Spatial Economic Analysis of a Rural Land Market

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ABSTRACT

Although significant progress has been made in rural land market modeling efforts, there is a need to develop improved procedures for examining the spatial characteristics of these markets. Geographical Information Systems (GIS) procedures are used to provide a spatial view of rural land value data. These procedures identified relationships for testing the effect of location and economic development on rural land values. Hedonic model results indicate that tract location and whether the tract is located in a metropolitan statistical area (MSA) has a statistically significant effect on rural land values in southeast Louisiana.

INTRODUCTION

Traditionally, rural land values have been influenced by site and other characteristics such as soil quality, type of crops grown, size of tract, relative accessibility, improvements, and government programs. However, more recently, population and economic development pressures have caused the expansion of urban areas, which has resulted in an increased demand for rural land. Development of suburban areas and the general movement of people into rural areas have also increased the demand for agricultural land. Raup (1980) reported that in 1960, 8.7 percent of the U.S. land area (48 contiguous states) was in Standard Metropolitan Statistical Areas (SMSA's), whereas, in 1980, 20 percent of the U.S. land area was estimated to be in SMSA's. The effect of this expansion on rural land markets is documented in several empirical studies. Chicoine (1981) noted that soil productivity's influence on farmland prices in the urban fringe market appears to be overshadowed by the locational attributes of parcels. Clonts (1970), in an analysis of land values at the urban periphery, estimated that urban development explained 30 percent of the variation in the value of land and improvements.

More recent studies have found location to have a significant influence in explaining the variation in per acre land values in rural land markets. In an Oklahoma study, Kletke and Williams (1992) concluded that location within the state was likely to be as important as any other factor in determining value. Adrian and Cannon (1992) found that land values in the urban fringe of Dothan, Alabama were almost three times the values in the rural segment. Shonkwiler and Reynolds (1986) concluded that in studies without variables to reflect the effect of non-agricultural use potential, distance variables must be recognized as measuring a set of the non-agricultural effects.

While previous studies have measured the effects location on rural land values, relatively few studies have measured the effect of potential economic development on rural land values. The general objective of this study is to develop a model that measures the effect of location and economic development on rural land values in southeast Louisiana. The approach of this study is to use geographical information systems (GIS) procedures to provide an insight into the spatial characteristics of this land market. In the next section, GIS procedures along with rural land market survey data are used to identify measures of location and economic development to be included in a hedonic analysis of rural land values for the area. Hedonic modeling procedures are presented in the following section, while the empirical results and conclusions are presented in final sections.

DATA AND GIS PROCEDURES

This study differs from other hedonic studies of rural land markets in that GIS procedures are used to review spatial characteristics of rural land sales data. GIS is defined as an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (Environmental Systems Research Institute, Inc., 1993). Burrough (1987) indicates that GIS should be thought of as a model of the real world, which is more than a means of simply coding, storing, and retrieving data.

Data for this study are based on rural land market sales for the southeast market area of Louisiana that were collected using mail survey techniques. Established procedures outlined by Dillman (1978) were used to conduct the mail survey on an annual basis. The survey procedure included an initial mailing of the survey, sending a post card reminder approximately 10 days after the initial mailing, and sending a duplicate questionnaire approximately four weeks after the original mailing.

The rural land market survey was mailed to state certified appraisers, officers in commercial banks, Farm Service Agency personnel, Federal Land Bank personnel, Production Credit personnel, members of the Louisiana Chapter of the American Society of Farm Managers and Rural Appraisers, and members of the Louisiana Realtors Land Institute. This comprehensive list of professionals familiar with rural land sales contributed to a relatively low individual response rate each year, but respondents typically provide multiple sales in their response. As a result, 1,811 sales were reported statewide for the period January 1993 through June 1996. For the market area reported here, a subset of the larger state data base, with 204 reported sales, was used.

Multivariate procedures were used to identify a rural land market in Southeast Louisiana (Kennedy et al., 1997). This market (Figure 1) consists of eight parishes where the primary soils of the area are Southern Mississippi Valley Silty Uplands, Coastal Plain, and Gulf Coast Flatwoods. The area is characterized by rolling hills with pine tree, nursery crop, dairy farm, and other animal production activities.

