Forecasting Agricultural Land Values in the Midwest States[1]

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Abstract

From a practical stand point, the precision and robustness of forecasting agricultural land values are evaluated in two out-of-sample time periods. Empirical application to five Midwestern states in the U.S. indicates the annually updated model performed well.

Background

Agricultural land values in the U.S. have fluctuated greatly over recent decades. Land market participants and practitioners, policy makers, and researchers are among the numerous entities who are constantly seeking to better understand these market dynamics and the key forces influencing the value shifts.

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The preponderance of recent land market research has tended to focus upon the structural aspects of the market that underlie land value changes. To do this, the approach is generally a modified asset pricing model in which land values reflect expectations about long-run streams of net returns to production and other income sources, all discounted appropriately to reflect time and risk (Goodwin, et al., 2003). Researchers have considered a variety of structural forces believed to impact the market including: general inflation, real agricultural debt, changes in the cost of capital, risk aversion, and transaction costs (Just and Miranowski, 1993; Chavas and Thomas, 1999; and Lence and Miller, 1999). While studying these structural aspects, researchers are often able to obtain strong predictability features of their models to actual, long-term value trends. Yet, others have sharply criticized their analysis, saying the predictability effect is largely values derived from exhibiting very strong trend patterns which force the predicted model results to conform to actual trends (Lence, 2001). While there is a general acceptance of the importance of discounted earnings as a basis for land values, land values have not always appeared to have tracked consistently with land rents (Clark, et al., 1993).

But in addition to the above, econometric analysis of the agricultural land market is subject to additional challenges associated with measuring variables and sampling procedures. First, the data set may not be of sufficient length and/or detail to encounter the full range of phenomena in order to accurately estimate the impacts of explanatory variables. Second, structural changes may be occurring which are difficult to quantify. For example, agricultural land values can be expected to change in response to tax law changes or federal commodity program shifts. These factors are difficult to quantify.

While the literature on agricultural land market modeling is extensive, the "goodness-of-fit" to real-world conditions has often left much to be desired. Despite more comprehensive modeling and econometric efforts, the estimated values may not correspond very well to actual values over time, particularly if the model is forecasting actual values "out-of-sample" or outside the data set used to derive coefficients of the model.

Despite the familiar list of qualities that appraisers associate with true market value, *self-interested and well-informed buyers and sellers operating in an open and competitive market under all conditions requisite to a fair sale*, the land market takes on a much more variable and uncertain nature, simply because people are involved. Thus, predictability is only an approximation of reality because of this human dimension.

Objective

Our purpose here is to apply and evaluate a relatively simple, straight-forward model for forecasting agricultural land values that mirrors the basic income-capitalization approach to agricultural land appraisal and the underlying assumptions. More specifically, we do not evaluate predictability by estimating the impact of factors affecting land values for a data set and then observing how well predicted land values using those parameters compare to actual land values for those years. Instead we use estimated parameters for a given series of years to develop parameter sets for the following year. Using this parameter set, land value for the following year is forecasted. This is sequentially done for a test period with the robustness of the forecast evaluated comparing predicted versus observed. This testing is therefore termed "out of sample." The purpose of this out-of-sample analysis is to test the robustness of the forecasting power of the model.

The setting for our analysis is five Midwestern states in the U.S., covering the time period, 1955-2002. The five states chosen include: Iowa, Kansas, Missouri, Nebraska, and South Dakota. These five states contain varying proportions of cropland suitability classes. Likewise, there is variability among states' proportions of land in broad land use classes; i.e., urban development, forest, pasture, and cropland. It is conceivable that aggregating land values from changing land class proportions could impact average cropland values apart from the basic economic forces impacting cropland values. Moreover, the differences in the proportion of cropland to non-cropland among the states could lead to differences in the forecasting accuracy of cropland values. However, we assume these impacts to be minor.

Theoretical Income Capitalization Model

To derive the magnitude of factors influencing land values, a simple linear ordinary least squares regression model was used. Compared to more complex estimation models, its advantage is its relative simplicity in deriving estimates and statistical significances of explanatory variables.

