Journal of Agricultural and Applied Economics, 40,2(August 2008):635–647

Residential Land Values in Urbanizing Areas

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Zoning decisions related to residential lot size and density affect residential land value. Effects of size on residential parcel value in Roanoke County, VA, are estimated with fixed effects hedonic models. Parcel size; elevation; soil permeability; proximity to urban areas, malls, and roads; and location influence parcel value, but the effects vary by value of construction and development status. Parcel value per square meter declines with increasing parcel size. The estimated relationships could be used to evaluate zoning decisions in terms of land values and tax revenues if model estimation uncertainties and responses by developers to zoning strategies are considered.

Key Words: development, fixed effects, hedonic model, property values, residential density, spatial econometrics

JEL Classifications: Q24, C25, C52

Heated discussions have arisen in local areas about the need to control growth through urban growth boundaries or other zoning measures. Proponents view rezoning to restrict urban sprawl as a necessary way to protect the environment from residential development and preserve the unspoiled character of rural areas (Rose). Opponents view these efforts as "takings," which devalue property and interfere with owners' ability to manage their properties efficiently (Woods). The outcomes of zoning and other public decisions affecting residential growth are important to urbanizing areas because these decisions affect the size of the tax base and demand for local services including schools, roads, water, and sewer. In setting land use and development policies, policymakers must also consider public concern for environmental protection. Traditional large parcel developments in suburban and exurban areas promote economic development and expand the tax base. However on a per-resident basis, large lots increase the amount of roads, rooftops, and other impervious surfaces thereby increasing potential pollution runoff. Large lots also reduce open space compared with more compact developments with smaller parcels.

Numerous studies have looked at effects of housing and location attributes including smart growth developments on land and housing values (Clark and Allison; Deaton; Geoghegan, Lynch, and Bucholtz; Hite et al.; Irwin; Leggett and Bockstael; Mahan, Polasky, and Adams; McCluskey and Rausser; Palmquist, Roka, and Vukina; Powe et al.; Song and Knaap 2003, 2004; Tu and Eppli 1999, 2001; Tyrvainen and Miettinen; and Uyeno, Hamilton, and Biggs). Fewer studies have looked at lot size–value relationships in a systematic way that would allow users to consider explicitly the trade-offs between land value (and associated tax revenue) and lot size for alternative resource bases. The objective of

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The authors express appreciation to Nicolai Kuminoff and an anonymous reviewer for helpful suggestions on an earlier version of the manuscript. This study was funded in part by EPA/NSF Water and Watershed Program Grant No. R 825760-01-0.

Table 1. Descriptive Statistics of Land Values and Explanatory Variables

	Average	Std. Dev.	Minimum	Maximum	Median
Price ($/m^2)	23.13	18.08	0.02	133.40	13.16
Size (m^2)	8,547.00	75,203.00	56.97	2,165,233.00	1,444.00
Elevation (m)	380.00	89.00	3.22	1,003.00	355.00
Slope (degrees)	5.49	3.54	0.00	34.56	4.79
Soil Quality 1	0.03	0.17	0.00	1.00	1.00
Soil Quality 2	0.87	0.33	0.00	1.00	0.00
Mall 1 (km)	8.86	4.28	2.00	27.02	8.58
Mall 2 (km)	9.25	4.77	0.44	27.48	10.55
Roanoke (km)	8.82	3.82	3.39	28.79	8.09
Blacksburg (km)	39.86	6.79	18.17	51.20	38.30
Road	0.05	0.22	0.00	1.00	0.00
Population (p/Ha)	5.90	4.60	0.05	18.65	4.70
Developed	0.88	0.33	0.00	1.00	0.00
Coordinate Y	16,882.00	6,022.00	1.81	30,586.00	16,322.00
Coordinate X	24,888.00	6,767.00	0.15	36,626.00	23,955.00
Year	0.49	0.50	0.00	1.00	0.00

our paper is to estimate the effects of residential parcel size on land values while controlling for location and other parcel attributes. Such analysis could be useful to policymakers concerned with the land value and tax base implications of alternative zoning strategies. The analysis is carried out in Roanoke County, an urbanizing area of southwest Virginia.

