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THE EFFECTS OF PARCEL CHARACTERISTICS ON THE VALUE OF AGRICULTURAL LAND IN WASHINGTON STATE

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ABSTRACT

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This study examines the effects of selected parcel characteristics on agricultural land values. A nonlinear hedonic model is estimated for each of six regions in Washington State. The nonnegative nature of land price was modeled directly via a truncated logistic distribution. The truncation effect was significant in half of the regions.

THE EFFECTS OF PARCEL CHARACTERISTICS ON THE VALUE OF AGRICULTURAL LAND IN WASHINGTON STATE

It has long been recognized that the value of a land parcel depends on the discounted future returns to that parcel.[1] These returns are a function of a bundle of characteristics embedded in the parcel as well as various economic and institutional factors that are external to the parcel. A land parcel and its associated permanent improvements enters the land market as an indivisible collection of attributes. Oftentimes it is not economical, nor may it be physically possible, to remove the improvements and sell them separately from the land parcel.

Each land parcel is characterized by a unique bundle of characteristics. Some of them are capital improvements, such as buildings, irrigation systems, fences, and perennial plantings that have been added to enhance the income earning potential of the parcel. Due to the inseparable nature of the land and its capital improvements, it is difficult to assign a value to each income enhancing characteristic.

This paper studies the contribution that the separate capital improvements make to the value and/or sale price of agricultural land. A hedonic price model is used to analyze the determinants of cross-sectional variations in farmland prices in Washington State. In the course of the analysis, a methodological contribution is made concerning an evaluation of the importance of directly incorporating the

[1]In the literature, it is conventional to talk about "land" as space or territory. "Land" is territory without buildings, fences, drainage, etc. When all these other characteristics are added, it becomes real estate. Here, both are referred to as "land."

nonnegatively truncated nature of land prices into the econometric model.

Current research on farmland values often uses a hedonic approach based on Rosen's work (1974). This approach involves conceptualizing a land parcel as a bundle of objectively measurable characteristics. The value of the parcel is hypothesized to be some function of the values of these individual characteristics. Empirically, the hedonic approach requires regressing the sale price of land parcels on some function of the quantities of the individual characteristics embodied in the parcels. An implicit or hedonic price for each characteristic can then be derived by calculating the partial derivative of parcel price with respect to the quantity of each characteristic. This hedonic price is an estimate of the market value of a marginal increase in the level of the particular characteristic.

Applications of the approach to analyze farmland values include Chicoine (1981), Miranowski and Hammes (1984), King and Sinden (1988), and Palmquist and Danielson (1989). To date, it would appear that no research has investigated the necessity of modeling land value as a nonnegatively truncated random variable.

Modeling Considerations

Unlike many other commodities, land has several special features that make its price or its value more difficult to anticipate. Foremost among the features are the heterogeneity, spatial fixity and durability of land.

Heterogeneity of land is consistent with the general hedonic approach. Land cannot be moved from one place to another, so trading occurs in a limited number of regions among buyers and sellers within a region. That the agricultural land market is localized can be seen by the overwhelming response of neighboring farm purchasers (Barkley and Wunderlich). The farm buyer is typically a local farmer who is uniquely aware of the prevailing farm situation in his area (Raup). This feature makes it advisable to examine a regional hedonic price function.

Three components of agricultural land values are commonly conceptualized as: the agricultural productive, the consumptive, and the speculative components. The agricultural productive component is commonly described as the present value of expected returns to land and may be considered the most fundamental component of agricultural land value. Land buyers may also desire to purchase a land parcel so that they can touch, feel, and enjoy the rural experience (Pope and Goodwin). This component is the portion of agricultural land values that is based on current and expected future consumption demand. The speculative component of agricultural land value arises from the expectation that agricultural land values will follow a rising or declining trend.

This study attempts to identify the major determinants that affect agricultural land values, no matter what their motivation. A hedonic model for land values can be represented as follow. Let $Z = (Z_1, \ldots, Z_n)$, be an objectively measured vector of land characteristics expressed on a per acre basis. The per acre sale price of a land parcel depends on the land characteristics through a hedonic price equation

(1) $P = P(Z_1, \ldots, Z_n)$.