In contrast to the many previous studies noted above that have focused upon the structural aspects of the agricultural land market and the factors underlying land value investments over time, our interest here is on forecasting agricultural land values. Forecasting approaches the estimation process with a projection accuracy objective as opposed to a structural or explanatory objective. Three economic variables are used here to reflect the income capitalization model for infinite-life assets including crop returns, government payments, and interest (discount) rates. At one time, agricultural land value estimation placed considerable emphasis on building value, location, and adjacent road quality. While these aspects are still considered in land appraisal for tracts at different locations, net expected returns from land is now considered the major determining force of land value changes over time.

The income capitalization model (Equation 1)

$$V = \frac{NR}{r} \quad (1)$$

describes the expected value (*V*) as a function of net returns for the asset (*NR*) divided by the discount or capitalization rate (*r*). Gross cash crop returns per acre is employed in this analysis to represent agricultural returns. Over the period 1910-2002, the correlation between U.S. crop receipts and net cash income was found to be .977. Hence crop receipt per acre is used in this study for each state analysis. Similarly, government payments are increasingly receiving attention as a contributor to land values. This component is separated from gross cash crop receipts in order to estimate differences between the two return components. For the denominator of Equation (1), the real interest rate is used and is defined by Equation (2):

$$r' = \frac{1+r}{1+f} - 1 \quad (2)$$

where r' is the real interest rate, r is the nominal interest rate for real estate, and f is the rate of inflation.

A real interest rate is used rather than the nominal rate so that the elements of the numerator and the denominator are on comparable inflation bases. A net return at a point in time is real because the annuity expression resulting from inflationary gains has not been incorporated. Thus a real interest rate in the denominator must be used in conjunction with real net returns in the numerator. An alternative model (termed discounted earnings) used to predict farmland values is described by Painter (2002) and embodies growth in the numerator and denominator. The earnings component includes capital asset changes as well as dividends.

Cash crop receipts, government payments, and real interest rates all involve year-to-year variability. At a given point in time, it is the expectation of the future magnitude of these variables that impacts the land market. To represent those expectations data from the recent past provides the base from which future expectations are derived. However, the exact manner in which past economic phenomena are processed to yield future expectations is unknown. This involves questions such as how many past observations should be used, whether a trend should be employed, or if data of recent years should be weighted more than previous years.

The expectations of the explanatory variables in this analysis are approximated by 1) cash crop receipts per acre for the two previous years, 2) government payments per acre for the two previous years, and 3) the real interest rate of the previous year. The use of data from previous years is an advantage in forecasting analysis because forecasted values for a particular year do not involve data for that year, only earlier years.

Finally two other explanatory variables are included in the forecasting model. One is the previous year's land value. Second is a trend in land values defined as the two-year change in values from three-year previous to the previous year. This impact could be considered as a speculative factor. It could also reflect the increase or decrease of credit capacity of market participants that arises from value changes of their existing land holdings.

Empirical Procedures and Data Sources

In analyzing the land value forecasting accuracy in each state, two analyses were completed. First, estimations of the effects of the five explanatory variables for the period 1955-2002 were derived and differences between actual versus forecasted values were contrasted. The purpose of the 1955-2002 analysis is to provide estimates of the impact of each explanatory variable over a long time period. Second, the accuracy of the 1955-2002 model will be compared to the accuracy of a 16 year updated model for each of two test periods. The two test periods involve 1991-2002 and the turbulent 1975-88 time period. Here, a preceding time period was used to generate estimates of land values for a time point and this was repeated for each year of the test period. This can be termed "out-of-sample" analysis compared to conventional analysis that only looks at forecasting accuracy over a given data set. Out-of-sample analysis provides a setting in which to better evaluate forecast accuracy compared to insample projections (Clements, et al., 2004; Tashman, 2000). It is commonly thought that forecasting outside a data set involves considerable less accuracy than within the set (Ashley, 2000 and Christofides, 1991).