The GIS software used in this analysis is the basic ARC/INFO data model. The model can be used to describe abstract geographic features in points, lines, and areas whose attributes are kept in relational tables (Environmental Systems Research Institute, Inc., 1995). An important feature of GIS and the ARC/INFO model is the ability to overlay data for analysis. Overlay is the process of stacking digital representations of spatial data on top of each other so that new information can be revealed, visualized, and analyzed. For example in Figure 1, the location of each sale tract is overlayed on a parish map. The overlay in Figure 1 not only provides a spatial view of the data but also suggests a positive relationship between the per acre value and the proximity to the Baton Rouge and New Orleans metropolitan areas. It is hypothesized that relatively large per acre tract values in St. Tammany parish result from the Lake Pontchartrain Causeway bridge that links New Orleans with this area. The bridge provides a convenient access across the lake for commuters from New Orleans.

Relatively large per acre sales in the Baton Rouge and New Orleans areas suggest that location has an influence in this market. GIS procedures were used to compute distance between each tract and the nearest city. These straight line distances (Figure 2) were estimated and electronically added to the rural land data base. GIS distance estimates in Figure 2 generally reflect three groups of sales. The first includes a group of sales north and within commuting distance of Baton Rouge, and another group of sales north and within commuting distance of New Orleans. Both areas are considered commuting communities for the respective cities, with a downtown drive time of approximately one hour or less. The final group of sales in the north-central section of the market area is not generally considered to be a convenient commuting distance to either metropolitan area.

Within the ARC/INFO software package, the Triangulated Irregular Network (TIN) was used to develop a land value contour map for the entire state. Similar to topographic maps that show equal elevation above sea level, the Louisiana land value contour map presented in Figure 3 was estimated from 1,811 sales and depicts areas with approximately equal per acre land values. Each contour line is drawn as a continuous line identifying land values at $500 price intervals. Isolines located close together indicate steep price gradients in short distances, while isolines located further apart indicate much smaller price gradients. Estimated contour lines presented in Figure 3 indicate substantial variation in rural land values throughout the state. Thick contour lines represent per acre values at $1,000 increments while the thin lines represent $500 increments.

The overlay of rural land value contours on Metropolitan Statistical Areas (MSA's) in Figure 3 suggests that economic activity and the potential for economic development has an influence in rural land markets. Moreover, these results generally indicate a strong correspondence between concentrated rural land value contours and Louisiana MSA's. In the market area, relatively steep land value gradients in southeast Louisiana lie at the heart of the Baton Rouge MSA. Similarly, a concentration of contours in St. Tammany parish, which is the northern most parish for the New Orleans MSA, suggests that economic activity in this area has a positive influence in the rural land market. In general, the concentration of contours on MSA's suggests that economic development has a positive influence on rural land values which implies a need to include this variable in a hedonic model of the rural land market.

HEDONIC MODEL

An empirical procedure used in this study is the hedonic pricing model. Rosen (1974) defined hedonic prices as the implicit prices of attributes and notes that they are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them. Prices of these characteristics are implicit because there is no direct market for them. Palmquist in 1984 provided a discussion of the theoretical basis for using hedonic analysis in rural land value studies, while Danielson in the same year used the procedure to empirically analyze the rural land market in North Carolina.

Following the approach used by Danielson, a transcendental function was specified for hedonic estimation in this study.

$$Price = \beta_0 Z_1^{\beta_1} \exp\left[\sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon \right] \tag{1}$$

where Price is the per acre price of land, Z_1 is the size of tract in acres, m is the number of additional continuous variables (X_i), n is the number of discrete (dummy) variables (D_j), and e is a random disturbance term. Taking the natural logarithm of both sides of equation (3.13) gives:

Figure 1
Tract Location and Magnitude of Per Acre Selling Price, Rural Land Market Survey, Southeast Louisiana, 1993-1996

