# Hedonic Estimation Applied to the Farmland Market in Georgia

**R.L. Elad, I.D. Clifton and J.E. Epperson***

*Abstract*

Farmland offered for its productive or consumptive value may be viewed as a class of goods characteristic of product differentiation. Using the generalized Box-Cox transformation, an unrestricted hedonic model was employed to derive implicit valuations of parcel attributes. Results suggest that the significance and level of importance of attributes on land pricing depends on the spatial extent of markets in Georgia. Differences in the productive or consumptive use of farmland may imply that different factors and functional forms are appropriate to different farmland markets.

**Key Words: farmland prices, functional form, hedonic pricing**

## Introduction

The commonly accepted theory of land valuation is that the value of land in a given use is the present discounted sum of net incomes or economic rents which the land is expected to yield over time. Therefore, the value of land depends on the discount rate employed and the length of time considered. Symbolically this relationship is generally given as

$$V = \sum_{t=1}^{n} \left( \frac{a_t}{(1+r)^t} \right)$$

where $a_t$ is the expected annual rent, $r$ is the annual interest rate, and $n$ is the number of years.

The actual market value of land depends on several factors other than the capitalized value of its future income stream. Market and parcel attributes such as the number of acres offered for sale, percentage of cropland in the parcel, the number of properties on the market, and government policies are examples. The motives of prospective buyers and sellers also influence to some extent the value of land (Moore).

Although land is a commodity that responds to market forces, it differs in several ways from other economic goods. The total quantity of land is fixed though transitory with respect to uses. Though land exists nationwide, the markets for land are often very localized with only a relatively small percentage of land changing hands each year. Buyers and sellers, therefore, do not have perfect knowledge of the market (Moore and Meyers).

It has been observed that the present value of land is determined by the expected future economic rents to the land. These expectations are determined to a great extent by the market participants and are thus subjective (Dunford, Marti, and Mittelhammer). A land owner's optimum reserve price embodies speculative components in its determination because of the uncertainty surrounding the buyers' bid prices. The reservation prices of buyers are impacted in a similar manner. Thus, as the expectations of buyers and sellers change, so too does the present value of land.

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The literature clearly reveals the importance of the major attributes of land parcels and the characteristics of buyers and sellers in determining the sales price of land (Zeimer and White; Pope and Gordon; Miranowski and Hammes; Reynolds; Moore and Meyers). An analysis encompassing such factors can contribute to a more accurate determination of the value of land. This analytic approach is best represented by the hedonic pricing framework which is based on the hypothesis that the qualities of nonhomogeneous goods are valued as a function of their utility-bearing attributes (Griliches).

Viewed this way, the magnitude of the nonhomogeneity problem is reduced considerably as land is considered as a combination of its attributes, and as a class of goods characterized by product differentiation. An additional advantage of the hedonic pricing approach is its ability to encompass factors based on a plurality of theories regarding land prices (Brown and Brown; Palmquist 1984). Further, the hedonic model suggests that simultaneous demand and supply functions can be estimated for each attribute in the price gradient from the market characteristics of the buyers and sellers (Epple).

This paper formulates a conceptual hedonic model for regional submarkets of farmland in Georgia (figure 1). Organization of the paper proceeds as follows: first, the conceptual hedonic model and the functional form for estimation are outlined; second, the data and study area are described; third, the results of the hedonic model and the estimated bid price functions are presented; and finally, research and policy implications are discussed.

## Conceptual Model

The theoretical model employed in this study is based on Rosen's model of hedonic pricing and implicit markets as refined by Epple and by Palmquist (1989). The selling price of farmland is dependent on a vector of its attributes, $Z$. This is represented by the hedonic function

$$P(Z) = P(z_1, z_2, ..., z_n), \tag{1}$$

which emerges from the interaction between buyers and sellers of farmland. For the purpose of this study, $P(Z)$ is assumed to have continuous second derivatives.

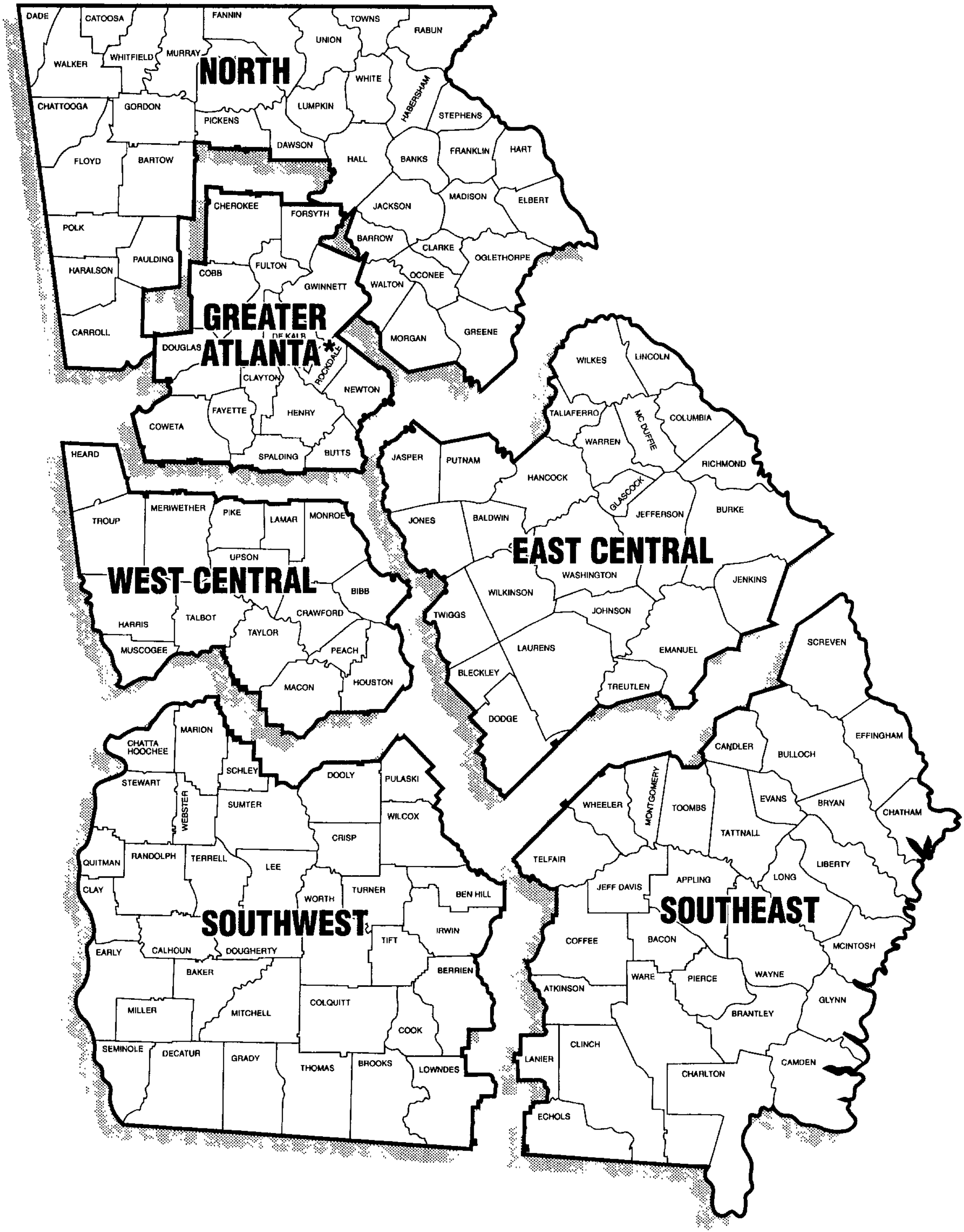
The buyer of the services of farmland has a utility function $U(X,Z,\alpha)$, where the value of $X$ is a composite numeraire of all other goods consumed, $Z$ is the vector of farmland attributes described in (1), and $\alpha$ represents characteristics of the particular buyer. Buyers face the budget constraint $Y = P(Z) + X$, where $Y$ is income. When farmland is used as a factor of production, the budget constraint also represents the buyer's cost function while the utility function represents the production function with $X$ as the net output. Let $G(Z,X,U,Y)$ specify the willingness of a buyer to pay for different values of $Z$ at a given level of income or profit, $Y$, and utility or production, $U$. The estimated partial derivative of $G$, obtained by regressing the marginal implicit prices of the attributes $P(z_i)$ on the farmland attributes and the market characteristics of the buyer represented by $\alpha$, gives