The first test involved years 1991-2002 developing projected values for 1991 from the data from 1976-91, 1992 estimates from data of 1977-92, etc. Another term commonly used for updated is "rolling over" (LeSage, 1989; and LeSage and Megure, 1991). It should be noted that in all models, the projection for a particular year uses data from the previous one, two, or three years depending on the explanatory variable. A second out-of-sample analysis was also completed for the turbulent 1975-88 time period which saw 1) a large increase in land values followed by, 2) a large decline, and 3) the beginning of a value recovery.

Table 1 details the data sources for the variables used in the analysis. Land values in dollars per acre are directly available while crop returns and government payments are converted to a per acre basis using land in farms. Real interest rates are computed using nominal interest rates and the implicit GDP price deflator.

Results

1955-2002 Model

The estimates for land values using the three income capitalization variables, the previous year's value, and the trend variable are presented in Table 2 for the period, 1955-2002. For the three elements derived from the income capitalization model, a long term analysis provides the opportunity for statistical confidence of financial factors which influence land values. The probability levels (in parentheses beside the coefficients) indicate the probability that the estimates are not different from zero (no effect). For example, the probability that the two year crop return impact on land values for Iowa (.729) is not different from zero is .002.

The five explanatory variables all have the expected sign and, for the most part, demonstrate high statistical significance across the five states. The exceptions (not in sign but only in statistical significance) are for the land value trend variable in Missouri and the crop return variable for South Dakota. The impacts of the previous year's land value range from .815 for Iowa to .954 for South Dakota. The land value trend variable ranged from .180 for Missouri to .289 for Iowa.

Elasticities (at the means) best describe the impacts of the income capitalization variables. Elasticities describe the percentage change in land values relative to a one percent change in an explanatory variable. For example, the elasticity of the crop return variable for Iowa is .1602. The interpretation for this is that as the past two years per acre crop returns increase by one percent, land values increased by .16 percent. The relative responses are greatest for crop returns per acre and the real interest rate compared to the government payments variable.

For both crop receipts and government payment receipts there are two major explanations for elasticities to be less than one. First, each involves uncertainty thus increased returns received over the previous two years are not fully perceived as permanent. Second, crop receipts are gross rather than net because aggregate cost data is not available. With respect to the impact of government payments on land values, it should be noted that only part of farm program expenditures are commodity payments. The lower elasticity level for government payments may also be caused by uncertainty regarding the permanent nature of farm commodity programs. The elasticity response for real interest rates, as with crop and government payments, is less than 1 percent demonstrating that one or two year changes in crop receipts, government payments, and real interest rates represent only a part of the true specification of the expectational variables.

The 1955-2002 projections compared to actual values for each of the five states are presented in Figures 1-5. While the estimated values generally track actual values closely, generally the time period 1977-90 presents the greatest estimation challenge. The overall deviation results from actual values for the period 1955-2002 are summarized in Table 3. The relative mean absolute deviations are similar among states and are calculated by dividing absolute deviations regardless of sign by mean land values. Mean absolute deviations thus can be interpreted as the annual average percentage differences between forecasted and actual values. Mean relative absolute deviations range from .044 for Kansas to .059 for Iowa. In other words, the projections were relatively most accurate for Kansas and least accurate for Iowa. It should be noted from Figures 1-5 that the highest deviations occurred in the period, 1975-88.

Out-of-Sample Analyses

Two short-term time periods were analyzed for this objective. The first was the recent period involving 1991-2002 and the second involved 1975-88. In Table 4 the out-of-sample deviation results are presented for each state for each of the two analyses periods. Mean absolute deviations over each analysis period for the previously discussed 1955-2002 model are summarized along with the updated model. The 1955-2002 model could also be termed as "in sample" because it estimates land values over the 1955-2002 period with data for the entire 1955-2002 period without any updating mechanisms. The updated model forecasts land values for 1991 using the 16-year data series of 1976?91, 1992 using data for 1977-92, etc. Mean absolute deviations for this period (1991-2002) as demonstrated by the 1955-2002 model in Table 4 compared to Table 3 (1955-2002) are relatively lower because land values were relatively stable during this segment of the entire period. In every case but two (Iowa and Kansas) the updated model outperformed the 1955-2002 model and in those two states the updated model performed nearly as well.