Data

The data were collected as part of an interdisciplinary effort to analyze the fiscal and environmental consequences of alternative residential development patterns using Roanoke County, VA, as a case study (Bosch et al.; Diplas et al.). A random sample of observations used to estimate the model was obtained from the Roanoke County Planning Department and the Roanoke County Division of Tax and Assessment database. There were 1,844 transactions of vacant and non-vacant land parcels for the period 1996–1997. Table 1 contains the descriptive statistics of variables used in estimating the land value model. The price of the parcels reflects the value of the land alone. Prices of parcels with structures were computed by subtracting the assessed value of the structure from the parcel's recorded transaction price. The sample average price per square meter is $23.13 while the median is $13.16.

Parcel size varies from 0.005 ha (a parcel close to the urban fringe of Roanoke County) to 216 ha (a parcel of steep and remote agricultural land). Elevation of the center of the parcel is measured in meters above sea level. Slope is the average slope of the parcel measured in geometric degrees. There is a high correlation ($R = 0.68$) between the slope of the parcel and its elevation. Most of the developed parcels are located on relatively flat land with low elevation. The soil quality of the land parcels was classified into three categories according to permeability. More permeable soils are associated with lower flood risk and soil erosion. The dummy variable representing soil quality, Soil1 (3% of the parcels) is the less absorbing category of soil, while Soil2 (87% of the parcels) has an intermediate level of penetrability

Point-to-point distances of parcels from shopping malls, the city of Roanoke, and the town of Blacksburg are measured in kilometers. The minimum distance of the parcels to either of two urban centers is about 3 km. However, the town centers may be less important than shopping malls in terms of daily commuting. The Roanoke County Planning Department estimates that several thousand consumers visit the two county malls daily. Additionally, these malls have become the center of development of hundreds of small businesses, which offer employment to thousands of Roanoke County residents. According to the Roanoke County Planning Department, the development rates of the areas close to the shopping malls are expected to be the highest in the county for the next 5 years.

About 5% of the parcels are located next to a major road, which may affect the land price negatively because of noise and air pollution. More open space and easier access to natural amenities may also be captured by the population density of the census blocks in which the parcel belongs. The average population density of the sample is about six people per hectare. The dummy variable for development indicates whether a parcel contains some type of construction (88% of the sample) or is undeveloped (12% of the sample). Coordinates X and Y identify the exact location of the center of each parcel and define the proximity and neighboring effects of parcels. Coordinate X increases in a west and northerly direction while coordinate Y increases in an east and northerly direction. The dummy variable Year indicates whether a parcel was sold in 1996 (Year=0) or in 1997 (Year=1). According to the U.S. Bureau of Census, the average price of rural land in Roanoke County increased by 1.5% in 1997 relative to 1996.

Empirical Model

While there have been numerous hedonic studies to estimate prices of goods or resources as a function of their attributes, strong theoretical arguments have not been developed for the shape of the hedonic price function. The choice of functional form in an empirical application is arbitrary. Cropper, Deck, and McConnell used simulation to investigate how different functional form assumptions affected the accuracy of their estimates for the true marginal implicit prices of housing characteristics. They assumed that the true utility function is either translog or Diewert, and found that four hedonic price functions performed consistently well: linear, semi-log, double-log, and Box–Cox. Subsequent empirical applications to the housing market typically address model selection by citing Cropper, Deck, and McConnell, and simply running one or more of the functional forms that performed best in their experiment.

However, there is no precedent for how *land characteristics* enter the hedonic price function. While Cropper, Deck, and McConnell treat land as homogeneous, it is not clear that characteristics like soil quality or slope would even enter households' utility functions. Thus, there is less reason to expect that the standard functional forms would necessarily perform the best. Given this uncertainty, we use the suggested approach of Spanos and let the data speak for themselves. The modeling proceeded iteratively beginning with an estimation of a basic OLS model assuming no spatial autocorrelation among parcel values. The initial model was tested for functional form adequacy and, based on specification test results, was reformulated and tested again for specification adequacy. This procedure of model reformulation and specification testing continued until a model was obtained that passed all specification tests simultaneously.