$$G_{zi} = \frac{U_z \quad (Z, Y - P(Z), \alpha)}{U_x \quad (Z, Y - P(Z), \alpha)}. \tag{2}$$

This is the second-stage equation which represents the buyer's bid-price function. $G_{zi}$ is the marginal implicitvalue of $z_i$ at a given income and utility level and indicates the demand price for an additional unit of $z_i$.

In order to derive the market equilibrium price, the sellers of farmland have to be considered. For this purpose the vector of attributes can be separated into two subvectors -- endogenous attributes, $Z1$ (can be altered by the seller, e.g., size), and exogenous attributes, $Z2$ (cannot be altered, e.g., soil depth) (Palmquist 1989). The seller thus maximizes profits given the total cost function, $C(M,Z1,Z2,\beta)$, where $M$ is a vector of input prices, $Z1$ and $Z2$ are vectors of endogenous and exogenous attributes previously discussed, and $\beta$ is a vector of parameters characterizing an individual seller. By altering the endogenous attributes, sellers maximize profits $\pi = P(Z1,Z2) - C(M,Z1,Z2,\beta)$, subject to $\pi \geq 0$, taking the price function $P(Z)$ as given. The first order profit-

**Figure 1.** Regional Farmland Submarkets




*** Greater Atlanta excluded from this study**

maximizing conditions in this case are given by Palmquist (1989) as

$$P_{zi} = \frac{C_{zi}(M, Z1, Z2,)}{M}, \tag{3}$$

which states that the marginal revenue from additional levels of attribute i is equal to its marginal cost.

Symmetrical to the demand side, the function representing the prices at which the seller would make farmland available to the market is given as $H(Z1,Z2,M,\beta)$. The partial derivatives of this function with respect to the endogenous farmland attributes and the vector of parameters characterizing an individual seller yield the second-stage equation of the hedonic model,

$$H_{zi} = \frac{C_{zi}(M, Z1, Z2, \pi, \beta)}{M}, \tag{4}$$

where the variables and parameters are as previously defined. From (4) the values of the offer functions are obtained (Palmquist 1989). A seller maximizes profits by equating the marginal offer price for the ith endogenous attribute to the marginal attribute price in the market. The offer price for exogenous attributes is entirely demand determined since such attributes cannot be altered.

This conceptualization of buyer and seller decisions is made under the assumption that the market-clearing equilibrium price, $P(Z)$, is determined by the simultaneous interaction of the bid- and offer-price functions for the attributes. However, if the supply of farmland with given attributes is inelastic (all the attributes are exogenous), offer functions are superfluous and bid-price functions are sufficient to derive equilibrium prices (Freeman). As indicated by Palmquist (1984), the bid functions can thus be consistently estimated (as in this study) by ordinary least square (OLS).

Given the uncertainty about buyer responses to different levels of an attribute, prior restrictions on the relationship between attributes and observed prices may obscure important behavioral information in the data. Hence the Box-Cox transformation of positive continuous variables (Box and Cox), made popular in economics as a device for letting the data determine what functional form is most appropriate, was employed. Hedonic analysis is sensitive to the choice of functional form since the results of the second-stage estimations are dependent on the specified functional form of the hedonic equation. The Box-Cox estimation is thus particularly valuable to hedonic analyses. The general unrestricted form of the Box-Cox transformation is given as

$$\Psi^{(\lambda)} = \begin{cases} \dfrac{\Psi^{\lambda} - 1}{\lambda}, & \lambda \neq 0 \\ \ln\Psi, & \lambda \to 0, \end{cases} \tag{5}$$

where $\Psi$ is the transformed variable, and $\lambda$ is the transformation parameter. Two special cases of the restricted Box-Cox transformation were also considered: the log-linear function, which results from the application of L'Hopital's rule as the transformations are continuous around $\lambda = 0$, and the simple linear function which results when $\lambda = 1$. In this study the equation to be estimated is given as

$$P^{(\lambda)} = \beta_0 + \sum_{i=1}^{m} \beta_i Z^{(\lambda)} + \sum_{j=1}^{n} \beta_j Z + V, \tag{6}$$

where $m$ is the number of transformed continuous variables, $n$ is the number of untransformed discrete variables, and $V$ is a disturbance term.

