several of these amenities adds approximately $42,000 as measured by the NATURE variable.[26]

Comparing these regressions, we see that all three have approximately the same fit. However, the NATURE variable in Regression 2 performs no better than the disaggregated amenity variables in Regressions 1 and 3, and disaggregation of the variables is more theoretically appropriate. Because the inclusion of the VIEW variable in Regression 1 does not significantly improve the fit as compared to Regression 3,[27] we believe that Regression 3 is the best of the three models. Initial tests for multicollinearity[28] and heteroskedasticity[29] were negative, confirming this choice.

Based on the estimates of this model, adjacency to open space increases residential home property values by approximately $40,000, or by 20% or our mean-valued home.

6. Conclusions

It appears that these results are in accord with theory and previous empirical work. The breadth of our geographic focus, however, lends a degree of generality to our estimate that previous studies have lacked. We can conclude, therefore, that adjacency to open space has positive externality effect of $40,000 on single family, residential home property values within the Minneapolis suburban area.[30]

These results have several important implications. First, open space must be considered when attaching value to residential property. Second, as residential homeowners value open space, planners and developers have

example, one would expect that large, expensive homes are more likely to be built near waterfront, open space, or on land with a nice view. An "interaction variable," generated by multiplying the amenity dummy vectors by the FLOOR (and other structural vectors) could have measured this type of interaction. We did not undertake this particular analysis.

[25] It should be noted that the RACE variable is correlated with the TIME, INCOME, and SCHOOL variables (correlation coefficients of –0.46, -0.37, and –0.34, respectively) which may both reflect multicollinearity and explain, in part, the correlation between higher minority population and lower home values.

[26] We should point out that these estimates may be overstated due to imperfect amenity data. For instance, say the online information only mentioned adjacency to riverfront. The property may have had a view factor that was not mentioned. In this case, then, the water dummy would be measuring both the effects of waterfront adjacency *and* a view, inflating the waterfront coefficient.

[27] Using an F-test, we accept the null hypothesis that the unrestricted model (Regression 1) is not significantly better than the restricted model (Regression 3) at the 95% level. F-critical for 1 degree of freedom in numerator and 60 degrees of freedom in denominator (which bounds our actual 49 degrees of freedom) is 4.00. F-actual is 3.6.

[28] While there were several disturbing correlations among some variables, no VIF exceeded 5.

[29] Initial tests for heteroskedasticity were performed by plotting residuals versus each of the independent variables. These initial tests proved negative.

[30] Our confidence in these estimates must be tempered by the recognition of the inherent limitations of our study—namely, imperfect data.

incentive to design future communities with this in mind. Finally, local and regional governments must factor in the tax revenue benefit of open space preservation (as realized through increased property values) when making fiscal decisions.[31]

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[31] This paper was originally the first part of a two-part study. In the second part, which examined the effects of open space on lot values within a particular suburban development, we estimated that adjacency to an open space wetland had a positive effect of $39,000 on lot values. While the striking similarity between this and our first estimate may be at least partially coincidental, it nonetheless serves to substantiate the estimate of $40,000 presented here.