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The value of open spaces in residential land use

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Abstract

The preservation of open spaces has become an important policy topic in many regions. Policy tools that have been used include: cluster zoning; transferable development rights; proposed land taxes to fund purchases of remaining open spaces; and private organizations that buy land. This paper develops a theoretical model of how different types of open spaces are valued by residential land owners living near these open spaces, and then, using a hedonic pricing model, tests hypotheses concerning the extent to which these different types of open spaces are capitalized into housing prices. The empirical results from Howard County, a rapidly developing county in Maryland, USA, show that "permanent" open space increases near-by residential land values over three times as much as an equivalent amount of "developable" open space. This methodology can be used to help inform policy decisions concerning open space preservation, such as effectively targeting certain areas for preservation, or as a means of creative financing of the purchase of conservation easements, through the increase in property taxes, resulting from the associated increase in property values.

Keywords: Open space; Land preservation; Hedonic models

Introduction

The preservation of open space is an important policy issue in the United States and elsewhere, as land in forestry and agricultural uses have been converted into residential and commercial uses. From 1982 to 1992, approximately 6.2 million acres of agricultural land and 5.1 million acres of forested land were converted to urban and other developed uses in the United States (Vesterby et al., 1997). Open space has associated with it many potential public goods, such as aesthetic, recreation, and biodiversity values as well as other associated ecosystem services, for example flood control and water purification. In response to the market failure associated with public goods, responses have been varied: cluster zoning; transferable development rights; proposed land taxes to fund purchases of remaining open spaces; and private organizations that buy land such as The Nature Conservancy and The Trust for Public Lands. Indeed, high public interest in the United States has been demonstrated in the results from the last three elections from ballot initiatives to generate funding for open space preservation: in 2000, 174 out of 208 ballot issues passed generating $7.4 billion in conservation funding; in 1999, $1.8 billion was authorized; and in 1998, $8.3 billion (Land Trust Alliance, http:\\www.lta.org).

As part of the policy discussion and to better inform policy decisions concerning how these monies can be efficiently spent, further research into the benefits of open spaces is needed. While there are a myriad of potential benefits associated with preserving open spaces, this paper focuses specifically on the benefits of local open spaces to residential consumers. This paper hopes to contribute some insights into this issue by developing a theoretical model of the economic value of open spaces in individual residential location choice, and subsequently estimating a hedonic model of residential land values that includes as explanatory variables measures of the different types of open spaces around each residential location. Specifically, this current research focuses on the differential value of "permanent" and "developable" open spaces have on near-by residential land prices.

The paper is structured as follows: the next section gives a brief background on relevant policies on preserving open space in the United States, followed by a review of the economic literature. Next a theoretical

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model of residential location choice is developed, followed by the empirical specification of a case study in a county in suburban Maryland with tests of the theoretical hypotheses, with econometric results. The paper concludes with a brief discussion and suggestions for further research.

Policies in the United States

In the United States, a myriad of local, state, and federal regulations have the potential to affect land use patterns (Platt, 1996). Land use planning and regulation is usually a function of state and local governments, traditionally performed through zoning regulations and subdivision ordinances. In addition, federal government activities can indirectly affect land use patterns. These include the allocation of resources for the transportation network and the deductions of mortgage interest and property taxes in the federal income tax code.

Zoning remains the most prevalent land use control tool in affecting the location of different land uses, but in general zoning can only affect the density of residential development and it is not prohibited outright. In addition, there are a few policy "levers" available to local governments that can be used to affect the incentives for development, either through mandatory or voluntary regulations. Examples of mandatory regulations include urban growth boundaries, adequate public facilities ordinances, differential development fees, down-zoning, and public provision of water and sewer. Governments can also use voluntary market mechanisms such as agricultural and other conservation easements, transferable development rights to create incentives for development to occur in specific regions, or they can explicitly buy parcels of remaining open space.