The initial estimated model assuming that sample observations are not spatially correlated is the following:

$$
\begin{aligned}
\text{Log(Price)} = {} & A_0 + A_1[\text{Log(Size)}] \\
& + A_2[\text{Log(Size)}]^2 \\
& + A_3[\text{Log(Elevation)}] \\
& + A_4[\text{Log(Elevation)}]^2 \\
& + A_5(\text{Soil1}) \\
& + A_6(\text{Soil2}) \\
& + A_7[\text{Log(Population)}] \\
& + A_8[\text{Log(Population)}]^2 \\
& + A_9[\text{Log(Mall)}] \\
& + A_{10}[\text{Log(Mall)}]^2 \\
& + A_{11}[\text{Log(Town)}] \\
& + A_{12}(\text{Developed}) \\
& + A_{13}(\text{Road}) + A_{14}(\text{Year}) \\
& + A_{15}[\text{Log(X)}] \\
& + A_{16}[\text{Log(Y)}] \\
& + A_{17}[\text{Log(X)Log(Y)}] + u
\end{aligned}
\tag{1}
$$

Table 2. OLS Estimates for the Land Value Model in Roanoke County

	Coefficient	Standard Deviation	*t*–Ratio
Constant	−17.46850	3.214461	5.434
Log(Size)	−0.483947	0.069485	6.964
[Log(Size)]^2	−0.030618	0.009440	3.243
Log(Elevation)	0.337926	0.274165	1.233
[Log(Elevation)]^2	−0.106225	0.065750	1.616
Soil1	−0.056682	0.019007	2.982
Soil2	−0.091607	0.036173	2.532
Log(Population)	0.004845	0.004217	1.149
[Log(Population)]^2	−0.000059	0.000023	2.571
Log(Mall)	1.402944	0.417148	3.363
[Log(Mall)]^2	−0.220563	0.057922	3.808
Log(Town)	0.250346	0.068201	3.671
Developed	0.094025	0.015405	6.103
Road	−0.070932	0.022242	3.189
Year	0.056391	0.009418	5.987
LogX	4.190094	0.732566	5.719
LogY	3.811132	0.695302	5.481
(LogX) * (LogY)	−0.930265	0.167058	5.569
R^2	0.809		
Adjusted R^2	0.807		

where u represents the error term, Mall is minimum distance to an existing mall, Town is minimum distance to the closest town (Roanoke or Blacksburg), and other variables are as described in Table 1.

If one were to assume neither spatial autocorrelation nor any other misspecification problems, the OLS model explains approximately 80% of the variation in the land transaction prices (Table 2). The value of a land parcel per square meter is expected to be lower for larger parcels. Parcels, which already have some type of residential or commercial development, have higher transaction prices, while parcels next to a major highway have lower prices. Lower water permeability (and consequently higher flood risk) affects parcel value negatively, while a parcel sold in 1997 has a higher value than a similar parcel sold in 1996. A careful analysis of the nonlinear relations of the model and the value range of the variables indicates that longer distance from the closest mall as well as lower population density affect land transaction prices positively but at a decreasing rate.

We conducted a comprehensive set of individual and joint misspecification tests on model (Equation [1]) (Spanos). We indicate here (Table 3) only those tests that indicated specification problems with the model. The Jarque–Bera test (Table 3) rejects the null hypothesis that the errors are normally distributed. However, this test is very sensitive to outliers. When 2% of the extreme sample observations were dropped, the hypothesis of normality was not rejected.

To evaluate potential spatial dependence in parcel values, we ordered parcels by neighborhoods and calculated a weight matrix of average land parcel values in each defined neighborhood. Neighborhoods are based on the classification scheme used by the Roanoke County Planning Department. The criteria used for this classification are geographic proximity of spatial units, level of economic development, and conventional and administrative definitions of neighborhoods from other departments of the local government. The sample contains 164 neighborhoods with an average of 12 land parcels included in the sample per neigh-