The maximum values of the log-likelihood functions of the restricted and unrestricted models were used to test the significance of the transformation parameter in the unrestricted model. The test statistic employed to determine the confidence intervals for $\lambda$ is

$$L_{max}(\lambda) - L_{max}(\lambda^*) < \frac{1}{2}\chi^2_{2,\alpha}, \tag{7}$$

where $\lambda$ is the restricted lambda, $\lambda^*$ is the unrestricted lambda, $L_{max}$ is the value of the log-likelihood function associated with each model, and $\alpha$ is the specified level of significance (Halvorsen and Pollakowski).

**Data and Study Area**

The primary data used in this study were obtained from individual records of land sales from the unpublished Farm-Rural Land Market surveys conducted by the University of Georgia over the period of 1986 to 1989. Secondary county level data necessary to obtain variables of socioeconomic importance were obtained from the *Georgia Statistical Abstract and the U.S. Census of Agriculture.* The observational unit for variables used in the hedonic analysis is measured on a per tract basis. Variables used in the hedonic analysis and expected signs for corresponding coefficients are shown in table 1.

Farmland was defined as all land in farms including attachments to the surface such as buildings and other improvements. The dependent variable, actual selling price of farmland (*PRICE*), was intended to reflect the average per acre value of farmland in the submarket area.

The independent variable, size of tract (*SIZE*), was included in the model because, all else equal, the price per acre was expected to decrease as the average size of the tract increased. Results from previous studies of farmland values substantiate this inverse relationship (Downing and Gamble; Foster).

The proportion of cropland in a parcel of farmland sold (*CROP*) was included as a measure of land quality, as well as the interaction of other economic forces. This variable was expected to reflect the differences in biological characteristics that influence the value of agricultural land. *CROP* was expected to be positively related to farmland values since cropland usually commands a higher value in use than other farmland uses, other things being equal (Moore and Meyers).

Economic logic posits that the distance from product and factor markets is an important determinant of variation in farmland prices. The distance variable (*DATL*), measured as the average distance from Atlanta, was included on the premise that Atlanta, a major regional center of commerce, dominates to an extent the input and product markets in the state of Georgia. An inverse relationship was generally expected between the distance variable and land values.

Other variables included in the model were binary variables representing the presence of buildings on the tract rated as good, absence of buildings, and reasons for purchase of the tract. The presence of buildings in good condition (*BLD)* was expected to enhance the value of the parcel, while the absence of any improvements (*NBLD*) was expected to result in lower land values. The rural-farm land survey indicated four potential farmland uses categorized as follows: agriculture and forestry (*AG*), commercial/industrial/mining (*COM*), residential/recreational (*RES*), and "other" uses. Each of the categories represents a variable that took on a value of one when the reason for purchase fell within that category, and zero otherwise. All of the binary farmland-use variables, except "other" were expected to have positive coefficients. The "other" category, including unstated or unknown farmland uses, which was expected to have a neutral net effect, is implicitly contained in the intercept.

Variation in land prices over time was expected since the collection period of the data ranged over four years. Intercept shifters for the years 1986-88 (*Y*1, *Y*2, *Y*3) were therefore included in the model. Corresponding coefficients were expected to be negative due to inflation since the last year (1989) was implicitly included in the intercept.

Marginal implicit prices of selected attributes obtained from the hedonic estimation were used as dependent variables in the second-stage system or bid-price equations. There were three bid-price equations, one for each continuous land attribute. proportion of cropland in parcel (*CROP*),

**Table 1.** List of Variables Used in the Hedonic Pricing Model

| Variable | Symbol | Expected Sign |
|---|---|---|
| Per acre price of land ($) | *PRICE* | Dependent variable |
| Acreage of cropland in tract sold | *CROP* | + |
| Presence of buildings on tract rated as "good"(1,0)[a] | *BLD* | + |
| Absence of buildings on tract (1,0)[a] | *NBLD* | - |
| Size of tract (acres) | *SIZE* | - |
| Average distance from Atlanta (miles) | *DATL* | - |
| Reason for purchase of tract is agricultural (1,0)[a] | *AG* | + |
| Reason for purchase of tract is industrial/commercial (1,0)[a] | *COM* | + |
| Reason for purchase of tract is residential/recreational (1,0)[a] | *RES* | + |
| Year of sale is 1986 (1,0)[a,b] | *Y1* | - |
| Year of sale is 1987 (1,0)[a,b] | *Y2* | - |
| Year of sale is 1988 (1,0)[a,b] | *Y3* | - |

Source: Rural-Farm Land Market Survey, 1986-89.

[a]These are discrete variables.
[b]The 1989 year of purchase was implicitly in the intercept.

parcel size (*SIZE*), and distance from Atlanta (*DATL*). The variables upon which the estimated marginal implicit prices of these land attributes were regressed, categorized as land attributes and socioeconomic characteristics, are listed in table 2.

To obtain more homogenous study areas, the Georgia farmland market was divided into five geographic subregions: the North, the West Central, the East Central, the Southeast, and the Southwest. The greater Atlanta region was excluded because this region, with less than 10 percent of its land area classified as land in farms, was not representative of the farmland market (figure 1).

A variety of crops, livestock, and timber are produced in all study regions of the state. Common crops include corn, cotton, small grains, soybeans, peanuts, sorghum, tobacco, and fruits, vegetables, and nuts. Common livestock enterprises include broilers, layers, cattle, dairy, and hogs (*Georgia Agricultural Facts*; Bachtel and Boatright).

The study regions are not entirely rural. Eight Metropolitan Statistical Areas (MSAs) are located totally or partially in Georgia (*Georgia Statistical Abstract, 1990-91*). In order to provide insight, farm enterprises and MSA population are briefly discussed by region of the state.

Sorghum, soybeans, fruits and vegetables, timber, broilers, layers, cattle, dairy, and hogs are common farm enterprises in the North region. Broilers, layers, and cattle are especially important enterprises in this region. Two substantially populated areas are encompassed or partially encompassed in the North region: the Athens, GA MSA with a population of 144,700 and the Chattanooga, TN-GA MSA with 438,100. Further, the Atlanta MSA, which is in close proximity to the North region, has a population of 2.7 million.

Peanuts, small grains, sorghum, soybeans, and timber are grown in the West Central region. But, the dominant enterprises are fruits, vegetables, nuts, broilers, layers, cattle, dairy, and hogs. Two significantly populated areas are contained or partially contained in the West Central region: the Columbus, GA-AL MSA with a population of 246,900 and the Macon-Warner Robins, GA MSA with 286,700.