Results from a recent survey show that 46 of the 50 US states have some form of open space preservation program in place (National Governors' Association, http:\\www.nga.org). These include using different funding sources such as real estate transfer fees and hunting licenses to generate monies to purchase land or conservation easements as well as grants for habitat protection and restoration. In 1997, the General Assembly in the state of Maryland (the location of the empirical case study below) adopted a number of programs to implement the "Smart Growth" initiative of Governor Parris Glendening. The goals of Smart Growth in Maryland are to revitalize previously developed areas, preserve open space, and to discourage sprawl development in rural areas. The state directs support and infrastructure funding to locally designated "Priority Funding Areas" and in addition, a "Rural Legacy Program" provides funding for the purchase of conservation easements on agricultural and forested lands (Maryland Office of Planning, hptt:\\www.op.state.md.us).

Review of economic literature

Questions concerning the economic value of open spaces have been addressed by economists using two broad methodological approaches for estimating economic values of market and nonmarket goods and services: stated preference and revealed preference. The former approach relies on survey techniques to elicit individual preferences and values for economic goods and services, while the latter approach uses observed market choices that individuals make to reveal their underlying preferences and to estimate their values for goods and services (Freeman, 1993). In the survey approach, for example, respondents are asked how much they are willing to pay to preserve land in open uses. The value of preserving agricultural land uses was estimated using this approach by Halstead (1984), Beasley et al. (1986), and Kline and Wichelns (1994, 1996a, b, 1998). In this latter series of papers, the authors find empirical evidence that in a region of the United States, high population and property values lead to greater support for agricultural land use preservation programs. This approach has also been used to estimate the value of preserving open space in an urban setting in the US (Breffle et al., 1998).

The revealed preference approach, which relies on market transactions and the hedonic pricing methodology, has also been used to estimate the value of open spaces. While further development of the hedonic pricing model approach is given below, as this is the modeling framework for the empirical study in this paper, the basic concept is that a residential property is a heterogeneous good made up of a bundle of characteristics, each of which contributes to the sales price of the good, including environmental attributes of the residential parcel, such as the amount of open space in the neighborhood of the parcel.

The early literature in this area focused on the value of urban parks and greenbelts in residential property values, with statistical results that showed that the farther away a residential property was from the greenbelt or park, the less its selling price, controlling for all other attributes (Kitchen and Hendon, 1967; Weicher and Zerbst, 1973; Hammer et al., 1974; McMillan, 1974; Correll et al., 1978; Peiser and Schwann, 1993). Later research analyzed the value of British forest land in residential prices in a series of papers by Garrod and Willis (1992a, b, c), similarly in Tyrvainen and Meittinen (2000) as well as the effects of a golf course on residential land values in Do and Grudnitski (1995). Ready et al. (1997) compare stated preference to hedonic models for measuring the amenity benefits from farmland and find that the two methodologies generate estimates within twenty percent of each other.

In a series of papers by Bockstael and colleagues (Bell and Bockstael, 2000; Geoghegan et al., 1997; Leggett and Bockstael, 2000) the authors find empirical effects of different kinds of open space, measured at different scales, on residential land values. For example, in Geoghegan et al. (1997), the authors find that within a tenth of a kilometer radius, the proportion of open space positively impacts land values, but within a 1-km buffer this variable negatively influences land prices. They interpret this result to suggest that individuals value open space as a view from their house, but that individuals prefer more diverse land uses at the larger scale. For example, this could be interpreted that individuals prefer to be able to walk to other important land uses from their houses, such as commercial land uses for local shopping.

For a case study in England, Cheshire and Sheppard (1995) use a hedonic model to analyze the difference between the effects of publicly and privately owned open space amenities on residential property in two towns. They include many location variables to capture local spatial amenities. However, given data constraints, these authors can only measure their variables of interest at an aggregate level of $1\,km^2$. Variables are measured by placing each residential observation in a 1-km grid, then extracting the percent of the relevant land uses in that $1\,km^2$. This results in one aggregate variable for all observations in $1\,km^2$. They use variables measuring the "percent of land in accessible open space", that is land with public access and "percent of land in inaccessible open space", land with no provision of public access to capture the difference between use and nonuse values of the open space. They find the impact depends on the amount of open space amenities in two towns.