Table 3. Misspecification Tests for the OLS Land Value Model

Test	Null Hypothesis	Specification	P Value
Jarque–Bera	Residuals are normally distributed.	JB = $(N - k)(4S^2 + (K - 3)^2)/24$. S is skewness, K is kurtosis, and $N - k$ are the degrees of freedom.	0.00
Auxiliary regression	No spatial autocorrelation (ordering according to neighborhoods)	$U = c + ax + bWu$. u is the vector of residuals, c is a constant, x is the vector of variables, and W is the weight matrix.	0.00
ARCH	No second order dependence	$u_z^2 = c + au_{x-1}^2 + bu_{z-2}^2 + du_{z-3}^3$. u, c, and x as in auxillary regression, and z is the ordering factor.	0.00
First joint mean[a]	Linearity, no spatial auto-correlation, structural stability.	$u = c + ax + bx^2 + dWu + kT$. u, x, and W are as described in ARCH, and T is a binary variable with 0 before the break point and 1 after.	0.00
Spatial autocorrelation	No spatial autocorrelation (in the joint mean test)	$u = c + ax + bx^2 + kT$. u, x, W, and T are as described in previous entries.	0.00
Second joint mean	No spatial autocorrelation, no neighborhood fixed effects	$u = c + au_s + bWu$. u, c, u_s, and W are as defined in previous entries.	0.00
Spatial autocorrelation	No spatial autocorrelation (in the joint mean test)	$u = c + au_s$. u, c, and u_s are as defined in previous entries.	0.00
Fixed effects	No neighborhood fixed effects (in the joint mean test)	$u = c + bWu$. u, c, and W are defined in previous entries.	0.00
Joint variance[a]	Homoskedasticity, no second order dependence and structural stability.	$u_z^2 = c + ax + bx^2 + du_{z-1}^2 + kT$. u, c, x, W, z, and T are as described in previous entries.	0.00
Second order dependence	No dependence in residual variance (in joint variance test)	$u_z^2 = c + ax + bx^2 + kT$. u, c, x, and T are as described in previous entries.	0.00
Fixed effects	No neighborhood fixed effects	$u = c + au_s$. u, and c are defined in previous entries, and u_s is the residual average of a neighborhood.	0.00

[a] Break point at $n = 213$.

borhood. Neighborhoods vary in size with some close to Roanoke City having a diameter smaller than 0.3 km, while neighborhoods at the borders of the Roanoke County are large enough to capture similar characteristics of remote parcels.

Test results indicate that spatial autocorrelation is probably the most serious problem in Equation (1). The auxiliary regression test indicates there is spatial autocorrelation of errors in model 1. The ARCH test rejects the null hypothesis of no second order spatial dependence. Thus, the residual terms of the land value model seem to exhibit first (of the means) and second (of the variance) order spatial dependence. The first and second joint mean tests in Table 3 confirm that the hypotheses of linearity, structural stability, and no spatial dependence do not hold jointly. In the first joint mean test, spatial autocorrelation has the lowest P value in the joint test. In the second joint mean test, the low P values of the no neighborhood fixed effects hypothesis and the joint hypothesis of no spatial autocorrelation and no neighborhood fixed effects contribute to rejection of the joint hypothesis. The second joint mean test and the fixed effects tests indicate that parameters (b and σ^2) may vary across neighborhoods. Second order dependence seems to be the main reason for the rejection of the joint variance test, which hypothesizes homoskedasticity, structural stability, and no second order dependence.

Given that missing neighborhood specific variables are often the source of spatial autocorrelation (Anselin 1988, 1999), a fixed effects model was estimated by deducting from all variables their average values within each neighborhood as defined by the Roanoke County Planning Department. The resulting model showed an improvement in the P value (auxiliary regression and joint mean test) of the hypothesis of no spatial autocorrelation, but there was still significant evidence of second order dependence. When observations were ordered by neighborhood, development status, and assessed value of construction, there was evidence of structural instability as indicated by Chow tests and low estimated P values for the first joint mean and joint variance tests.

There is strong evidence for a structural break between developed and undeveloped parcels. The P value of the Chow test for $n = 213$ corresponding to the vacant parcels is close to zero. Plots of recursive OLS estimates indicate substantial change in the magnitude of coefficient estimates for several variables after the first 213 observations corresponding to vacant parcels. Plots also indicate the possibility of structural instability in the developed parcels when they are ordered according to the assessed value of their construction. Almost all plots have some type of "jump" around the 750th observation, when the assessed value of the construction is about \$60 per square foot. Land parcels with expensive construction may follow a different stochastic process than parcels with inexpensive construction.