The hedonic function is regarded as providing average implicit prices for land characteristics resulting from the interaction of buyers and sellers in the land market. From the hedonic function, implicit prices can be calculated for each of the parcel characteristics, under the assumption of ceteris paribus.

Data and Variables

The data were gathered using a telephone survey of buyers of agricultural land in 25 rural Washington counties who purchased a land parcel of 10 or more acres in the years 1980 through 1987. The 25 counties were aggregated into six reasonably homogeneous agricultural regions. This was done so that possible differences among regional hedonic price functions could still be analyzed, while providing adequate degrees of freedom for a statistically meaningful hedonic analyses by region.

An attempt was made to contact all 1,806 land purchasers, which yielded 906 completed and useable observations that in turn formed the data set. Variable definitions are provided in Table 1. Further information concerning regional definitions and survey procedure can be found in Xu (1990).

Empirical Model and Results

In constructing a statistical model to explain land prices, it is logically meaningless to allow a positive probability of a negative price. It is more reasonable and proper to utilize a truncated distribution[2] for sale price with all negative values being truncated. A normal truncated distribution is one possible choice. However, due to numerical instability in computations, a logistic truncated distribution, which closely resembles the normal distribution (Greene, pp. 663-666), was also analyzed and was used in all of the results reported below.

[2]A truncated distribution is the part of a distribution that is above and/or below some specific value, properly rescaled so that the entire probability mass equals one.

The search for a useful model began with the general hedonic functional relationship (1). A number of functional forms were initially investigated including linear, logarithmic, exponential, interactive terms with logarithmic form, and the Box-Cox transformation. Various subsets of on-site characteristics were examined to explain land values. Based on plausibility, statistical significance, and overall interpretability and sensibility of the results, together with non-nested functional form hypothesis tests based on the P-Test procedure of Davidson and MacKinnon (1981), and MacKinnon, Davidson and White (1983), the final model was ultimately chosen to be of the following form (apart from the truncation correction):

$$(2) \quad SALEPR = G = TOTACRES^{\alpha}e^{\beta TIME} \{ \Sigma_{i=1,k} C_iCNTY_i + B_0 + B_1GI + B_2DTOWN + B_3\ln(LNDCAP) + B_4WDBK + \Sigma_i B_5SIZEB_i\ln(B_6 - AGEB_i) + B_7NUMP(B_8 - AGEP) + B_9IRRICP + B_{10}IRRISP + B_{11}IRRIR + B_{12}PASTURE \} + B_{13}SIZEH\ln(B_{14} - AGEH) + B_{15}MACH,$$

The terms in the $\{\cdot\}$ are factors that are considered to be inherent characteristics that are generally nonseparable from the parcel. Many of the characteristics relate to factors that influence the revenue-generating capability of the parcel. This perceived revenue generating ability of a parcel can vary over time, and the time function multiplies the bracketed expression in an attempt to account for changing discount factors and general secular changes in the profitability of farming. Even if the perceived revenue generating abilities on a per acre basis are the same for two parcels, parcel size might be expected to have a negative effect on the per acre sale price since the market for large parcels is characterized by fewer buyers due to the requirement that they possess more substantial financial resources. House and machinery variables are separated from other revenue generating factors since they can potentially be resold immediately following purchase. An interaction is expected between NUMP and AGEP for milking parlors, between SIZEB and AGEB for barns, and between SIZEH and AGEH for house.

The functional form of the specified model, incorporating truncation via the logistic distribution, is,

(3) $SALEPR_* = \sigma(1+\exp(-G/\sigma))\ln[1+\exp(G/\sigma)]$,

where α, β, B_0, B_1, B_2, ... , B_{15}, and C_i's are parameters to be estimated.