While these two variables are similar in spirit to the "permanent open space" and "developable open space" variables in this paper, there are important differences. The data for this current paper are spatially explicit and disaggregate, so the variables included in this paper vary for *each* observation. Rather than examining the influence of access, the variables in this paper are used to examine the willingness to pay higher prices for the availability of open space around a residential location. Because the data contain permanently preserved as well as developable agricultural and forestland, this paper measures the effect of both current land uses and future expectations of surrounding land uses.

The theoretical model

The theoretical model developed in this paper follows in the tradition of the basic residential location choice model. There is a rich history of spatial economic models of land use, which can be grouped into two basic categories: monocentric city models and public finance/spatial amenities models (Mieszkowski and Mills, 1993). The modern monocentric city model of urban spatial structure, where the distribution of land uses on a featureless plain around a central business district (CBD) is a result of an equilibrium between the declining land rent gradient and increasing transportation costs, was developed by Alonso (1964), Mills (1967), and Muth (1969). In more recent times, these models have become more realistic and complicated by incorporating polycentric cities, different expectations concerning the future, etc. (for a complete review of this literature, see Anas et al., 1998).

The public finance/spatial amenities models are derived from the Tiebout (1956) model, where individuals choose their residences based on location-specific public goods. That is, individuals "vote with their feet" for a package of housing services, as well as local fiscal and nonfiscal amenities in their choice of residential location (Hoyt and Rosenthal, 1997). The applied literature, largely based on aggregate spatial data such as census data, has incorporated aspects of both strands of theoretical models, for example, by including as explanatory variables distance measures and neighborhood measures, such as Dubin (1988, 1992), Can (1990, 1992) and McMillen (1992, 1995). The model developed in this paper similarly incorporates both strands of the literature by including both aspects of location. That is, it is assumed that individuals have preferences on their locations: specifically, as the location relates to commuting distances as well as the spatial amenities surrounding their location.

The theoretical model is an extension of Brueckner (1983). It is assumed that there are identical consumers with the utility function:

$$U(c, q, y, s_{\text{permanent}}, s_{\text{developable}}), \qquad (1)$$

where c is the composite nonhousing numeraire good, q the consumption of housing floor space, y the consumption of private yard space, $s_{\text{permanent}}$ the permanent open space surrounding parcel and $s_{\text{developable}}$ the developable open space surrounding parcel.

There are two potential types of open space around a residential parcel: permanent open space, such as parks and lands that have conservation easements (i.e. have sold their development rights); and developable open space, such as privately owned forested land and agricultural land. In the model, the open space goods are public goods, not individually owned by a residential homeowner. But it is hypothesized that consumers prefer more open space to less and this will be capitalized into the selling price of the home. Consumers are assumed to be myopic, that is, they do not expect that the farm next to their neighborhood will get converted to residential use at any time soon, although we do expect individuals to value "permanent" open space higher. This differentiation between types of open space is the addition to the Brueckner (1983) model as well as the empirical test of the hypotheses developed.

It is assumed that all consumers receive the same income m at their place of employment in the CBD, so that in equilibrium, consumers have a uniform level of utility. All consumption bundles must satisfy $U(c, q, y, s_{\text{permanent}}, s_{\text{developable}}) = \underline{U}$, where $\underline{U}$ is the uniform utility level. For each consumer to reach $\underline{U}$, the rental payment R for a house located x miles from the CBD with a given q, y, $s_{\text{permanent}}$, and $s_{\text{developable}}$, must be

$$U(m - t(x) - R, q, y, s_{\text{permanent}}, s_{\text{developable}}) = \underline{U}, \tag{2}$$

where $t(x)$ is the commuting cost from distance x. This equation implicitly defines the consumer bid-rent function

$$R = R(q, y, s_{\text{permanent}}, s_{\text{developable}}, x, m, \underline{U}). \tag{3}$$

To test this theory, a hedonic model of land values is developed to test the hypotheses that individuals are willing to pay more for locations with greater private open space and public open space, controlling for the other variables that affect residential land values as suggested by the above theoretical model, such as distance to CBD, other spatial amenities, and characteristics of the parcel and housing structure.