In addition, window OLS does not support the hypothesis that the parameter estimates for developed parcels are the same before and after the 750th observation. This lack of support is demonstrated by the low P value of the Chow forecast test. The Chow forecast test estimates the fixed effects model for the subsample of observations 214 through 750 (parcels with an assessed value below \$60 per square foot), and then examines the difference between actual and predicted land values for observations 751 through 1,803 (parcels with an assessed value between \$60 per square foot and \$200 per square foot). Based on these results and the improved performance on misspecification tests described in the following section, the final models used in the study involved separate estimates for vacant parcels and two subgroups of developed parcels. The first group contains parcels with inexpensive construction, while the second group has parcels with expensive construction.

Developed Parcels

Equations (2) and (3) are estimated for developed parcels with expensive and inexpensive construction, respectively. For simplicity, neighborhood effects are not reported.

$$\begin{aligned}(2)\quad \text{Log(Price)} = {} & A_1[\text{Log(Size)}] \\ & + A_2[\text{Log(Size)}]^2 \\ & + A_3[\text{Log(Size)}]^3 \\ & + A_4[\text{Log(Population)}] \\ & + A_5[\text{Log(Elevation)}] \\ & + A_6(\text{Soil1}) \\ & + A_7(\text{Soil2}) \\ & + A_8[\text{Log(Mall)}] \\ & + A_9[\text{Log(Town)}] \\ & + A_{10}[\text{Log(X)}] \\ & + A_{11}[\text{Log(Y)}] + A_{12}[\text{Year}] \\ & + u\end{aligned}$$

$$\begin{aligned}(3)\quad \text{Log(Price)} = {} & A_1[\text{Log(Size)}] \\ & + A_2[\text{Log(Population)}] \\ & + A_3[\text{Log(Elevation)}] \\ & + A_4(\text{Soil1}) \\ & + A_5(\text{Soil2}) \\ & + A_6[\text{Log(Mall)}] \\ & + A_7[\text{Log(Town)}] \\ & + A_8[\text{Log(Town)}]^2 \\ & + A_9[\text{Log(X)}] \\ & + A_{10}[\text{Log(Y)}] \\ & + A_{11}[\text{Year}] + u.\end{aligned}$$

The *P* values of individual and joint misspecification tests indicate that there is adequate support for all underlying assumptions for models 2 and 3. Specification problems with the original model are largely cleared up as shown by tests results in Table 4. The Jarque–Bera test provides adequate support for the assumption of normality in developed parcels. Relatively high *P* values for the auxiliary regression confirm that spatial autocorrelation does not exist in this model, while ARCH test results also indicate that there is no second order dependence. In addition, Chow tests at break points of $n = 200$, 400, and 800 and the joint mean test provide support for the structural stability of the model. Because the redundancy test indicates that coefficients of Road and LogX * LogY are statistically equal to zero in both models, these variables are omitted from the models as reported in Table 5. The omission of these variables does not alter the conclusions of the misspecification tests.

The fixed effects land value model for parcels with expensive construction explains 73% of the variation in land transaction prices (Table 5). Parcel size is an important determinant of land value in this group. Larger land parcels are associated with lower land values per square meter. Higher elevation is associated with higher land values, while weaker evidence indicates that impermeable soils (as indicated by the Soil1 and Soil2 dummies) are associated negatively with land values. Higher elevation and soil permeability are indicators of lower flood risk and results indicate that lower flood risk areas have higher land values. Roanoke County has experienced several floods in the last 50 years (Roanoke County Planning Department). Land parcel values decline with distance from the two major malls, perhaps because of the shopping facilities, entertainment amenities, and other services provided. The average price of land parcels sold in 1997 is higher than those sold in 1996. Estimates for population, distance from town, and Log X and Log Y of the site's location are not statistically significant although they were significant in the original OLS specification.