All of the farm enterprises commonly found in Georgia are represented in the East Central

**Table 2.** List of Variables Used in the Estimation of Bid-price Functions

| Variable | Symbol | Type of Variable |
|---|---|---|
| Acreage of cropland sold (acres) | *CROP* | land attribute |
| Presence of buildings rated as good (1,0)[a] | *BLD* | land attribute |
| Absence of buildings (1,0)[a] | *NBLD* | land attribute |
| Size of tract (acres) | *SIZE* | land attribute |
| Distance from Atlanta (miles) | *DATL* | land attribute |
| Reason for purchase is agricultural (1,0)[a] | *AG* | s.c.[b] |
| Reason for purchase is commercial/industrial (1,0)[a] | *COM* | s.c. |
| Reason for purchase is residential /recreational (1,0)[a] | *RES* | s.c. |
| Buyer is a farmer (1,0)[a] | *BF* | s.c. |
| Average per capita county net income | NI | s.c. |
| County population density (population/square mile) | *POP* | s.c. |
| County net farm income ($1,000) | *NFI* | s.c. |
| Percentage of land in farms in county | *LF* | s.c. |
| Average size of farms in county (acres) | *FSIZ* | s.c. |

Source: Rural-Farm Land Market Survey, 1986-89, *Georgia Statistical Abstract*, 1987-1990, and *US Census of Agriculture*, 1987.

[a]These are discrete variables.

[b]Socioeconomic characteristics.

region though to a lesser extent for peanuts, sorghum, and tobacco. Cattle and dairy are especially important enterprises in this region. The Augusta, GA-SC MSA is largely contained in the East Central region and has a population of 396,400.

Farm enterprises common in Georgia are all prominent in the Southwest region except broiler production. The smallest MSA in Georgia is located in the Southwest region. The Albany MSA has a population of 116,300.

The Southeast region encompasses all of the farm enterprises common to Georgia. Hog and timber production are especially prominent in this region. The only major populated area in this region is the Savannah, GA MSA with a population of 244,400.

This regional delineation is the same as that applied by the Georgia Department of Agriculture and closely follows the mapping of farming areas in Georgia as delineated by the U.S. Department of Agriculture. Spatial differences in farm and non-farm factors which may affect farmland values are shown in appendix table 1. Agriculture dominates the southern part of the state, hence rates of return to farmland would be expected to clearly reflect farm income in that part of Georgia. In contrast, in the northern part of the state, farm income is not a dominant determinant of farmland prices. The regions in between are regarded as transition areas with respect to agricultural enterprise and farmland prices.

## Results

### *Hedonic Model*

The hypothesis test to determine the "best" functional form to use for empirical analysis indicated that the linear model failed to capture the relationship between farmland values and the explanatory variables in any of the regions (table 3). The log linear model was representative of the farmland market in the southern regions only. Thus, the unrestricted Box-Cox model was adopted

**Appendix Table 1.** Mean Values of Variables Used in Bid-Price Estimation

| Variable[a] | North | West Central | East Central | Southeast | Southwest |
|---|---|---|---|---|---|
| | Regions | | | | |
| *PRICE* | 1602.10 | 789.88 | 534.01 | 556.98 | 635.64 |
| | (1398.00)[b] | (565.38) | (396.06) | (33.50) | (253.12) |
| *CROP* | 50.30 | 118.50 | 104.65 | 103.87 | 160.60 |
| | (81.71) | (172.31) | (167.80) | (130.54) | (307.40) |
| *BLD* | 0.14 | 0.08 | 0.04 | 0.09 | 0.05 |
| | (0.34) | (0.27) | (0.21) | (0.28) | (0.22) |
| *NBLD* | 0.62 | 0.72 | 0.76 | 0.64 | 0.68 |
| | (0.49) | (0.45) | (0.43) | (0.48) | (0.46) |
| *SIZE* | 114.73 | 240.75 | 236.55 | 197.51 | 293.04 |
| | (235.96) | (295.88) | (312.77) | (209.96) | (544.65) |
| *DATL* | 62.76 | 73 18 | 119.34 | 183.01 | 150.86 |
| | (15.51) | (21 56) | (21.96) | (25.95) | (27.34) |
| *AG* | 0.64 | 0.68 | 0 71 | 0.77 | 0.81 |
| | (0.48) | (0.47) | (0 45) | (0.42) | (0.39) |
| *RES* | 0.06 | 0.06 | 0 06 | 0.03 | 0.03 |
| | (0.25) | (0.24) | (0.24) | (0.16) | (0.18) |
| *COM* | 0.35 | 0.16 | 0.18 | 0.15 | 0.09 |
| | (0.48) | (0.37) | (0.39) | (0.36) | (0.29) |
| *BF* | 0.28 | 0.39 | 0.31 | 0.45 | 0.52 |
| | (0.49) | (0.45) | (0.49) | (0.49) | (0.50) |
| *NI* | 11181.00 | 10873.00 | 9967.80 | 9734.50 | 9969.80 |
| | (2246.00) | (1206.70) | (904.80) | (996.39) | (959.14) |
| *POP* | 442.10 | 157.51 | 49.71 | 33.77 | 68.00 |
| | (182.16) | (222.44) | (95.97) | (15.59) | (78.47) |
| NFI | 15244.00 | 4970.20 | 5919 90 | 9409.60 | 16762.00 |
| | (20294.00) | (7234.90) | (4054.00) | (4180.10) | (6552.00) |
| *LF* | 26.90 | 30.83 | 31 19 | 31.47 | 50.94 |
| | (17.19) | (16.53) | (9.63) | (13.67) | (14.11) |
| FSIZ | 142.06 | 291.10 | 345.24 | 288.85 | 478.98 |
| | (60.57) | (136.63) | (119.73) | (101.56) | (117 23) |
| *N* | 292 | 207 | 270 | 182 | 367 |

[a]Defined in tables 1 and 2.

[b]Standard deviation.

for the study since it best captured the relationship between farmland prices and the explanatory variables for all regions.

In the hedonic model, only point estimates of the marginal prices were obtained using the observable measures of the attributes and the per-acre prices paid. Thus, implicit prices could only be evaluated for individual sale transactions, and no direct implications could be drawn from the results of these point estimates (Danielson). The results of the hedonic model specified in equation (6) are given in table 4.

Many of the coefficients for the variables in the North region were significant. All of these coefficients had the expected signs shown in table 1.

In the West Central region the lack of a large number of significant coefficients relates to the fact that this region lies between the predominantly agricultural south and the highly urbanized north. The land market in this region is thus not largely responsive to agriculturally oriented land attributes and neither is it greatly responsive to non-farm attributes associated with urbanization. There is also a high proportion of part-time farming occurring in this region. Therefore, returns from farming in the West Central region may not be a priority. This could also explain the lack of significance of most of the coefficients in this region.