The estimated coefficients for the updated models are not shown because of space limitations. Coefficients change annually in an updated model. A period greater than 16 years would likely result in more coefficient stability compared to the 16 year updated model. Yet, an advantage of only a 16-year period is the greater responsiveness to structural changes that are occurring.

For the turbulent period of 1975-88 the updated model results are also presented in Table 4 along with the results of the 1955-2002 model. Here, the results are more dramatic compared to the 1991-2002 period. The updated model (1960-75, 1961-76, etc.) performed unambiguously strong. In nearly all cases the mean absolute deviations for the updated model were half of that for the 1955-2002 model. Obviously even using only 16 years, updating coefficients demonstrates strong forecasting accuracy for cropland value estimation in these five mid-west states.[2]

Conclusions

Using variables representing the income capitalization model along with the previous year's land value and a two-year trend in land values, a time series analysis of forecasted land values for five Midwest states was completed using Ordinary Least Squares. The income capitalization variables included the previous two years of cropland receipts, the previous two years of government payments, and the previous year's real interest rate. The major objective was to analyze the performance of the model outside the data set used to estimate the model coefficients.

Estimated coefficients had the expected signs and demonstrated high statistical significance. The results demonstrated little difference among the five states in the performance of models and forecast accuracy. Crop receipts and the real interest rate had higher response elasticities than government payments.

Two time periods (1991-2002 and 1975-88) were used to compare estimates from three models. One was an in-sample model estimated for 1955-2002. The second model was an updated model. For the first test period this involved estimates for 1976-91, 1977-92, etc. while in the second test period the model used data for 1960-75, 1961-76, etc.

The updated model performed roughly the same or better than the in-sample model for the 1991-2002 test period. For the more unstable 1975-88 time period, forecast accuracy was nearly always less than for the 1991-2002 test period. However, the updated model performed relatively strong in that period of unstable land values.

Using only 16 years of data, the strong performance of the updated model demonstrates that a long data series is not required for land value forecasting accuracy. The updating characteristic also indicates that the causal factors underlying land values are complex. By allowing coefficients to change across time, an updated model provides opportunity to capture a changing complex market environment.

The results of this basic forecasting model add credence to the underlying aspects of the income-capitalization approach used in agricultural land appraisal. Recent cash crop receipts and government payments used in this model are very consistent with the appraiser's focus upon recent income levels generated from the subject property as well as from comparable sale properties in the current market. In essence, the underlying assumption is that market participants will heavily consider recent history in framing their expectations for returns into the immediate future. Likewise, using a real interest rate in this analysis is essentially considering the opportunity cost of capital investment. These factors, in combination with recent changes in values (to indicate current and projected patterns of value levels) are reflected strongly in the income-capitalization approach to appraisal. Consequently, the fact that forecasted value levels in this model were generally consistent with real levels suggests that conventional appraisal techniques for agricultural are sound.

Endnotes

[1] A contribution of the University of Nebraska, Agricultural Research Division, Lincoln, Nebraska 68583. Journal Series No. 14875.

[2] A fixed coefficient model in which estimated coefficients for the 1970--90 period were held constant and used to estimate land values for 1991-2002 was also evaluated. Similarly, this was completed for the 1975-88 time period. In every case, this model did not perform well relative to the updated model.