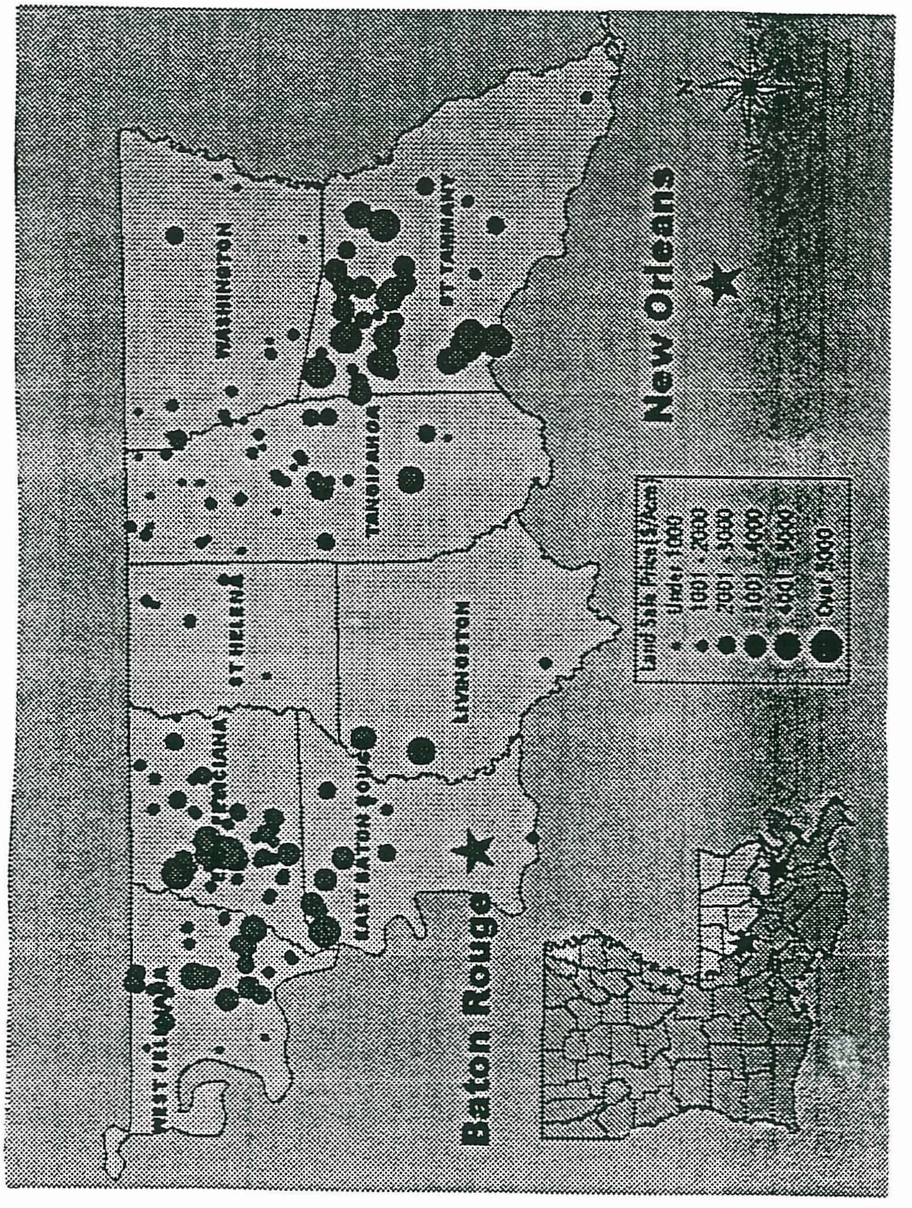


Figure 2
GIS-Estimated Straight Line Distance Between Each Tract and Nearest City, Rural Land Market Survey, Southeast Louisiana, 1993-1996.