The expected signs were obtained for all of the significant coefficients in the East Central and Southeast regions. In the Southwest region, the

**Table 3.** Values of the Log-Likelihood Function and Results of Hypotheses Tests for Functional Form for the Hedonic Model

| Region | Values of Unrestricted λ | Values of Log-Likelihood Function | | | Chi-Square Values | | Table Values | Conclusion | |
|---|---|---|---|---|---|---|---|---|---|
| | | Unrestricted λ | λ = 1 | λ = 0 | λ = 1 | λ = 0 | | Ho: λ = 1 | Ho: λ = 0 |
| North | 0.13 | -2314.44 | -2465.89 | -2319.19 | 302.90 | 9.50 | 9.49 | Reject | Reject |
| West Central | 0.25 | -1529.70 | -1587.49 | -1536.90 | 132.80 | 30.00 | 9.49 | Reject | Reject |
| East Central | -0.41 | -1937.77 | -2153.78 | -1935.86 | 432.02 | 36.18 | 9.49 | Reject | Reject |
| Southeast | 0.20 | -1355.77 | -1415.89 | -1319.90 | 120.24 | 8.26 | 9.49 | Reject | Cannot reject |
| Southwest | 0.20 | -26.04 | -2653.25 | -2608.60 | 98.00 | 0.92 | 9.49 | Reject | Cannot reject |

**Table 4.** Estimated Coefficients of the Unrestricted Box-Cox Hedonic Model[a]

| Variable[b] | Region | | | | |
|---|---|---|---|---|---|
| | North | West Central | East Central | Southeast | Southwest |
| *CROP* | 0.039 | 0.033 | -0.004 | 0.078 | 0.095 |
| | (0.87)[c] | (0.58) | (-1.26) | (1.32) | (3.10)*** |
| *BLD* | 1.030 | 1.360 | 0.017 | 4.650 | 0.920 |
| | (3.40)*** | (1.45) | (2.10)** | (3.93)*** | (2.95)*** |
| *NBLD* | -0.782 | -0.494 | -0.015 | -0.414 | -0.362 |
| | (-3.80)*** | (-0.84) | (-3.50)*** | (-1.71)* | (-2.59)*** |
| *SIZE* | -0.364 | -0.214 | -0.057 | -0.250 | -0.194 |
| | (-6.56)*** | (-3.06)*** | (-4.13)*** | (-3.77)*** | (-5.70)*** |
| *DATL* | -0.734 | -0.393 | -0.348 | 0.154 | 0.254 |
| | (-3.97)*** | (-1.52) | (-5.39)*** | (0.65) | (1.75)* |
| *AG* | 0.636 | 0.832 | 0.004 | 0.155 | 0.046 |
| | (3.16)*** | (1.66)* | (1.05) | (0.56) | (0.25) |
| *COM* | 0.279 | -0.117 | -0.001 | 0.244 | -0.122 |
| | (0.73) | (-0.12) | (-0.177) | (0.35) | (-0.35) |
| *RES* | 1.050 | 0.766 | 0.024 | 0.893 | 0.158 |
| | (5.30)*** | (1.25) | (5.44)*** | (2.92)*** | (0.68) |
| *Y1* | -0.367 | 1.560 | -0.093 | -0.490 | -0.768 |
| | (-0.75) | (2.21)** | (-5.05)*** | (-1.29) | (-3.37)*** |
| *Y2* | 0.301 | -0.031 | -0.100 | -0.500 | -0.877 |
| | (1.43) | (-0.05) | (-2.01)** | (-1.54) | (-4.63)*** |
| *Y3* | -0.245 | -0.450 | -0.011 | -0.290 | -0.709 |
| | (-1.09) | (-0.70) | (-1.15) | (-0.79) | (-3.65)*** |
| Intercept | 17.300 | 21.400 | 2.730 | 12.770 | 12.653 |
| | (15.99)*** | (11.02)*** | (21.53)*** | (5.71)*** | (10.13)*** |
| $R^2$ | 0.42 | 0.17 | 0.30 | 0.29 | 0.20 |
| *F*-value | 18.43 | 3.63 | 10.89 | 7.00 | 8.69 |
| *N* | 292 | 207 | 289 | 201 | 386 |

[a]The dependent variable is price per acre.

[b]Defined in table 1.

[c]*t*-ratio in parentheses below the coefficient; ***denotes significance at the 0.01 level, **denotes significance at the 0.05 level, and *denotes significance at the 0.10 level.

coefficient for *DATL* (distance from Atlanta) was positive. The reason for this is that the economic impact of a major urban center begins to wane at some point as distance from the center increases. And farm income from this major peanut producing region dominates the generally negative effect of *DATL*.

Within regions, the coefficients for the yearly intercept shifters were not all significant. The East Central and Southwest regions however, showed land price increases with time. Rising land prices were associated with a rebounding agricultural export market and higher prices for row crops commonly produced in these two regions and elsewhere (U.S. Department of Agriculture). Further, in the East Central region, rising land prices were also associated with economic growth and the increasing shift in land use from farm to non-farm uses (Shideed, Brannen, and Glover).

*Implicit Prices*

Though only point estimates of the marginal implicit prices were obtained, it was nonetheless possible to observe the magnitude and direction of influence of the attributes by examining the implicit prices at the mean values of farmland price and attribute measure. When the coefficient of an attribute is positive, the marginal implicit price is necessarily positive, meaning that an increase in the measure of that attribute leads to an increase in the value of farmland. Negative marginal implicit prices resulting from negative coefficients have a depressing effect on farmland prices. The mean marginal implicit prices for the farmland attributes are given in table 5.

The proportion of cropland (*CROP*) in the tract sold in the North region had the highest mean marginal implicit price (table 5). However, the coefficient was not significant (table 4). In any event, the topography is generally hilly, and the farmland tracts for sale are relatively small in this region (appendix table 1). A farmland tract with a high proportion of cropland is an indication that most of the tract is relatively level which is highly regarded by both farm and non-farm users of land. The lowest implicit price for cropland was obtained in the East Central region and was negative. Again, however, the coefficient was not significant (table 4). Farmland prices and net farm income, though, were relatively low in this region (appendix table 1).