The OLS fixed effects land value model for the inexpensive construction parcels explains about 65% of the variance in land transaction prices. Larger parcels have lower land value per square meter. Lack of soil permeability to water (as indicated by the Soil1 and Soil2 dummies) is expected to lower land prices. The negative relationship of land values with distance from the nearest town reflects the effects of distance to amenities and lower residential and commercial development potential. The quadratic term of the distance to the nearest town indicates that the parcel value

Table 4. Misspecification Tests for Land Value Models for Developed and Undeveloped Parcels

			P Values		
Test	Null Hypothesis	Specification	Expensive Construction	Inexpensive Construction	Undeveloped Parcels with Spatial Lags
Jarque–Bera	Residuals are normally distributed.	$JB = (N - k)[4S^2 + (K - 3)^2]/24$. S is the skewness, K is the kurtosis, and $N - k$ are the degrees of freedom.	0.377	0.511	0.000
Auxiliary regression	No spatial autocorrelation(ordering according to neighborhoods)	$u = c + ax + bWu$. u is the vector of residuals, c is a constant, x is the vector of variables, and W is the weighting matrix.	0.177	0.425	0.425
ARCH	No second order dependence	$u_z^2 = c + au_{z-1}^2 + bu_{z-2}^2 + du_{z-3}^3$. u is the vector of residuals, c is a constant, x is the vector of variables, and z is the ordering factor.	0.085	0.098	0.002
Chow[a]	Existence of structural change	F statistic based on the comparison of restricted and unrestricted sum of square residuals.	>0.1	>0.1	0.395
Joint mean[a]	Linearity, no spatial autocorrelation and structural stability	$u = c + ax^2 + bWu + dT$. u, x, and W are as described in previous entries. T is a binary variable with 0 before the break point and 1 after.	>0.1	>0.1	0.164
Joint variance[a]	Homoskedasticity, no second order dependence and structural stability	$u_z^2 = c + ax^2 + bu_{z-1}^2 + dT$. u, c, x, W, z, and T are as described in previous entries.	>0.1	>0.05	0.077
Redundancy[b]	Variables "Road" and "LogX*LogY" are essential for the land value model.	F-test comparing residual sums of squares for the land value model with and without these variables.	0.000	0.000	0.000

[a] Break points of $n = 400$ and $n = 800$ for the expensive construction group, $n = 200$ and $n = 400$ for the inexpensive construction group, and $n = 100$ for the undeveloped parcels.
[b] Road is not redundant and Soil1 and Soil2 are redundant in the undeveloped parcel model.

Table 5. OLS Estimates for the Fixed Effects Land Value Model for Observations in the Expensive and Inexpensive Construction Groups

	Coefficient	Standard Deviation	*t*-Ratio
Expensive construction group			
Log(Size)	−0.829923	0.021288	39.3
[Log(Size)]^2	0.056520	0.031224	1.37
[Log(Size)]3	0.000737	0.040547	2.59
Log(Population)	−0.002805	0.003200	0.87
Log(Elevation)	0.288472	0.167098	1.82
Soil1	−0.020531	0.034965	0.58
Soil2	−0.086192	0.049628	1.74
Log(Mall)	−0.192311	0.010076	1.97
Log(Town)	0.024088	0.251096	0.09
LogX	−0.109929	0.177109	0.62
LogY	0.155010	0.128656	1.20
Year	0.044958	0.007231	6.21
R^2	0.7316	Adjusted R^2	0.7286
Inexpensive construction group			
Log(Size)	−0.747182	0.027792	26.9
Log(Population)	−0.004161	0.002680	1.56
Log(Elevation)	0.054530	0.070985	0.77
Soil1	−0.102809	0.045168	2.27
Soil2	−0.153847	0.078481	1.97
Log(Mall)	0.019926	0.137524	0.14
Log(Town)	−0.369564	0.183270	2.06
[Log(Town)]2	−0.002119	0.000856	2.25
LogX	0.230214	0.035913	6.27
LogY	−0.097929	0.113661	0.85
Year	0.061557	0.012926	4.76
R^2	0.6556	Adjusted R^2	0.6497

increases at a decreasing rate when a parcel is closer to the town center. The importance of location is also reflected by the statistical significance of Coordinate X, which locates the parcel from southeast to northwest in Roanoke County. The price of lots sold in 1997 is higher than those sold during the previous year. Estimates for elevation, population in the area surrounding the tract, distance from a mall, and Log Y of the site location are not statistically significant although they were significant in the original OLS specification.