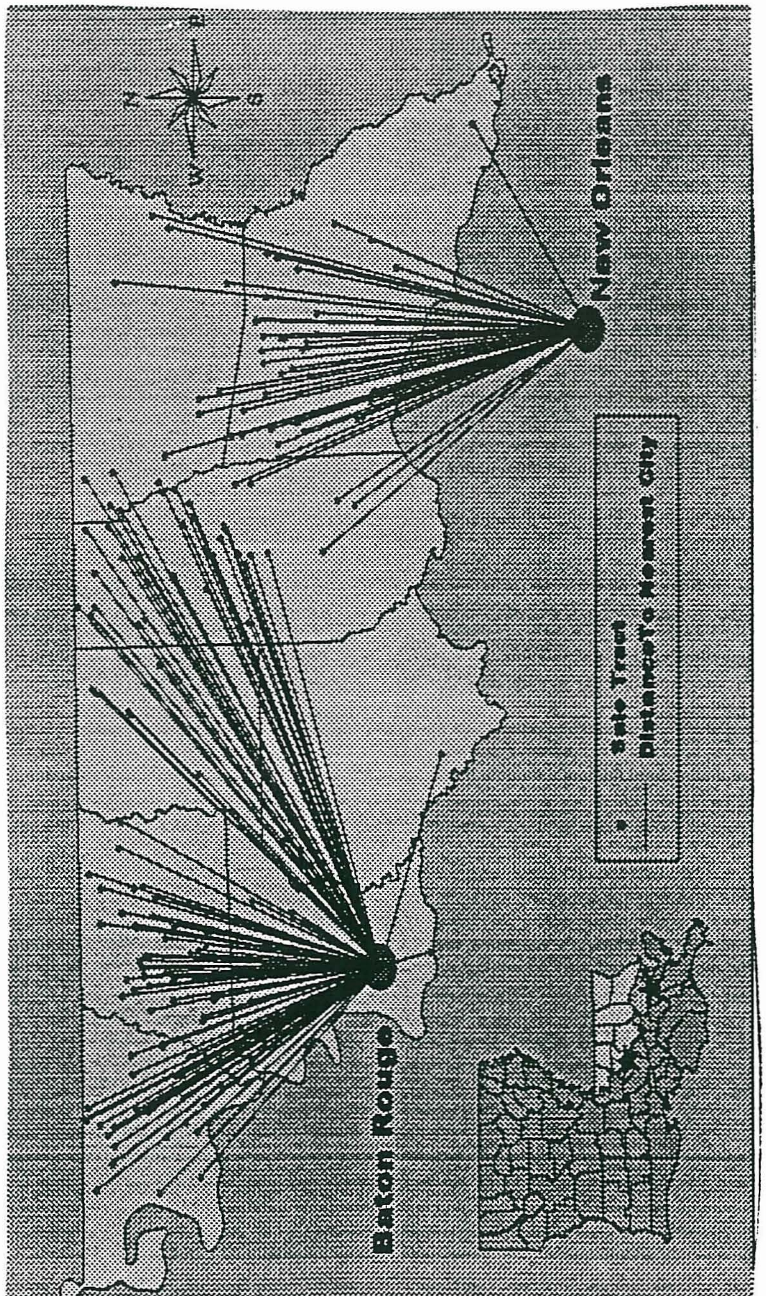
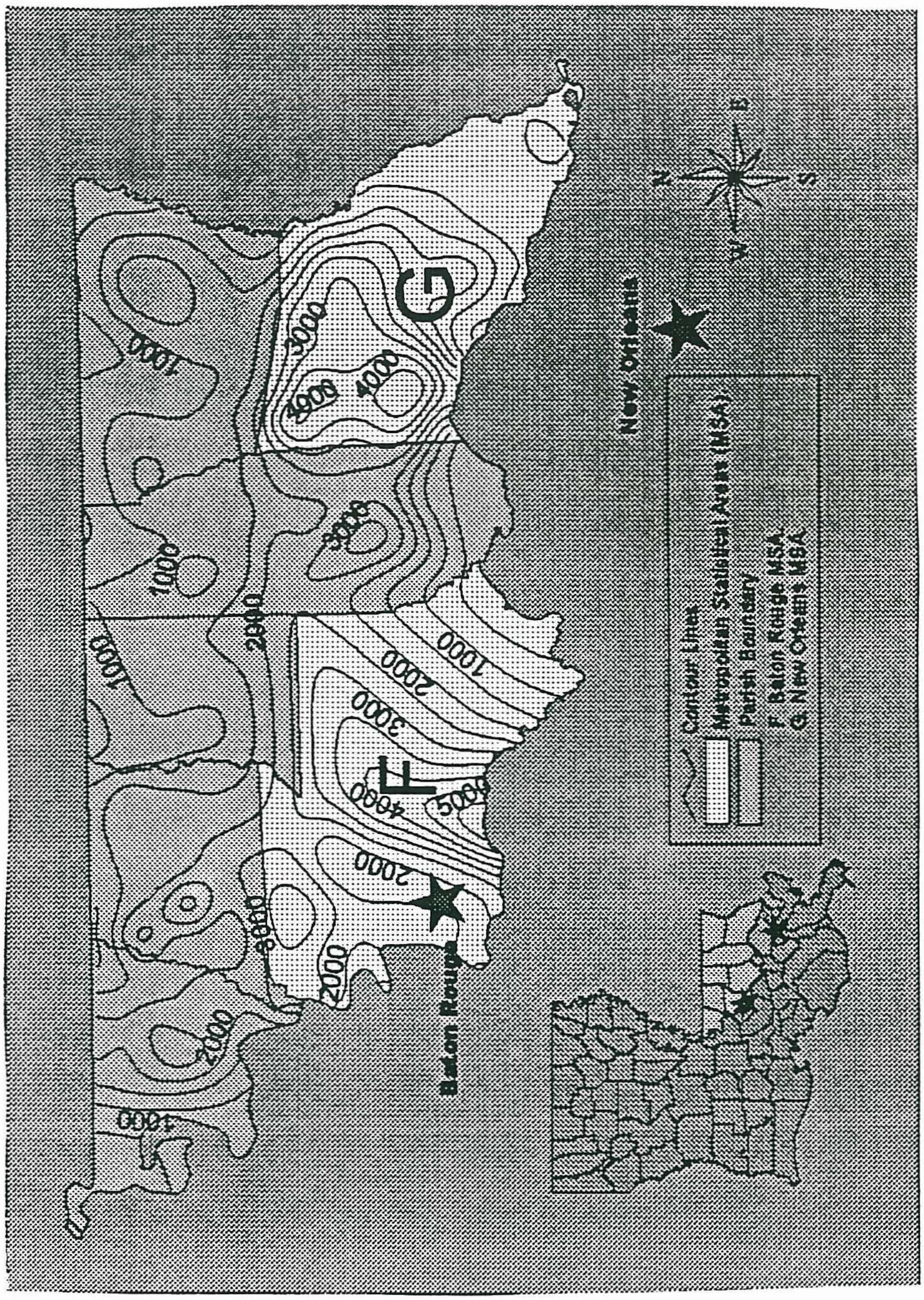