The final estimation results are reported in Table 2. In two regions, the effect of barns was represented by $\Sigma_i B_5 SIZEB_i$ as opposed to $\Sigma_i B_5 SIZEB_i \ln(B_6 - AGEB_i)$ because B_6 was estimated to be extremely large and insignificant, an indication that the logarithmic functional form was approaching a limiting linear functional form (i.e., the derivative with respect to $SIZEB_i$ was effectively unchanged by the value of $AGEB_i$). The question of the significance of the truncation effect was analyzed via the significance of the estimated σ-value, since it can be shown that (3) -> (2) as σ -> 0. In half of the regions, the effect of truncation of sale price was statistically significant at level of 0.06.

All coefficients have acceptable signs based on a priori expectations. Results show that all estimated coefficients are significant at the 0.10 level except coefficients for SIZEB in region six and IRRISP in region three. These two variables were retained in the model primarily because they had consistently significant effects in all other regions to which they applied, and their signs were consistent with a priori expectations.

Summary results on values of parcel characteristics for each region are provided in Table 3. These results are calculated at the mean levels of variables. The base value is calculated based on the following assumptions regarding parcel characteristics: no irrigation systems, no house, no barns and no farm machinery are included in the sale price; and the number of total acres, time, gross income, distance to the nearest town and land capability class are at their respective mean levels.

The results indicate that each characteristic affects sale price differently in magnitude even though there is a general agreement on the directional effect. Regional differences in characteristics levels are obvious.

The effect of distance to the nearest town on sale price varies, ranging from -$17.23 to -$66.07 among the six regions. The implication that sale price decreases as the distance to the nearest town increases is consistent with the findings of other studies. In this study the hypothesis of a linear effect of the distance variable on sale price, conditional on acreage level and time of sale, could not be rejected.

Parcel size has a significant negative effect on land value in each of the six regions. Measures of the elasticity of parcel size are -.55, -.33, -.63, -.25, -.43 and -.31 for regions one through six, respectively. The implication that a larger parcel has a lower value per acre is consistent with prior expectation and previous studies.

The annual depreciation rates range from 4.07 to 13.50 percent, which is consistent with the general rate of decreases in land prices over the study period, 1980-1987. The magnitude varies among regions.

The assessed value of machinery affected the sale price significantly in the four regions where data were available. A hypothesis of a one-to-one relationship between sale price and assessed value of machinery can be rejected for some regions. The ratio of sale price to assessed value of machinery are distributed around a one-to-one ratio: ranging from .85:1 to 1.68:1 in the four relevant regions.

A positive effect of irrigation systems is found to be significant. In regions where more than one type of irrigation system was utilized, the rank order of value contributed by the irrigation types was consistent with a priori expectations, i.e., center pivot > sprinkler > rill.

The presence of barns adds to land values, with older barns contributing less value than newer barns. A threshold age at which barns no longer contribute to land value is estimated to be 84, 72.7, 54 and 54 years old for regions one, four, five and six, respectively.

The presence of a house adds to land values, with older houses adding less value than newer houses. A threshold age at which a house no longer contributes to land value is estimated to be 94.6, 92.7, 74.5, 91.6, 78.1 and 84.1 for regions one through six, respectively.

Concluding Comments

It is difficult to determine the value of parcel characteristics embedded in agricultural land since such characteristics are not directly traded and priced in explicit markets. The hedonic approach has been used to determine the relationship between land values and parcel characteristics in order to explain and predict the differences in land values due to differences in the levels of parcel characteristics.

It is generally accepted that expected net returns to land is the driving force behind land values. Expected net returns was not available to be used as a variable in any of the regional models per se. An indirect approach was used to proxy for the effects of net returns: gross income, soil productivity, irrigation, buildings and the like were all used in combination as a proxy. The proxy approach appeared to perform quite well in this application.

Some general conclusions that can be drawn from this study include:

(1) Individual parcel characteristics are significant factors in the determination of agricultural land values in Washington State;

(2) A large majority of the variation in parcel values is explained by variation in the levels of characteristics imbedded in individual parcels;

(3) Land markets are notably regional in character, as evidenced by the difference in hedonic price functions across regions of Washington State; and

(4) Explicit modeling of the effects of nonnegative truncation of sale price in hedonic analyses of agricultural land values may be a necessary procedure.