Undeveloped Parcels

The fixed effects model (Equation [4]) was estimated for the group of undeveloped parcels.

$$
\begin{aligned}
\text{Log(Price)} = {} & A_1[\text{Log(Size)}] \\
& + A_2[\text{Log(Size)}]^2 \\
& + A_3[\text{Log(Elevation)}] \\
& + A_4[\text{Log(Population)}] \\
& + A_5(\text{Soil1}) \\
& + A_6(\text{Soil2}) \\
& + A_7[\text{Log(Mall)}] \\
& + A_8[\text{Log(Town)}] \\
& + A_9(\text{Road}) \\
& + A_{10}(\text{Year}) + A_{11}[\text{Log(X)}] \\
& + A_{12}[\text{Log(Y)}] \\
& + A_{13}[\text{Log(X)}][\text{Log(Y)}] + u.
\end{aligned} \tag{4}
$$

Individual and joint misspecification tests provide support for the assumptions of

Table 6. OLS Estimates for the Fixed Effects Land Value Model for Undeveloped Parcels

Variable	Coefficient	Standard Deviation	t–Ratio
Log(Size)	−0.695926	0.028389	24.50
$[\text{Log(Size)}]^2$	0.019661	0.012441	1.58
Log(Mall)	−0.313128	0.106184	2.95
Log(Town)	1.722006	0.376349	4.57
Road	−0.210169	0.057640	3.64
LogX	0.437769	0.139052	3.15
LogY	−0.195595	0.099372	1.97
Year	0.023158	0.020734	1.12
WLog(Price)	−1.725382	0.075915	22.70
WLog(Size)	−1.197150	0.069400	17.20
WLog(Town)	3.371006	0.844649	3.99
Wroad	−0.343883	0.085956	4.00
WlogX	0.959943	0.423241	2.27
WlogY	−0.555855	0.272661	2.04
Wyear	0.084640	0.047181	1.79
R^2	0.9516	Adjusted R^2	0.9482

linearity, homoskedasticity, and structural stability. Low P values were reported for the Jarque–Bera test, suggesting possible violation of the normality assumptions. However, when some observations (less than 1%) were excluded from the sample, the P value of the Jarque–Bera tests exceeded 0.1, and provided support for the assumption of normality. However, the auxiliary regression, ARCH, and the joint mean and variance tests have low P values, indicating that the assumptions of no first and second order spatial dependence are violated. This subgroup of parcels is probably less homogeneous than the two subgroups of developed parcels.

Following Spanos we estimated a fixed effects model for the vacant parcels, which also allows spatial lags of the dependent and independent variables. Parcels are ordered by neighborhood. As shown in Table 4, the joint mean, joint variance, and auxiliary regression tests provide support for the assumptions of linearity, homoskedasticity, structural stability, no spatial autocorrelation, and correct functional form. However, there is still limited support for the hypothesis of no second order spatial dependence (ARCH test). The coefficients of Soil1 and Soil 2, as well as LogX * LogY and its spatial lag are not statistically different from zero, and the joint F-test recommends dropping these variables from the model. The final model estimated is Equation (5) and model estimates are shown in Table 6.

$$
\begin{aligned}
\text{Log(Price)} = {} & A_1[\text{Log(Size)}] \\
& + A_2[\text{Log(Size)}]^2 \\
& + A_3[\text{Log(Mall)}] \\
& + A_4[\text{Log(Town)}] \\
& + A_5(\text{Road}) + A_6[\text{Log(X)}] \\
& + A_7[\text{Log(Y)}] \\
& + A_8(\text{Year}) \\
& + A_9[\text{WLog(Price)}] \\
& + A_{10}[\text{WLog(Size)}] \\
& + A_{11}[\text{WLog(Town)}] \\
& + A_{12}(\text{WRoad}) \\
& + A_{13}[\text{WLog(X)}] \\
& + A_{14}[\text{WLog(Y)}] \\
& + A_{15}(\text{WYear}) + u.
\end{aligned}
\tag{5}
$$