The empirical model

Hedonic models are reduced form statistical models that seek to trace out, at a point in time, the locus of equilibrium transactions prices as a function of the characteristics of the heterogeneous real estate transacted. Innumerable applications exist in the literature, dating from the 1950s. Because real estate is a complicated good with many dimensions, differences in selling prices of houses will be dictated by a number of factors, including the quality of the housing structure on the property, neighborhood characteristics, the accessibility to the CBD, as well as the environmental amenities associated with the property. In the past several decades, environmental economists have used these types of models to reflect the contribution of environmental amenities to the selling price of a house. The first application in environmental economics (Ridker and Henning, 1967) tested the relationship between property values and air quality and did indeed find a statistically significant relationship (for further information on hedonic models, see Freeman (1993)). Other environmental applications include: the value of agricultural erosion (Dorfman et al., 1996); the impact of hazardous waste sites (Michaels and Smith, 1990); and the recreational and aesthetic value of water (Lansford and Jones, 1995).

In general, hedonic pricing models assume that the heterogeneous housing good is comprised of a bundle of characteristics, such as

$$R = \alpha + S\beta + L\gamma + G\tau + \varepsilon, \tag{4}$$

where R is an $(n \times 1)$ vector of housing prices, S is an $(n \times k)$ matrix of parcel/structure characteristics, L is an $(n \times l)$ matrix of neighborhood characteristics, G is an $(n \times m)$ matrix of spatial and locational variables, α, β, γ, τ are the associated parameter vectors and ε is an $(n \times 1)$ vector of random error terms.

A specific version of this general hedonic pricing model is estimated to test the hypotheses that different types of open space around a residence contributes positively to housing values. The empirical application is focused on one suburban county of Washington, DC and Baltimore, MD that is undergoing some of the most rapid growth in Maryland: Howard County. As tax rates, public services, school quality, and crime rates vary over counties, but not within counties in this area, the model includes a single county in order to focus specifically on the land use issue and to abstract away from these other issues.

The data for this paper are from the Maryland Office of Planning's (MOP) geocoded data of land parcels and associated sales transactions including descriptions of the parcel and associated housing structure. The sales transactions used to estimate the hedonic model included all geocoded and consistent transactions between September 1993 and June 1996 of residential properties, resulting in a dataset of 5599 observations. The selling prices were deflated annually using the urban Consumer Price Index. Data from the 1990 US Population are used to control for neighborhood effects.

Data on land use are also from the Maryland Office of Planning, which is used as a "base map" for land use, with further information on conservation easements from the Maryland Department of Natural Resources added to this base map, for the creation of the "permanent open space" land use category. The data on conservation easements were not in a map format; the dataset only included land area of the easement and the location of the centroid of the easement parcel. Therefore, in order to add these data to the land use map, all of these parcels were assumed to be circular in shape, with an associated radius so that the area of each circle was the area of the conservation easement parcel in the original dataset. See Fig. 1 for this final land use map and associated transaction points for the hedonic model. This approach will add some amount of error to the calculations of land use areas, but as long as these errors are not systematic in any way, the estimation results will not be biased.

