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Source: *American Journal of Agricultural Economics*, Vol. 66, No. 5, Proceedings Issue (Dec., 1984), pp. 745-749
Published by: Blackwell Publishing on behalf of the Agricultural & Applied Economics Association
Stable URL: http://www.jstor.org/stable/1240990

Accessed: 13/09/2010 16:44

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Determinants of Farmland Prices: Impacts of Location, Soil Characteristics, and Government Credit Programs
(Karl Gertel, ERS USDA, presiding)

Implicit Prices of Soil Characteristics for Farmland in Iowa

John A. Miranowski and Brian D. Hammes

Arguments have long persisted that purchasers pay too much for poor land (i.e., less productive, more erosive) relative to the higher quality counterpart. In other words, purchasers are either irrational or poorly informed relative to the differences in land productivity between poor and good farmland. Similar arguments have been advanced concerning the willingness-to-pay rent on the part of tenant operators.

Little empirical evidence exists to support or reject this hypothesis. Farmland appraisals are sometimes cited as evidence to support the contention, but such empiricism may indicate more about the quality and biases of appraisers than about the behavior or efficient functioning of the farmland market. Resolution of this issue is extremely important to the formation of soil conservation policy designed to protect soil productivity. Irrational behavior on the part of land purchasers may lead one to infer that the market system is failing to recognize adequately the soil productivity consequences of soil erosion. If this oversight consistently leads to excessive soil erosion from society's perspective, then some form of government intervention may be necessary to protect the welfare of society, assuming that such intervention is capable of correcting the market failure.

The issue is largely an empirical question. Are land purchasers properly discounting land prices to reflect foregone soil productivity caused by soil erosion and to reflect the potential erosivity of the land or the costs necessary to prevent future productivity declines due to erosion? This analysis will not attempt to provide a definitive answer to the question.[1] Rather, the study will only attempt to apply an implicit price analysis to isolate the value that land purchasers place on topsoil depth and the costs attributed to greater potential erosivity.[2] Alternatively, this study could be viewed as an attempt to identify the benefits associated with deeper topsoils and the benefits attributed to reduced erosion hazards.

The implicit or hedonic price approach has been applied in the urban housing markets to determine the hedonic prices of housing, neighborhood, and service characteristics as well as to isolate the benefits associated with improvements in air and other environmental quality characteristics. Likewise, the wage equation used in the human capital literature is an implicit price equation. Intuitively, the implicit price technique is analogous to the subjective process followed by a farmland appraiser when attempting to place a market value on a parcel of land. The major distinction between the appraisal and implicit price approaches to valuation is that the appraisal approach yields subjective assessments of the values of characteristics based on comparable cases, while the implicit price approach yields objective empirical estimates of the values of particular land and locational characteristics. The empirical estimates should provide a useful check on the value assigned by farmland appraisers, as well as providing "implicit prices" for soil loss and potential soil erosivity.

Session sponsored jointly with the Association of Environmental and Resource Economists.

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The authors wish to acknowledge valuable comments from Ralph Heimlich, Wallace Huffman, and Neill Schaller and assistance in acquiring data from Duane Harris, Gerald Miller, and Paul Rosenberry.

[1] Ultimately, a more definitive answer could be provided by comparing the costs associated with previous erosion and with potential erosivity to the marginal value products of topsoil depth and erosivity.

[2] The terms implicit and hedonic price models are used interchangeably in the literature and to some extent in this paper.

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Analytical Framework

A simple intuitive justification of the land market valuation process can be provided by a soil productivity illustration from the land economics literature. Suppose that we have two identical parcels of farmland except that parcel I has a higher level of soil productivity than parcel II. If soil productivity is valued by farmers, then parcel I's price should be higher than parcel II's price by the value placed on the difference in soil productivity. If the price of I exceeds that of II by less than the value of the productivity differential, then purchasers of farmland would increase their bid prices for I relative to II, increasing the price differential. Alternatively, if the farmland price differential exceeds the value of the difference in productivity, bid prices would respond to narrow the price differentials between parcels I and II.[3]

If sufficient data are available, the implicit price model can be utilized to estimate the market value of various farmland characteristics, including land quality. The implicit or hedonic price approach to valuing the separate characteristics of a good is relatively new. The theory was developed by Griliches, Rosen, and Lucas.

Certain assumptions must be made before the hedonic method can be properly utilized. The first of these assumptions is that the area, in this case the state of Iowa, can be considered a single market. Embedded in this assumption is the assumption that all individuals have information on all goods in the market. These assumptions assure that all individuals have knowledge of all options available to them. The consumers have information about the various packages of characteristics and, hence, are able to maximize their utility. The sellers know that there are individuals willing to pay various amounts for the different packages of characteristics and, hence, the sellers are able to maximize their profits.