Mean marginal implicit prices for *BLD* (buildings rated as good) were positive and were negative for *NBLD* (no buildings) as expected. Mean marginal implicit prices for *SIZE* (acreage in farmland tract) were negative reflecting a common occurrence of discounting the price of larger tracts of farmland. Mean implicit prices for *DATL* (distance from Atlanta) were negative except in the southern part of the state where farm income was a dominant determinant of farmland prices. This was consistent with the expected influence of a major metropolitan area on the value of farmland. Farmland prices were expected to be inversely related to distance from Atlanta in regions nearer to Atlanta. This relationship would not necessarily hold in regions further from Atlanta due to other dominating influences. The relatively large and positive mean implicit prices for *AG* (tract purchased for agricultural purpose) in the North and West Central regions largely reflected the impact of the poultry industry. In regions where the mean implicit prices for *COM* (tract purchased for industrial/commercial purpose) were negative, the magnitudes were relatively small. Mean implicit prices for *RES* (tract purchased for residential/recreational purpose) were positive as expected.

*Bid-Price Functions*

The OLS results of the estimation of bid prices for farmland attributes are presented in tables 6-8. As a practical matter and given the focus of this research on regional differences in marginal implicit prices, the discussion of explanatory variables in bid-price functions will be limited to cases where coefficients for a given variable were significant in at least three regions. However, all own-attribute variables with significant coefficients are discussed.

According to economic theory, the sign of an own-attribute in a bid-price function is expected to be negative. This demonstrates diminishing marginal implicit prices for an attribute with an increase in its measure. The impacts of the other explanatory variables were expected to vary by region; thus, no *a priori* signs of the coefficients could be ascribed.

The results for the bid-price function for the farmland attribute *CROP* (acreage of cropland in the tract) are presented by region in table 6. As the marginal implicit price for *CROP* in the East Central region was negative, this bid-price equation was multiplied by -1 for convenience allowing direct interpretation of the impacts of the explanatory variables (table 6).

**Table 5.** Marginal Implicit Prices[a] of Farmland Attributes at Their Mean Regional Values

| Region | *CROP* | *BLD* | *NBLD* | *SIZE* | *DATL* | *AG* | *COM* | *RES* |
|---|---|---|---|---|---|---|---|---|
| North | 356.69 | 1.02 | -0.78 | -23.88 | -21.82 | 0.640 | 0.280 | 1.05 |
| West Central | 53.34 | 1.36 | -0.49 | -7.75 | -11.97 | 0.830 | -0.120 | 0.77 |
| East Central | -106.28 | 0.03 | -0.02 | -132.36 | -337.51 | 0.004 | -0.003 | 0.02 |
| Southeast | 30.24 | 1.65 | -0.42 | -7.22 | 10.68 | 0.160 | 0.240 | 0.89 |
| Southwest | 20.12 | 0.92 | -0.36 | -7.07 | 9.10 | 0.050 | -0.120 | 0.16 |

[a]Unit of measurement is dollar per acre.

Note: The attributes (variables) are defined in table 1.

**Table 6.** OLS Estimates of the Coefficients of the Regional Bid-Price Functions for the Implicit Price of *CROP*

| Variable[a] | Region: North | | West Central | | East Central[b] | | Southeast | | Southwest | |
|---|---|---|---|---|---|---|---|---|---|---|
| *CROP* | -0.087 | (-14.04)***[c] | 0.022 | (11.20)*** | 0.020 | (6.85)*** | -0.042 | (-7.52)*** | -0.027 | (-14.45)*** |
| *BLD* | 0.216 | (0.27) | 0.584 | (2.07)** | 7.960 | (1.36) | 0.467 | (0.77) | 0.932 | (3.97)*** |
| *NBLD* | -0.814 | (-1.65)* | 0.145 | (0.81) | -0.200 | (-1.89)* | 0.498 | (1.40) | 0.200 | (1.98)** |
| *SIZE* | 0.719 | (1.30) | -0.204 | (-1.44) | -1.460 | (-0.58) | 0.410 | (1.25) | 0.180 | (1.66)* |
| *DATL* | 0.1E-3 | (0.52) | -0.8E-3 | (-3.47)*** | 0.6E-2 | (1.68)* | -0.3E-2 | (-3.36)*** | -0.3E-3 | (-2.74)*** |
| *AG* | -0.3E-2 | (-3.90)*** | -0.7E-3 | (-3.27)*** | 0.6E-2 | (0.27) | 0.2E-3 | (0.92) | -0.3E-5 | (-0.04) |
| *COM* | -0.3E-2 | (-1.67)* | -0.3E-2 | (-3.69)*** | -0.130 | (-6.46)*** | -0.5E-2 | (-0.40) | 0.4E-3 | (0.45) |
| *RES* | 0.7E-2 | (0.44) | 0.045 | (4.00)*** | -0.035 | (-0.41) | 0.2E-2 | (0.23) | 0.5E-2 | (2.20)** |
| *BF* | 0.3E-4 | (2.32)** | 0.9E-6 | (0.03) | -0.3E-2 | (-1.04) | -0.9E-4 | (-1.86)* | 0.2E-6 | (0.02) |
| *NI* | 0.011 | (0.36) | 0.018 | (2.11)* | 0.203 | (1.25) | 0.019 | (1.08) | -0.4E-3 | (-1.36) |
| *POP* | -0.018 | (-4.32)*** | -0.015 | (-3.86)*** | 0.019 | (1.44) | 0.4E-3 | (0.19) | -0.5E-3 | (-1.30) |
| *NFI* | 0.017 | (0.03) | -0.140 | (-0.81) | -0.704 | (-0.26) | -0.970 | (-0.23) | -0.238 | (-1.68)* |
| *LF* | -0.790 | (-0.80) | -0.056 | (-0.19) | -0.156 | (-0.40) | -0.587 | (-0.69) | 0.661 | (2.58)*** |
| *FSIZ* | 0.410 | (0.76) | -0.388 | (-2.04)** | -13.370 | (-4.32)*** | 0.094 | (0.21) | 0.139 | (0.80) |
| *Intercept* | 9.870 | (3.08)*** | 10.640 | (4.15)*** | -22.520 | (-1.09) | 1.420 | (0.54) | 3.240 | (3.58)*** |
| $R^2$ | 0.55 | | 0.60 | | 0.59 | | 0.29 | | 0.43 | |
| *F*-value | 23.88 | | 20.68 | | 27.95 | | 5.34 | | 19.91 | |
| *N* | 292 | | 207 | | 289 | | 201 | | 386 | |

[a]Defined in table 2.

[b]The equation was multiplied by -1.0 for interpretation of the signs of the coefficients in the usual way.