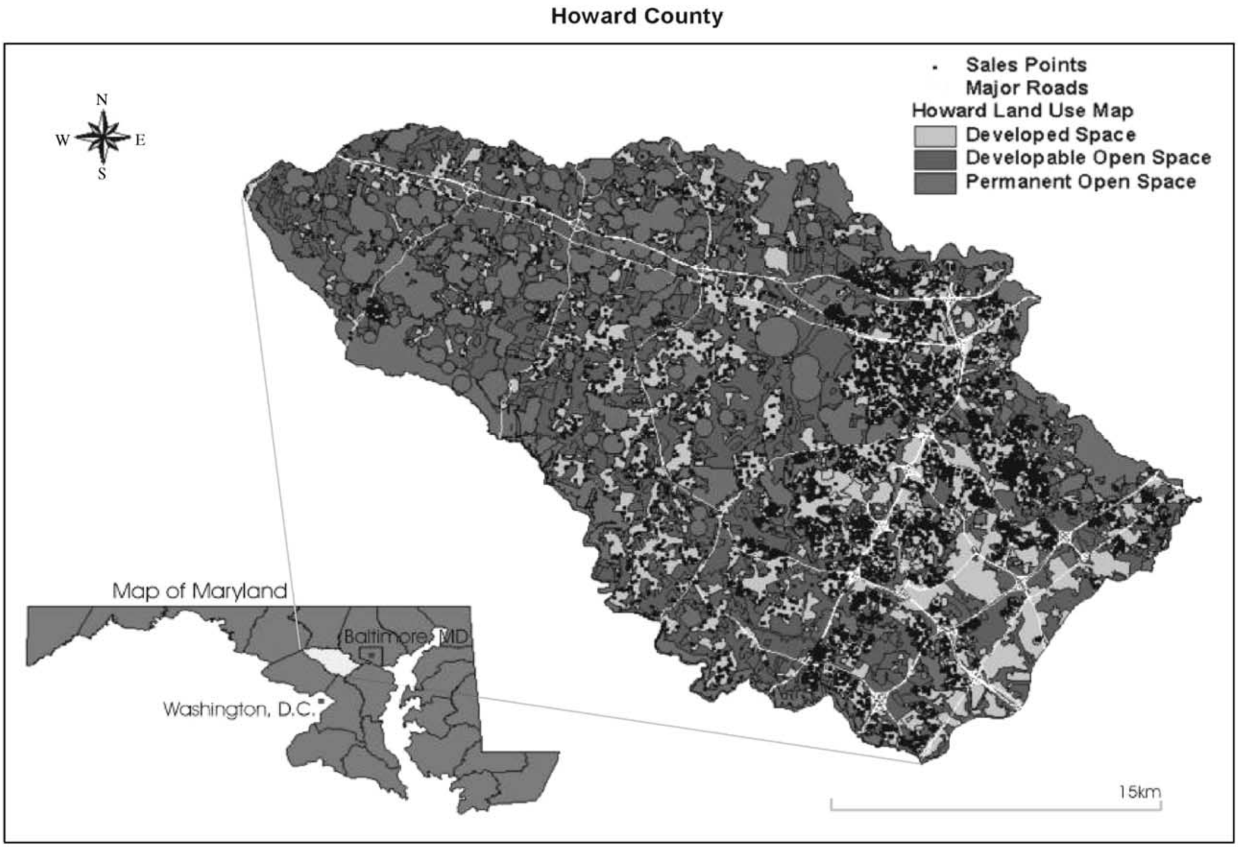

Fig. 1. Howard County Land use.

In explaining the variation in the transaction price of the parcel, four types of explanatory variables are used, which are the specific variables for the general variables in Eq. (4). All of the variables, with brief descriptions, can be found in Table 1. The parcel characteristic's set includes the lot size (LOTSIZE), the year the house was built (YRBLT), and square footage of the house (SQFT). As with many previous hedonic models, the price of a parcel is assumed to be nonlinearly related to these variables. Thus, the natural log of these variables are used. Binary variables are included to control for the assessor's perceived quality of the house (FAIR, AVER, GOOD, VGOOD, with the omitted category of FAIR in the regression below), and the number of stories (NOSTORY) in the house. It is expected that lot size, size of the house, and quality of construction will all contribute positively to the selling price of the house. As the county does not have a significant amount of 'antique' houses, which could command a premium price as elsewhere in Maryland, it is expected that newer houses will also have higher prices, all else equal.