Parcel size is again significantly and negatively related to land price per square meter as indicated by the statistical significance of the linear term of log of size. Higher land values should be expected for parcels that are closer to the shopping malls, but far from town centers. Land value is also lower when the parcel is next to a major road. The importance of the parcel location is also underlined by the statistical significance of X and Y. The Year variable is not significant, although it was significant in the original OLS model. Finally, spatial lags are used in addition to fixed neighborhood effects to control for spatial autocorrelation. The coefficients of spatial lags are larger than the coefficients of the respective explanatory variables, implying that neighborhood hedonic characteristics may have stronger effects on a parcel's value than the characteristics of that parcel. The signs of spatial lags are consistent with the signs of their respective explanatory values. For example, an increase in the size of a parcel and increases in the sizes of the parcels in a neighborhood move the price of the land parcel in the same direction. The high R^2 value of 0.95 suggests that spatial lags capture additional variation of the dependent variable in this case study compared with the original OLS specification. However, the high R^2 value would have no meaning if the model were not well specified.

Conclusions

Three alternative models using OLS and fixed effects of neighborhoods were estimated to explain the variation in prices of parcels that are undeveloped, parcels with inexpensive construction, and parcels with expensive construction in Roanoke County. The study found no spatial dependence in the developed parcel markets, but there is spatial dependence in the undeveloped parcel market. Spatial dependence in the undeveloped parcels is probably due to those parcels being more diversified than developed parcels, and their values are largely influenced by specific neighborhood characteristics.

A major similarity among the models is the relationship between size and price. All three models estimate a negative relationship between size and price per square meter. The relationships are linear, linear, and cubic (in logs) for parcels with inexpensive construction, no development, and expensive construction, respectively. Population density in the area surrounding the parcel is not significant in any of the models. All models show higher estimated prices in the second year of transaction data, although the relationship is not significant for undeveloped parcels.

Some major dissimilarities among the models include the influence on land value of elevation and location relative to a mall, town, or road. Elevation is positively related to value for expensive construction, but not significant for parcels with inexpensive construction or undeveloped parcels. The importance of views to property values has been noted by others (Paterson and Boyle). Perhaps higher elevations have better views, which are more valued for expensive homes. The values of parcels with expensive construction and undeveloped parcels decline with distance from a mall while value of parcels with inexpensive construction declines with distance from the town. It may be that owners of expensive homes are more concerned with access to amenities provided by a mall while owners of inexpensive homes are more concerned with amenities provided in the town itself. Being located on a primary or secondary road reduces the value of undeveloped parcels, but does not affect values of developed parcels. While results are specific to Roanoke County, VA, the study area is representative of other small to midsize metropolitan areas in the southeastern United States, indicating that these results may be able to be generalized across these types of land markets.

The analysis described here has potentially useful application to the analysis of tax and land value implications of alternative zoning strategies. Possibly zoning strategies permitting large lot developments could maximize net tax revenues when land is abundant relative to incoming residents while zoning strategies focused on small lot developments might maximize net tax revenues when land is limiting relative to incoming residents. However, analysis of zoning strategies should also incorporate statistical uncertainty of the estimates of the relationship between land value and parcel size and potential behavioral responses by developers and home buyers to alternative zoning plans.

The better statistical fit of the model for undeveloped parcels compared with developed parcels may be due to the procedure of estimating values of developed parcels by subtracting the assessed value of the development from the total of the real estate. Possibly market values of structures are not well reflected in assessed values. Further research is needed on the assessed values and ways of explicitly incorporating the potential noise in assessed development values into a hedonic price function.

More research is necessary to examine how parcel size affects land value. Of particular interest is how demand for larger lots is affected by the form of residential development. More research also is needed on the effects of demographic characteristics including age, number of children, and income on demand for larger residential lots. Possibly as the population of a region ages, demand for larger lots will decline relative to demand for access to other urban amenities.

[Received October 2006; Accepted November 2007.]

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