Figure 3
GIS Land Value Contour Map Estimated at $500 Increments and Overlayed on Southeast Louisiana MSA's, Rural Land Market Survey, 1993-1996



$$\ln \text{Price} = \ln \beta_0 + b_1 \ln Z_1 + \sum_{i=1}^{m} a_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \epsilon. \tag{2}$$

Because the price of land is hypothesized to decline as the size of tract (Z_1) increases, but at a decreasing rate, nonlinearities were incorporated for Z_1. Therefore, b_1 is hypothesized to be negative, although the specification allows it to be negative or positive.

The implicit marginal price of each characteristic is an estimate of the amount by which the per acre land price changes, given a unit change in the characteristic. For all except the discrete variables in equation (2), the implicit marginal prices (i.e., the partial derivatives) are given by the following:

$$\partial \text{Price}_t / \partial Z_{1,t} = \text{IMPSIZE}_{1,t} = [\beta_1 / Z_{1,t}] \times \text{Price}_t$$
$$\partial \text{Price}_t / \partial X_i = \text{IMPX}_{i,t} = a_i \times \text{Price}_t. \tag{3}$$

The subscript, t, implies that there are implicit marginal prices associated with each land transaction. An estimate of the implicit marginal price at the mean price and mean level of characteristic over all observations is obtained by substituting mean values of each variable in equation (4).

The derivation of implicit prices for discrete variables (D_j) in semilogarithmic equations is not as straightforward. Kennedy (1981) suggests the following estimation procedure where the variance of the coefficient of the discrete variable is taken into account:

$$\text{IMPD}_j = (\exp [c_j - 2\ V(c_j)] - 1) \times \text{Mean Price}, \tag{4}$$

where IMPD_j is the implicit price of the discrete variable, c_j is the estimated coefficient of the discrete variable parameter, D_j; $V(c_j)$ is the variance of the estimated coefficient, c_j; and Mean Price is the mean price per acre over all observations used in the model. Taking $V(c_j)$ into account can lead to less bias in the estimate when the variance of c_j is substantial.