Perhaps the last conclusion above is the most troubling for past and future hedonic analyses of agricultural land values. In particular, ignoring a significant truncation effect has the same consequences with respect to truncation bias as in any other case of limited dependent variables, despite the fact that a model might otherwise be correctly specified both in terms of functional form and the inclusion of all relevant explanatory variables.

TABLE 1. Definitions of Variables as Used in the Statistical Analysis

Variable	Definition and Source
SALEPR	Per acre sale price excluding payment for crops, but including the value of any machinery included in the transaction, divided by the CPI (original data)
TOTACRES	Parcel size in acres (original data)
TIME	Monthly time index, where January 1980=1, ..., and December 1987=96 (calculated)
GI	Gross income per acre around the time of sale, divided by the CPI (calculated)
PASTURE	Proportion of total acres that is pasture (original data)
$CNTY_i$	Dummy for county i, or for several counties in a region that are tested to have no county-specific difference in values (original data)
DTOWN	Distance to the nearest town with a service station and grocery store in miles (original data)
LNDCAP	Land capability class, ranging from 1 to 7, where 1 is the best-quality land, and 7 the poorest (calculated)
WDBK	Length of windbreak, in feet, per acre in parcel (original data)
NUMP	Number of stalls in the milking parlor, on a per acre basis (original data)
AGEP	Age of the milking parlor in years (original data)
IRRICP	Proportion of total acres irrigated by center pivot irrigation (original data)
IRRISP	Proportion of total acres irrigated by sprinkler irrigation (original data)
IRRIR	Proportion of total acres irrigated by rill irrigation (original data)
$SIZEB_i$	Size of barn i in square feet per acre in parcel (original data)
$AGEB_i$	Age of barn i in years (original data)
SIZEH	House size in square feet per acre in parcel (original data)
AGEH	House age in years (original data)
MACH	Assessed value of machinery per acre in parcel, divided by the CPI (original data)
C	A constant value (original data)

Note: The CPI refers to Western United States consumers who resided in areas having a population of less than 75,000. See United States Labor Statistics Bureau: CPI Deflated Report. The index value for 1980 is 1.00.

TABLE 2. The Estimated Parameters of Selected Models by Region

Parameter	Characteristic	Region 1	2	3	4	5	6
				Coefficient (t-Value)			
α	TOTACRES	-.2056 (4.75)	-.1199 (3.54)	-.3881 (5.08)	-.0851 (2.72)	-.3494 (7.86)	-.1405 (4.68)
β	TIME	-.0114 (6.97)	-.0074 (5.33)	-.0156 (5.73)	-.0041 (4.48)	-.0146 (8.48)	-.0081 (5.45)
B_0	CONSTANT	8628.01 (5.64)	6431.59 (5.74)	38525.32 (2.97)	5024.02 (7.26)	9541.42 (4.68)	3646.12 (4.56)
C_1	$CNTY_1$	1848.01 (4.04)		18939.93 (2.48)			-584.54 (2.21)
C_2	$CNTY_2$						616.89 (2.10)
C_3	$CNTY_3$						1271.05 (4.12)
B_1	GI	1.2206 (1.68)	1.3591 (2.30)	3.0906 (2.96)	1.3299 (8.46)	10.9868 (4.68)	2.1315 (2.25)
B_2	DTOWN	-125.07 (2.01)	-133.38 (2.13)	-731.78 (1.99)	-74.0216 (2.01)	-483.15 (2.70)	-56.57 (3.55)
B_3	LNDCAP	-1560.16 (2.14)	-2075.44 (3.26)	-9848.49 (2.46)	-2338.98 (5.00)	-3967.81 (2.74)	-1185.24 (2.93)
B_4	WDBK				9.2574 (1.65)	173.97 (4.07)	
B_5	BARN	1.9145 (3.13)	2.6700 (2.52)	56.4500 (2.19)	3.1433 (6.69)	10.3576 (2.10)	8.7392 (1.35)
B_6	BARN	85.0238 (1749.46)			73.6780 (10.05)	55.0014 (6254.46)	55.0004 (22334.18)
B_7	PARLOR		217.12 (2.65)				
B_8	AGEP		26.2183 (8.56)				
B_9	IRRICP					5352.67 (2.61)	
B_{10}	IRRISP		1645.69 (2.35)	2701.07 (0.99)	681.07 (2.45)	4806.49 (3.22)	
B_{11}	IRRIR				528.05 (2.00)	4310.15 (3.10)	
B_{12}	PASTURE		1463.69 (3.62)				
B_{13}	HOUSE	4.3564 (15.31)	5.7513 (8.98)	3.8209 (3.28)	2.9466 (5.96)	4.3516 (6.05)	7.4103 (21.94)