[c]*t*-ratio in parentheses next to the coefficient; *** denotes significance at the 0.01 level, ** denotes significance at the 0.05 level, and * denotes significance at the 0.10 level.

**Table 7.** OLS Estimates of the Coefficients of the Regional Bid-Price Functions for the Implicit Price of *SIZE*

| Variable[a] | Region[b] North | | West Central | | East Central | | Southeast | | Southwest | |
|---|---|---|---|---|---|---|---|---|---|---|
| *CROP* | 0.058 | (3.19)***[c] | 0.5E-2 | (2.29)** | 0.011 | (1.01) | 0.3E-2 | (1.35) | 0.2E-2 | (2.92)*** |
| BLD | 4.030 | (1.96)** | 0.076 | (0.29) | 5.380 | (2.97)*** | 0.400 | (1.66)* | 0.355 | (2.87)*** |
| *NBLD* | 0.522 | (0.37) | -0.159 | (-0.85) | -0.019 | (-0.03) | -0.066 | (-0.44) | 0.070 | (0.96) |
| *SIZE* | 1.450 | (0.99) | -0.053 | (-0.28) | 2.800 | (3.40)*** | 0.074 | (0.53) | 0.040 | (0.69) |
| *DATL* | -0.8E-2 | (-3.50)*** | -0.1E-2 | (-5.66)*** | -0.4E-2 | (-2.78)*** | -0.3E-2 | (-7.77)*** | -0.3E-3 | (-6.13)*** |
| *AG* | -0.4E-3 | (-0.60) | 0.1E-3 | (0.45) | 0.9E-2 | (1.65)* | -0.4E-4 | (-0.45) | 0.5E-4 | (1.21) |
| *COM* | -0.9E-2 | (-1.68)* | -0.2E-2 | (-2.15)** | -0.4E-2 | (-1.06) | 0.5E-2 | (0.54) | -0.5E-3 | (-1.21) |
| *RES* | -0.096 | (-2.25)** | 0.7E-2 | (0.59) | -0.018 | (-0.66) | 0.2E-2 | (0.710) | 0.6E-3 | (0.52) |
| *BF* | -0.2E-4 | (-0.72) | 0.4E-4 | (1.26) | 0.8E-4 | (0.79) | -0.2E-4 | (-1.00) | 0.1E-4 | (2.69)*** |
| *NI* | -0.151 | (-2.04)** | -0.2E-2 | (-0.25) | -0.177 | (-2.20)** | 0.5E-2 | (0.72) | -0.8E-2 | (-2.99)*** |
| *POP* | -0.013 | (-1.13) | -0.4E-3 | (-0.10) | -0.5E-2 | (-1.08) | -0.8E-2 | (-1.06) | -0.4E-3 | (-2.09)** |
| *NFI* | 2.550 | (1.73)* | 0.181 | (1.00) | -1.710 | (-1.96)** | 0.020 | (0.11) | -0.031 | (-0.39) |
| *LF* | 2.200 | (1.73)* | 0.061 | (1.00) | -0.072 | (-0.05) | -0.209 | (-0.49) | 0.243 | (1.78)* |
| *FSIZ* | 8.210 | (5.99)*** | 0.011 | (0.08) | -5.480 | (-5 39)*** | 0.931 | (5.04)*** | 0.235 | (2.58)*** |
| Intercept | 9.900 | (1.16) | 0.152 | (0.06) | 0.034 | (1.09) | 1.420 | (0.54) | 0.258 | (0.54) |
| $R^2$ | 0.26 | | 0.28 | | 0.29 | | 0.42 | | 0.20 | |
| $F$-value | 6.97 | | 5.32 | | 7.81 | | 9.52 | | 6.57 | |
| $N$ | 292 | | 207 | | 289 | | 201 | | 386 | |

[a]Defined in table 2.

[b]The equations were multiplied by -1.0 for interpretation of the signs of the coefficients in the usual way.

[c]$t$-ratio in parentheses next to the coefficient; *** denotes significance at the 0.01 level, ** denotes significance at the 0.05 level, and * denotes significance at the 0.10 level.

**Table 8.** OLS Estimates of the Coefficients of the Regional Bid-Price Functions for the Implicit Price of *DATL*

| Variable[a] | Region North[b] | | West Central[b] | | East Central[b] | | Southeast | | Southwest | |
|---|---|---|---|---|---|---|---|---|---|---|
| *CROP* | 0.031 | (2.18)***[c] | 0.4E-2 | (1.50) | -0.4E-2 | (-0.511) | 0.3E-3 | (0.75) | 0.2E-2 | (4.40)*** |
| *BLD* | 7.910 | (4.31)*** | 0.595 | (1.69)* | 4.180 | (3.04)*** | 0.181 | (3.90)*** | 0.201 | (4.32)*** |
| *NBLD* | -2.310 | (-1.89)* | -0.271 | (-1.22) | -0.490 | (-0.70) | -0.012 | (-0.45) | 0.043 | (1.85)* |
| *SIZE* | 0.316 | (0.24) | -0.323 | (-1.45) | 2.680 | (4.55)*** | -0.036 | (-1.65)* | 0.011 | (0.47) |
| *DATL* | -0.5E-2 | (-2.21)** | -0.7E-3 | (-2.39)** | -0.2E-2 | (-1.96)** | -0.2E-3 | (-3.78)*** | -0.2E-4 | (-1.02) |
| *AG* | -0.3E-4 | (-0.06) | 0.2E-3 | (0.62) | 0.9E-3 | (2.19)** | 0.1E-4 | (0.65) | 0 4E-4 | (2.64)*** |
| *COM* | -0.6E-2 | (-1.40)* | -0.4E-3 | (-0.42) | 0.4E-2 | (0.76) | 0.4E-2 | (4.21)*** | -0 2E-3 | (1.14) |
| *RES* | -0.309 | (-8.25)*** | 0.036 | (2.55)** | -0.076 | (-3.80)*** | -0.4E-2 | (-4.21)*** | -0.3E-2 | (-6.65)*** |
| *BF* | -0.2E-4 | (-0.66) | 0.4E-4 | (1.20) | 0.3E-3 | (4.53)*** | 0.2E-5 | (0.49) | 0.4E-5 | (1.99)** |
| *NI* | -0.079 | (-1.21) | 0.020 | (1.86)* | -0.108 | (-2.85)*** | -0.1E-2 | (-1.10) | -0.2E-2 | (-1.66)* |
| *POP* | -0.024 | (-2.44)** | 0.7E-3 | (0.14) | -0.3E-2 | (-0.91) | -0.6E-4 | (-0.47) | -0.3E-3 | (-3.59)*** |
| *NFI* | 2.550 | (1.88)* | 0.396 | (1.86)* | -0.740 | (-1 17) | 0.044 | (1.40) | -0.020 | (-0.64) |
| *LF* | -1.400 | (0.600) | 0.7E-2 | (0.02) | -0.632 | (-0.61) | 0.015 | (0.19) | 0.3E-2 | (0.06) |
| *FSIZ* | 6.780 | (5.44)*** | 0.336 | (1.42) | 3 250 | (4.47)*** | 0 141 | (1.14)*** | 0 050 | (1.44) |
| Intercept | 35.200 | (4.72)*** | 2.700 | (0.85) | 5.670 | (1.16) | 0.830 | (4.07)*** | 0.870 | (4.77)*** |
| $R^2$ | 0.48 | | 0.44 | | 0.44 | | 0.43 | | 0.24 | |
| $F$-value | 18.12 | | 10.85 | | 15 13 | | 11.73 | | 8 44 | |
| $N$ | 292 | | 207 | | 289 | | 201 | | 386 | |