The second set of explanatory variables relates to the location attributes of the parcels. This includes the Euclidean distance from each parcel to Washington, DC (DISTDC) and Baltimore, MD, (DISTBALT) the two principal employment centers in the region, as well as the distance to nearest town (DTOWN). The theoretical model developed in this paper predicts that the coefficients on the distance variables to be negative, reflecting the trade-off between housing prices and commuting costs. To account for neighborhood characteristics, the third set of variables include information on the block group that each parcel is in, which were extracted from the 1990 US Census of Population. These include: population density (POPDEN); percent of population with college education or higher (PEDUCB); and the natural log of the median household income (LNINC). It is expected that higher population density would decrease housing prices, while education level and median household income would increase housing prices, holding all else equal.

Finally, indices were constructed to calculate the amount of "developable open space" (DEVPOPEN) and "permanent open space" (PERMOPEN) that surrounds each parcel within a 1600-km radius. This distance was used to capture the open spaces that could be seen in a 20-min walk from each parcel. The land uses that were included in "developable open space" included agricultural cropland, pasture, and forest, and "permanent open space" included parks and lands

Table 1
Variable names and definitions ($n = 5599$)

Variable name	Definition	Units	Mean value
PRICE	Deflated transaction price	\$ (1996 = \$1)	241,000
LOTSIZE	Size of parcel	Acres	3.5
YRBLT	The year the house was built	yr	1982
SQFT	Size of house	Square feet	2300
NOSTORY	Number of stories in house	Count	1.8
FAIR	Quality of house	0, 1	0.03
AVER	Quality of house	0, 1	0.57
GOOD	Quality of house	0, 1	0.36
VGOOD	Quality of house	0, 1	0.04
DISTDC	Euclidean distance to Washington, DC	km	39
DISTBALT	Euclidean distance to Baltimore, MD	km	15
DISTTOWN	Euclidean distance to nearest town	km	5
POPDEN	Population density in block group	Individual/km^2	0.0006
PEDUCB	Percent of individuals in block group with bachelor's degree	Percent	17
INCOME	Median income of block group	\$ (1990)	63,000
DEVPOPEN	% of land in 1600-m buffer in developable open space	Percent	35
PERMOPEN	% of land in 1600-m buffer in permanent open space	Percent	12

with conservation easements. The main theoretical hypotheses to be tested in the empirical model are that each of the estimated coefficients on these open space variables is positive, while the coefficient on the permanent open space variable is of larger magnitude than the estimated coefficient on the developable open space variable.

As hedonic models are reduced form models of an equilibrium locus of offers and bids for residential land, economic theory cannot inform the empirical specification (see Cropper et al. (1988) for further discussion). Therefore, following previous research, (Bockstael, 1996; Geoghegan et al., 1997) flexible function forms were used, with a semi-log specification as the best fit. The equation that is estimated is

$$\begin{aligned}\ln \text{Price} = {} & \beta_1 + \beta_2 \ln \text{LOTSIZE} + \beta_3 \ln \text{YRBLT} \\ & + \beta_4 \ln \text{SQFT} + \beta_5\ \text{NOSTORY} \\ & + \beta_6\ \text{AVER} + \beta_7\ \text{GOOD} + \beta_8\ \text{VGOOD} \\ & + \beta_9\ \text{DISTDC} + \beta_{10}\ \text{DISTBALT} \\ & + \beta_{11}\ \text{DISTTOWN} + \beta_{12}\text{POPDEN} \\ & + \beta_{13}\ \text{PEDUCB} + \beta_{14} \ln \text{INCOME} \\ & + \beta_{15}\ \text{DEVPOPEN} + \beta_{16}\ \text{PERMOPEN}. \quad (5)\end{aligned}$$