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Table 1. Data Sources of Variable Used in the Analysis, 1950-2002

Variables	Units	Sources
Land Value per acre	$/acre	1950-1995: http://www.usda.mannlib.cornell.edu/data-sets/land/86010/ 1995-2002: Agricultural Land Values & Agricultural
Crop Returns per acre	$/acre	1950-2002: http://www.ers.usda.gov/Data/farmincome/finfidmu.htm
Government Payments per acre	$/acre	1949-2002: http://www.ers.usda.gov/Data/farmincome/finfidmu.htm
Interest Rates	Percent	1950-1980: Economic Indicators of the Farm Sector: National Financial Summary, 1993 ECIFS 13-1 December 1994, USDA, ERS 1980-2002: Agricultural Income and Finance Outlook, March 2003, AIS-80
Implicit GDP price deflator	Index	1950-2002: http://www.bea.doc.gov/bea/dn/home/gdp.htm
Land in farms	Number of acres	1949-2002: http://www.ers.usda.gov/Data/farmincome/finfidmu.htm

Table 2. Estimated Coefficients, Probability Levels, Correlation Indexes, and Coefficient Elasticities – 1955-2002 for Five Midwest States

Coefficients	Iowa	Kansas	Missouri	Nebraska	South Dakota
Land Value	.815 (.0001)	0.88	0.839	0.82	0.954
(t-1)		-0.0001	-0.0001	-0.0001	-0.0001
Land Value	0.289	0.23	0.18	0.216	0.197
(t-1 - t-3)	-0.001	-0.017	-0.121	-0.013	-0.058
Crop Returns Per Acre	0.729	0.43	0.986	0.72	0.199
(t-1 + t-2)	-0.002	-0.054	-0.007	-0.001	-0.189
Government Payments Per Acre	1.112	0.966	2.33	1.136	0.844
(t-1 + t-2)	-0.019	-0.009	-0.001	-0.006	-0.028
Real Interest Rate	-2120.024	-693.14	-1161.530	-1100.36	-380.28
(t-1)	(.010)	(.004)	(.017)	(.001)	(.009)
Elasticities					
Crop Returns Per Acre	.1602	0.096	0.1719	0.1654	0.0394
(t-1 + t-2)					
Government Payments Per Acre	0.0427	0.05	0.0668	0.0515	0.0422
(t-1 + t-2)					
Real Interest Rate	-0.1177	-0.1017	-0.1165	-0.1463	-0.0992
(t-1)					
R^2 adj.	0.98	0.985	0.985	0.983	0.984

Table 3. Deviation Summary of 1955-2002 Estimations for Five Midwest States

	Iowa	Kansas	Missouri	Nebraska	South Dakota
Mean Absolute Deviations	46.61	13.06	22.2	17.66	7.65
Mean Relative Absolute Deviation	0.059	0.044	0.051	0.053	0.045

Table 4. Mean Absolute Deviations for the 1991-2002 and 1975-1988 Out-of-Sample Analyses for Two Models for Five Midwest States

1991-2002					
Model	**Iowa**	**Kansas**	**Missouri**	**Nebraska**	**South Dakota**
1955-2002 In-sample	23.14	8.18	16.1	11.14	11.9
Relative to Mean	0.018	0.018	0.021	0.021	0.022
16-Year Updated	24.32	9.05	13.03	10.99	7.71
Relative to Mean	0.019	0.02	0.017	0.02	0.014
1975-1988					
Model	**Iowa**	**Kansas**	**Missouri**	**Nebraska**	**South Dakota**
1955-2002 In-sample	103.85	27.55	49.14	36.78	14.19
Relative to Mean	0.09	0.065	0.083	0.079	0.061
16-Year Updated	52.19	14.62	16.89	19.79	7.19
Relative to Mean	0.045	0.034	0.029	0.043	0.031