Variables used in the hedonic pricing analysis and their expected signs are presented in Table 1. PRICE in Table 1 is the dependent variable used in the first stage hedonic model and represents the average per acre selling price for each tract of rural land and improvements. Continuous variables expected to have an inverse relationship with per acre selling price include size of tract (SIZE) and distance to nearest city (DNC). There is generally a negative relationship between size of tract and per acre selling price because there are fewer buyers competing in markets for larger tracts; whereas, there are generally many buyers competing in markets for smaller sized tracts. Location theory generally suggests an inverse relationship between distance to markets and per acre selling prices.

Characteristics expected to positively influence rural land values include the value of improvements made on or to the tract (VALUE), the presence of paved road access (RT), the time of sale (TIME), and if the tract is located in a metropolitan statistical area (MSA). Paved road access is expected to reflect development potential and accessibility. Similarly, the location of a tract in an MSA is expected to be influenced by economic development. For the study period, land values have been trending upward, hence time is expected to have a positive influence on per acre values in the area. The sign for TIMBER is expected to depend on the nature of sale tracts in the area. Merchantable and pre-merchantable timber is expected to have a positive influence on value, whereas cut-over timber is expected to have a negative influence on per acre value.

Table 1
Variables Used In Hedonic Model Estimation, Southeast Area, Louisiana Rural Land Market Survey, 1993-1996.

Symbol	Variable	Expected Sign
Continuous Variables		
PRICE	Per acre price of land ($)	
SIZE	Size of tract (acres)	(-)
TIMBER	Percent of timber in tract	(+ or -)[a]
VALUE	Value of improvements ($)	(+)
DNC	Distance to nearest city (miles)	(-)
TIME	Month of sale	(+)
Discrete Variables (1,0)		
RT	Paved access road	(+)
MSA	Parish located in a metropolitan statistical area	(+)

[a] Merchantable and pre-merchantable timber would be expected to have a positive influence on the per acre selling price. Cut over timber land would be expected to have a negative influence.

EMPIRICAL RESULTS

First stage hedonic results for the southeast Louisiana rural land market are presented in Table 2. Results indicated that hypothesized variables explain 53 percent of the variation in rural land values. The multicollinearity condition number (17.58) was under 20, which suggests that multicollinearity is not a problem in the rural land value model. Similarly, the Keifer-Salmon test does not indicate a rejection of the hypothesis that error terms are normally distributed at the one percent level. The Breusch-Pagan and the White tests suggested that heteroskedasticity was not a problem for the hedonic model.

First-stage OLS hedonic regressions for each market area, using the model specification given by equation 2, are presented in Table 2. Estimates indicate that the mean size of tract was 115.878 acres. Moreover, the coefficient for size of tract (SIZE) was statistically significant and the negative sign for the coefficient reflects the expected inverse relationship between per acre value and size of tract.

All coefficients for the hedonic rural land value model were estimated to be statistically significant at the .10 significance level, and all coefficients were estimated to have the correct hypothesized signs. Specifically, size of tract (SIZE), the percent of timber in the tract (TIMBER), and the distance to the nearest city (DNC) were estimated to have a negative relationship with per acre value, while value of improvements (VALUE), time of sale (TIME), road type (RT), and metropolitan statistical area (MSA) variables were estimated to have a positive influence on per acre value.

Marginal implicit prices are used to observe the magnitude and direction of influence of various model factors on per acre land values. For convenience, marginal implicit prices are evaluated at mean values of per acre price and of the characteristic. A positive marginal implicit price suggests that an increase in that characteristic results in an increase in the per acre price of rural land, other factors held constant. Conversely, a negative marginal implicit price resulting from a negative coefficient has a depressing effect on per acre real estate prices. Marginal implicit prices in Table 2 are estimated from mean values and equations 3 and 4.

Table 2.
Estimated Variable Means, Coefficients Of First Stage Hedonic Model, And Marginal Implicit Prices Of Characteristics At Mean Levels, Southeast Louisiana, 1993-1996.