Estimation results and discussion

The results of this estimation are presented in Table 2. A Cook–Weisberg test for heteroskedasticity, using the fitted values of the dependent variable, fails to reject the null hypothesis of homoskedasticity. The estimated coefficients on all the structural characteristics are positive and statistically significant, as expected. Larger lot sizes, larger houses, newer houses, and houses of higher quality all contribute positively to the selling price of a house. As is predicted by the theoretical model, the farther a house is from the major employment centers of Washington, DC and Baltimore, MD, the lower the selling price; both of these estimated coefficients are negative and statistically significant. The distance to nearest town variable is positive and statistically significant. While towns can also be employment centers as well as locations of stores and other amenities, the positive coefficient suggests that there might be congestion effects occurring near these towns, so that individuals are not willing to pay as much for a house there, all else equal. The census neighborhood variables are also all statistically significant and of the expected sign. Higher population density in a neighborhood decreases housing values, while higher incomes and education levels increases housing values, again, holding all else equal.

The main hypothesis to be tested from the theoretical model and the policy question raised in this paper, concern the estimated coefficients on the open space variables. The estimated coefficients on both permanent open space and the developable open space are positive, with the estimated coefficient on permanent open space being over three times the magnitude as the estimated coefficient on developable open space, as was hypothesized. However, only the estimated coefficient on permanent open space is statistically significant at the 5% level, while the estimated coefficient on the developable coefficient is statistically significant at slightly less than the 10% level, with a p-value of 0.08. Nonetheless, this result does suggest that individuals value permanent open space more than developable open space, as they are willing to pay more to live near permanent open space, all else being equal.

Table 2
Regression results[a]

Variable name	Estimated coefficient	T-statistic
CONSTANT	8.55[b]	11.42
LNLOTSIZE	0.081[b]	11.42
LNYRBLT	0.066[b]	5.66
LNSQFT	0.211[b]	15.34
NOSTORY	0.109[b]	7.76
AVER	0.276[b]	9.68
GOOD	0.464[b]	15.09
VGOOD	0.627[b]	15.77
DISTDC	−4.45e–06[b]	−3.99
DISTBALT	−6.38e–06[b]	−5.65
DISTTOWN	1.29e–05[b]	6.04
POPDEN	−24.88[b]	−2.15
PEDUCB	0.341[b]	3.16
LNINCOME	0.133[b]	5.25
DEVPOPEN	0.074	1.74
PERMOPEN	0.257[b]	4.84

[a] Dependent variable: LNPRICE, $N = 5599$, $R^2 = 0.34$.
[b] Signifies statistical significance at the 5% level.

Conclusions

As a greater number of local governments develop policy initiatives to preserve open space, research, such as presented in this paper, can help contribute to the analysis and design of such policies, particularly in assisting in target economic-based programs, such as the purchase of development rights, conservation easements, or complete parcels. Using a spatially explicit approach, as was done here, can also help in targeting specific locations for the spending of public monies, and can potentially demonstrate the trade-off between buying more area in rural areas, where land values are generally cheaper, versus buying land in more densely populated regions, where land is more expensive, but could potentially contribute further to local housing values. Or, given further data on environmental values, such as habitat and watershed protection benefits, this modeling approach could be used to rank parcels according to these values as well.

The definition and calculation of the ‘‘permanent open space’’ variable includes farms that have sold their development rights. The positive and statistically significant coefficient on this variable in the hedonic regression demonstrates that individuals value this type of near-by farmland in their residential location choice, so these values are not only potentially capitalized into the individual farmland prices (Nickerson and Lynch, 2001), but also into the surrounding residential land prices. Further research will focus on the relationship between how increases in nearby residential parcels from conservation easements increase the assessed value of a property. In turn, this could potentially lead to an increase in the land tax revenue from the parcel, yielding a return on the land preservation investment, which could be targeted to finance further conservation easements or more simply as general local government revenue. Future research, therefore, includes using the current residential land tax for each parcel to compute the expected increase in county tax revenue generated over 20 yr by the current land preservation programs in Howard County, and then to compare this revenue to the cost of preserving the lands in question. Then simulations can be performed to investigate where the program could be spatially targeted in the county to generate the largest net local benefits of the program.

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