It must also be assumed that the land market is in equilibrium . The demand for goods with the specific levels of $X_1, X_2, \ldots, X_n$ must be equal to the supply of goods with those attributes. Along the price function, $P(X_1, X_2, \ldots, X_n)$, the quantity demanded is equal to the quantity supplied. In other words, the price must clear the market for each bundle of characteristics. If the market is in equilibrium, this means that each individual has made the decision that will maximize his utility given the alternate land parcels (Freeman).

A final assumption is that there must be a large number of available properties having different levels of characteristics from which the land purchaser may choose. This will allow the buyer to find an acreage which will maximize his utility. Freeman compares this to thinking of the market as a huge supermarket offering the characteristics $X_1, X_2, \ldots, X_n$ packaged in various combinations. There must be a sufficient number of combinations to allow the purchaser to acquire the combination from which he will derive the most satisfaction.

Given the above assumptions, the general price equation used in this study can be expressed as

$$P = P(X)$$

where P is the price of farmland per acre and X is a vector of soil characteristics of the farmland. Since the study attempts to explain differences in the values of properties available to the same set of buyers, the investigation is done in terms of differences in the characteristics of the properties rather than in terms of differences in the characteristics of the purchasers.

The partial derivative of farmland price with respect to a characteristic gives the marginal implicit price of that characteristic, i.e., the additional amount that a purchaser must pay to move to a bundle with one more unit of that characteristic, holding all other things constant.

The soil characteristics included in the analysis are topsoil depth, *RKLS*, and *PH*. Topsoil depth is a measure of a composite of productivity-related factors that is directly observable by the buyer and seller. *RKLS* is a measure of potential erosivity, reflecting the impacts of rainfall intensity and amount, soil properties on erodibility, length of slope, and steepness of slope. *PH* is a measure of soil acidity.

Two data sources are utilized in this analysis. First, cross-section observations for the ninety-nine counties in Iowa are employed. The county average farmland price per acre is from the 1978 Iowa Land Value Survey (Harris, Lord, and Weirich). These price estimates, collected from licensed real estate brokers, are average farmland values exclusive of buildings and related improvements. County average soil characteristics were created by weighting the average value of a characteristic for a given soil type represented in the county by the percentage of that soil type in the county (Miranowski).

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[3] Because land values are essentially capitalized rents, the differences in values are measures of buyers' willingness to pay for the future productivity of the soil.

Second, because county-level aggregation may mask the heterogenous nature of farmland in particular counties, individual farm transactions from Iowa covering the 1974–79 period are also utilized. These ninety-four observations were collected for a real estate appraisal course conducted by Harris at Iowa State University. Transactions prices were converted to 1978 dollars using county average farmland price data (Harris, Lord, and Weirich). Soil characteristic variables for the transactions data were created by weighting the value of characteristics for a given soil type by the percentage of that soil type on the farm using soil maps and legal descriptions (Hammes).

The most important limitation of the transactions data is that these data are not from a random sample. Because the students were not randomly drawn from across the state nor were their observations and because soil maps were not available for all counties, the data set is nonrandom. A large number of observations are found in central Iowa. As will become clear, this limitation will have a significant impact on the empirical results.

Summary statistics for the two data sets are reported in table 1.

Results

Three models are presented in table 2. Based on the results from a Box-Cox transformation, we conclude that a linear functional form was appropriate for all three models. Given the relatively deep topsoils and the relative homogeneity of topsoils and subsoils in most parts of Iowa, the linear relationship is not surprising. If the topsoils were shallow and the subsoils dramatically less productive, then a nonlinear relationship would be anticipated.

Table 2. Estimated Coefficients of Implicit Price Models for Soil Characteristics in Iowa, 1978

	Model 1	Model 2	Model 3
Intercept	−1296.44 (−1.36)[a]	−2138.30 (−1.65)	−2120.53 (−1.58)
Topsoil depth	52.77 (3.46)	32.69 (2.57)	33.24 (2.56)
PH	380.48 (2.41)	575.82 (3.00)	571.89 (2.88)
Depth**RKLS*	−.41 (−4.74)	−.40 (−4.90)	−.39 (−4.46)
Assessed building value			1.05 (3.09)
R^2	.51	.38	.33

[a] *t*-statistics in parentheses.

Model 1 estimates are based on the county average data for the ninety-nine Iowa counties in 1978. Model 2 estimates are based on ninety-four transactions with assessed building value removed from the per acre price. Model 3 estimates are based on per acre selling price with buildings included from the transactions data. To adjust for the price impact of buildings, assessed building value per acre is introduced as an explanatory variable.