Variable	Variable Mean[a]	Estimated Coefficients[b]	Marginal Implicit Price[c]
ln SIZE	115.878	-0.2272970	-4.51773
	(158.498)	(-7.199)***	
TIMBER	36.598	-0.0012685	-2.92157
	(41.480)	(1.748)**	
VALUE	18,099.240	0.0000027	0.00629
	(39,432.290)	(3.492)***	
DNC	37.171	-0.0120229	-27.69085
	(11.541)	(-4.524)***	
TIME	22.328	0.0142245	32.76153
	(12.513)	(5.638)***	
RT	0.632	0.2227960	569.26202
	(0.483)	(3.592)***	
MSA	0.314	0.523175	1,573.64834
	(0.465)	(7.478)***	
Intercept		8.325890	
		(45.066)***	
PRICE	2,303.180		
	(1584.190)		
R^2		0.5327	
F-Value		31.9227	
N		204.00000	

[a] Standard deviation in parentheses.
[b] Student t-ratios in parentheses, *** denotes significance at the .01 level, and ** denotes significance at the 0.10 level.
[c] Unit of measurement is in dollars.

The marginal implicit price for size of tract at the mean size and price is estimated to be \$-4.51773 in Table 2. This means that per acre land price declines by -\$4.52 (rounded) with a one acre increase in size at the mean. However, the marginal implicit price varies with the size of tract. This means that tracts larger than the average size of 115.878 acres in the Southeast area yield implicit marginal prices that decline less than \$4.51773 per acre with a one acre increase in size while the converse is true for tracts below the mean size. For example, if the mean per acre size was 150, the marginal implicit price is estimated at -\$3.49 per acre, whereas, if the average size was 50 acres, the marginal implicit price is estimated at -$10.47 per acre.

The marginal implicit price for the value of improvements was estimated to be 0.00629 while this estimate for the percent of timber in the tract was -2.92157. This suggests that $10,000 of improvements on a tract of land in the southeast Louisiana would increase land value by $62.90 per acre, assuming all other factors constant. Similarly, each percent increase in cut-over pine timber is expected to decrease per acre value by $2.92. The marginal implicit price for time of sale indicates that each month between January 1993 and June 1996 adds $32.76 to per acre value.

Marginal implicit prices in Table 2 suggest that nonagricultural factors representing economic development and location (metropolitan areas, distance to nearest city and type of road adjacent to rural property) have substantial impacts on rural land value in the market area. The marginal implicit price for the MSA variable indicates that tracts located in a MSA generally sell for $1,574 more per acre than tracts not located in a MSA. The effect of location suggests that as distance to nearest city declines by one mile, the per acre value of land increases by $27.69 per acre. Similarly, the marginal implicit price for paved road access (RT) is valued at $569.26 per acre. Timber was the only agricultural variable to be statistically significant, with an additional acre of timber actually reducing land value by $2.92 per acre.

CONCLUSIONS

Visual observation, using GIS procedures, suggests the existence of a spatial relationship between per acre rural land values and the distance to the metropolitan statistical areas of Baton Rouge and New Orleans for the southeast Louisiana market area. Results of a statistical model of the market area indicate that the nonagricultural variables, distance to the nearest city and location in an MSA, have a significant impact on rural land prices. Selected tract characteristics (value of improvements, month of sale, and paved road access) also influence tract value. The only agricultural variable to be statistically significant was percent of timber in the tract, and it actually decreased tract value as the percentage of timber increased.

The model analysis supports several conclusions. One is that the value of rural land in the southeast Louisiana market is greater for land located within either the Baton Rouge or New Orleans MSA. In addition to the MSA effect, distance to the nearest city also increases the value of rural tracts the closer the tract is to the city. These results suggest the combined effect of proximity to cities and economic development in these areas has a substantial effect on rural land values. Results of this study also support the conclusion that agriculture does not have a significant positive effect on land values in the market area.

Taken together, these conclusions support the proposition that alternative nonagricultural uses for rural land heavily influence land prices. Residential and commercial use of rural land is driving the price of land in the southeast Louisiana area above agricultural market levels. With continued population increases and economic growth, the long term implication is a continual transition of agricultural land to urban and suburban use for this area.

In general, most rural land value studies have not used GIS procedures in data analysis and computation. Research presented here illustrates that analyses of data using GIS can be used to complement econometric research procedures. This initial research effort should be expanded in the future to explore integration of the rural land data set with other geo-referenced sets of socio-economic characteristics. Further research should continue to integrate GIS procedures into economic problems that are related to space.

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