Figure 1. Actual versus Predicted Land Values, Iowa, 1955-2002

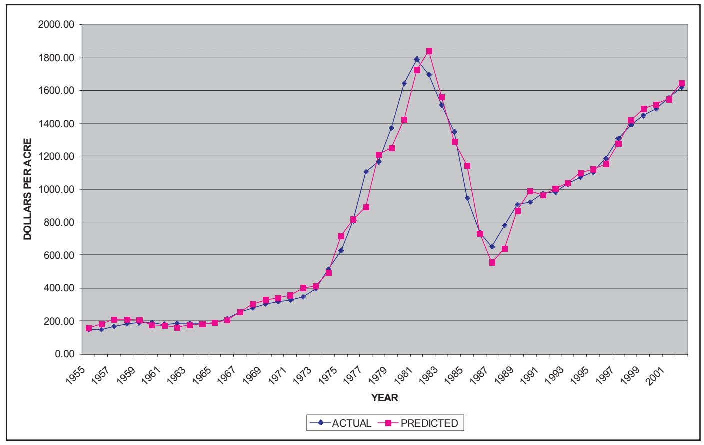

Figure 2. Actual versus Predicted Land Values, Kansas, 1955-2002

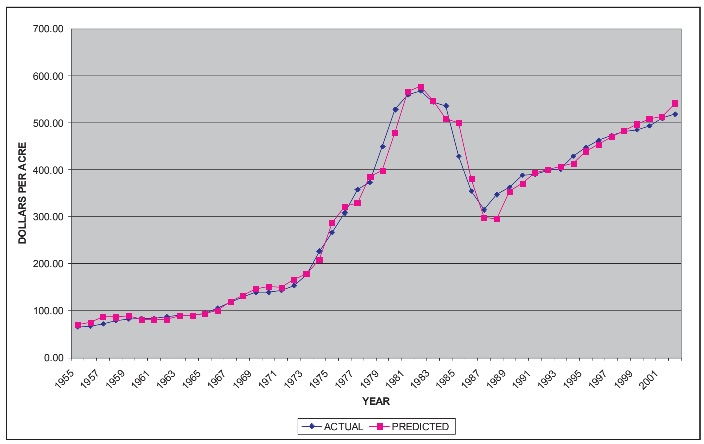

Figure 3. Actual versus Predicted Land Values, Missouri, 1955-2002

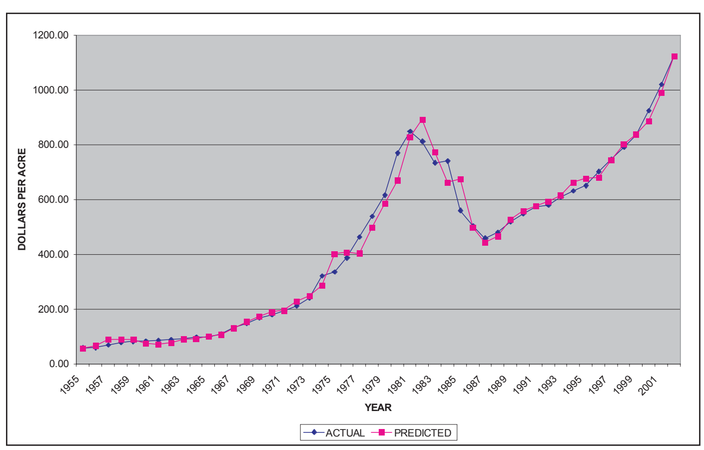

Figure 4. Actual versus Predicted Land Values, Nebraska, 1955-2002

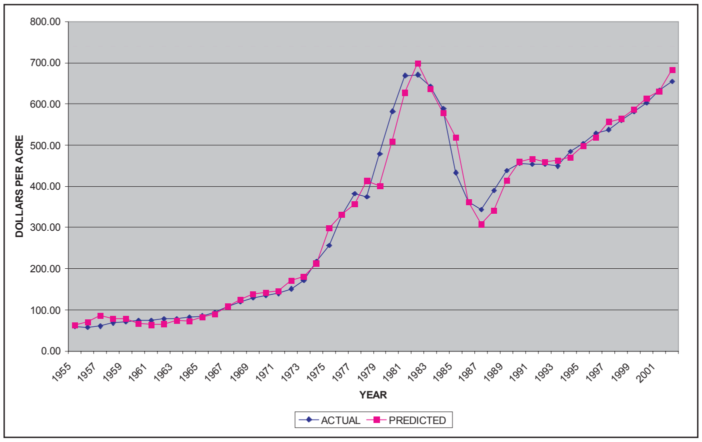

Figure 5. Actual versus Predicted Land Values, South Dakota, 1955-2002