B_{14}	HOUSE	95.6002 (36.67)	93.6590 (8.16)	75.5404 (140.58)	92.6361 (3.42)	79.1130 (2.74)	85.1139 (251.31)
B_{15}	MACH			1.7379 (3.57)	1.3098 (4.78)	1.2322 (3.95)	0.9122 (2.08)
n		137	120	81	225	184	159
R^2		.8367	.8045	.9409	.8673	.9039	.9015
Root MSE		692.76	710.41	775.09	721.40	449.15	301.65
Mean SALEPR		2612.37	3329.94	2444.91	2802.40	1518.73	915.08
σ				310.01 (2.51)	320.28 (1.56)	487.56 (9.30)	

Note: Values in parentheses are absolute t-values.

For regions one, four, five and six, barn variables are in the form $\Sigma_i B_5 SIZEB_i \ln(B_6 - AGEB_i)$, while for regions two and three, the variable is $\Sigma_i B_5 SIZEB_i$. County dummies are defined as follows: $CNTY_1$ is 1 if Grays Harbor, Lewis or Pacific, and 0 otherwise (Cowlitz or Thurston) for region one; $CNTY_1$ is 1 if Stevens, and 0 otherwise (Chelan, Douglas or Okanogan) for region three. For region six, $CNTY_1$ is 1 if Lincoln, and 0 otherwise (Walla Walla, Whitman, Columbia, or Garfield); $CNTY_2$ is 1 if Walla Walla, and 0 otherwise; $CNTY_3$ is if Whitman, and 0 otherwise.

TABLE 3. Summary of Empirical Results by Region

Item	Region					
	1	2	3	4	5	6
Base Value ($/Acre)	2373.53	2030.94	3261.48	1767.71	847.34	552.17
Depreciation Rate (%/Year)	9.00	7.08	13.50	4.07	8.76	8.05
Elasticity of Size	-.5503	-.3277	-.6284	-.2480	-.4336	-.3075
GI ($/Acre)	.36	.67	.23	.76	.76	.65
MACH ($/Acre)	NA	NA	1.68	1.31	.85	.91
WDBK ($/Acre)	NA	NA	NA	5.32	8.29	NA
IRRICP ($/Irrigated Acre)	NA	NA	NA	NA	254.89	NA
IRRISP ($/Irrigated Acre)	NA	815.11	202.16	391.54	228.88	NA
IRRIR ($/Irrigated Acre)	NA	NA	NA	303.57	205.27	NA
DTOWN ($/Acre)	-36.55	-66.05	-54.75	-42.56	-23.01	-17.23
NUMP ($/Stall per Parcel)	NA	623.55	NA	NA	NA	NA
at AGEP (Year)	NA	15	NA	NA	NA	NA
SIZEB ($/sq.ft. per Parcel)	2.09	1.30	4.22	6.40	1.75	7.28
at AGEB (Year)	33.0	NA	NA	33.0	19.0	39.0
SIZEH ($/sq.ft. per Parcel)	17.76	21.60	12.81	11.68	12.10	21.96
at AGEH (Year)	36.9	50.9	48.0	40.0	20.0	47.1
LNDCAP ($/Acre)	-132.64	-376.19	-170.37	-453.64	-58.94	-94.28
(at MEANS)	3.44	2.73	4.16	3.09	3.21	3.87
Threshold Value						
AGEP (Year)	NA	26.2	NA	NA	NA	NA
AGEB (Year)	84.0	NA	NA	72.7	54.0	54.0
AGEH (Year)	94.6	92.7	74.5	91.5	78.0	84.0

Note: NA denotes "not applicable."

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