[a]Defined in table 2.

[b]The equations were multiplied by -1.0 for interpretation of the signs of the coefficients in the usual way.

[c]$t$-ratio in parentheses next to the coefficient; *** denotes significance at the 0.01 level, ** denotes significance at the 0.05 level, and * denotes significance at the 0.10 level.

As expected, the *CROP* coefficients were negative and significant in the North, Southeast, and Southwest regions implying a diminishing marginal implicit price for *CROP*. The unexpected signs for *CROP* in the central regions may indicate a preference by the timber industry to purchase large tracts, often encompassing large acreages of cropland, to facilitate economies of size in timber harvesting.

The coefficients for *NBLD* (absence of buildings) were negative for the North and East Central regions and positive for the Southwest region. The negative signs indicated a plausible detraction from the value of cropland in the absence of buildings on the parcel. However, in the major row-crop area of the state, the Southwest region, it would seem that acreage not tied up in buildings, that is, available for crop production was seen as a plus.

The significant coefficients for *DATL* (distance from Atlanta) were negative in the West Central and southern regions, indicating a declining marginal implicit price of *CROP*. Whereas, the positive sign for the East Central region suggests that tracts with large acreages of cropland were not discounted as distance from Atlanta increased.

*COM* (commercial/industrial reason for land purchase) had a negative and significant impact on the marginal implicit price of *CROP* in the North and central regions. Apparently, the negative coefficient indicated the purchase of less expensive farmland for non-farm, commercial and industrial purposes.

The results for the bid-price functions for the farmland attribute, *SIZE* (size of tract) are presented by region in table 7. Recall that the marginal implicit prices for *SIZE* were negative; thus, for convenience, the bid-price equations for *SIZE* were multiplied by -1 allowing direct interpretation of the impacts of the explanatory variables as shown in table 7.

*CROP* was directly related to the marginal implicit price of *SIZE* in the North, West Central, and Southwest regions, indicating that larger parcels were purchased for cropping purposes. *BLD* was positively associated with the marginal implicit price of *SIZE* in all regions except in the West Central region where the relationship was not significant. Apparently the presence of buildings rated as good tended to enhance the value of larger tracts.

The coefficients for *DATL* were negative in all regions. This indicates that as the distance from Atlanta increased, the discount for parcel size increased. Generally, then, discounting for parcel size tended to be greater in the more rural areas.

The negative coefficients for *NI* (county net income) in the North, East Central, and Southwest regions indicate that a high average county income was associated with a lower marginal implicit price for size. Apparently, the size of a tract was less important in the less rural (more urban) counties.

Of the coefficients that were significant for *FSIZ* (average size of farms in the county), one was negative -- the coefficient in the East Central region. Thus, larger farm sizes tended to reduce the discounting of larger tracts except in the central part of the state.

The results for the bid-price functions for the farmland attribute *DATL* (distance from Atlanta) are presented by region in table 8. The North, West Central, and East Central marginal implicit prices for *DATL* were negative; thus, multiplying these bid-price equations for *DATL* by -1 conveniently allows direct interpretation of the impacts of the explanatory variables as represented in table 8.

The relationship between *BLD* and the marginal implicit price for *DATL* was positive for all regions. Indications are that the discounting of tracts further from Atlanta was reduced or reversed with the presence of buildings rated as good.

As expected, the coefficient for *DATL* was negative in all regions. This, of course, reflects a decreasing marginal implicit price for *DATL* as the distance from Atlanta increased.

The effect of *RES* was negative except in the West Central region. This suggests that residential/recreational uses increased the discounting for tracts further from Atlanta.

Apparently, RES reduced the discounting of tracts further from Atlanta in the West Central region.

The coefficients for *NI* were positive in the West Central region and negative in the East Central and Southwest regions. The positive sign indicates an easing of discounting of tracts further from Atlanta in conjunction with higher county incomes. Higher county incomes within the East Central and Southwest regions were associated with lower farmland prices and population densities relative to those in the West Central region which is closer to Atlanta.

The relationship for *FSIZ* was significant and positive in the North, East Central, and Southeast regions. A positive relationship reflects a decrease in the discounting of farmland tracts with larger average county farm sizes as distance from Atlanta increased.

## Conclusions

The hedonic pricing technique was used to make explicit the impact of implicit farmland attributes and market participant characteristics that contribute to the value of farmland. The study presents econometric evidence that attributes and characteristics surrounding farmland can differ markedly in importance and direction of influence on marginal implicit prices and thus farmland values depending on regional location. Thus, a "farmland market," as pertaining to the transfer of land suitable for agricultural uses, for an entire state such as Georgia probably does not exist.

The hedonic model is a reduced-form specification with no theoretically derived functional form. Since results may be sensitive to functional form, the unrestricted, Box-Cox functional form was used for the analysis. Variables representing socioeconomic characteristics not employed in the (first-stage) hedonic model estimation were included in the bid functions in order to avoid bias and misinterpretation of the second-stage estimations.

The application of the hedonic methodology to the farmland market has been shown to be valuable in understanding the effects of attributes in the market and revealing their marginal prices. Moreover, these marginal implicit prices have been shown to be impacted in an array of magnitudes and in different directions depending on locational circumstances. Given the extreme importance of regional sensitivity, it should be weighed heavily when hedonic pricing is used to estimate welfare effects of policy changes on farmland owners.

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