All the coefficients have the hypothesized signs and are significant at the one percent level. Increased topsoil depth and *PH* have a positive impact on land values, and potential erosivity (*RKLS*) has a negative effect. An interaction between topsoil depth and *RKLS* is hypothesized and supported by the results. Increased topsoil depth is less valuable if subject to a greater threat of erosion or loss.

Table 1. Summary Statistics for Iowa Data

	County Data		Transactions Data	
	Mean	Standard Deviation	Mean	Standard Deviation
Land price per acre (1978 dollars)	1645.22	474.45	2,059.16	699.59
Topsoil depth (inches)	13.92	2.82	14.20	4.69
RKLS	54.19	38.75	51.29	63.93
PH	6.53	0.27	6.67	0.32
Assessed building value per acre (1978 dollars)			132.51	195.87

Based on the coefficient on assessed building value, it appears that the market valuation of building value is not significantly different from assessors' observations.

Locational characteristics and regional dummies (based on MLRA's and market districts) were introduced into the models. Some locational characteristics were significant in Model 1 but not in Models 2 and 3. Because exclusion of these factors had little impact on the coefficients of the soil characteristics in Model 1, locational factors are not considered in this analysis. Dummy variables, based on MLRAs and market reporting districts, were introduced into the analysis, but the coefficients were not significantly different from zero in most cases.

The really interesting results are the marginal implicit prices of land characteristics which are presented in table 3. The implicit price of an acre inch of topsoil ranged from $12 using the transactions data to $31 based on the county average data. Although both estimates may appear somewhat low, the discrepancy between these two data sources may be related to the differences in the geographical distribution of the observations.[4] The transactions observations, which are nonrandom, are more concentrated in areas with deeper topsoils. Thus the marginal value of an additional inch of topsoil is expected to be biased downward, which may account for the relatively lower marginal implicit price. Considering all farmland in the state leads to the inclusion of farmland with more shallow topsoil, and the marginal inch commands a higher market price because additional losses of topsoil depth may significantly reduce crop yields in the near future. Thus, if the transactions data were reweighted to reflect more accurately the actual distribution of soil characteristics in the state, we would expect a relatively higher marginal implicit price of topsoil using the transactions data.

The *RKLS* coefficients are consistent between models and indicate that the marginal value of a one-unit reduction in potential erosivity is valued at approximately $5.70. Holding topsoil depth constant, increasing erosivity decreases the value of farmland. One interpretation is that either the soil will not be around for productive purposes as long or that investments, which reduce net returns, will have to be made to keep the soil in place.

Table 3. Implicit Prices of Soil Characteristics in Iowa, 1978

	Model 1	Model 2	Model 3
		($)	
Topsoil depth	30.55	11.81	12.67
PH	380.48	575.82	571.89
RKLS	−5.71	−5.65	−5.56
Building value			1.05

Given the limited range of *PH* values in Iowa, the results indicate that increasing the *PH* index has a positive impact on farmland values. Yet, in regions with sufficiently high index values, increasing the *PH* index may be expected to have a negative impact on farmland values.

Conclusions

This study presents econometric evidence that differences in soil characteristics are reflected in farmland prices. The regressors, including a variable measuring topsoil depth and an interaction term composed of topsoil depth and erosivity potential, have significant coefficients with correct signs. The empirical models provided estimates of the marginal value of an additional inch of topsoil ranging from a low of $12 per acre to a high of $31 per acre. The estimates of the marginal value of a one ton per acre reduction in the erosion potential are about $5.60. Thus, the results suggest that both buyers and sellers of farmland value important soil characteristics, i.e., there is a positive gross return from protecting farmland from erosion. However, it is difficult to ascertain whether the market is discounting the value of farmland sufficiently to account for the loss of productive capacity.

Finally, caution must be exercised in using the implicit price approach and in interpreting the results. First, the implicit price model is a reduced-form equation without a theoretically derived functional specification, and the results may be sensitive to the specification. Second, as the results of this analysis indicate, the estimated implicit prices may be quite sensitive to the data used. Particularly, the use of a nonrandom sample may bias the results. Likewise, previous hedonic analyses of housing market characteristics may be subject to the same problem if based on transactions data. Third, the implicit prices of soil characteristics derived from market data ignore nonmarket benefits that may be perceived by society.

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[4] Given the deep topsoils and good subsoils in most areas of Iowa, loss of average topsoil depth will have a relatively small yield impact and thus a relatively low implicit price.

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