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Structural Models and Automated Alternatives for Forecasting Farmland Prices

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Abstract

This report compares the accuracy of forecasts of farmland prices from a structural model estimated by ordinary least squares with forecasts generated from available software packages. Forecast accuracy was examined for both long-term and short-term forecasts, with emphasis on sharp changes in trends that have characterized the farmland market. Forecasting performance was improved when the structural model was re-estimated to allow for variable parameters.

Keywords: Alternative models, automated forecasts, farmland prices, forecasts, ordinary least squares

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Summary

Forecasts of farmland prices are important to private and public decisionmakers as land constitutes approximately 70 percent of the value of all farm assets. The demand for farmland price forecasts has been met mostly by informal analysis and surveys of expert opinion. Econometric models of farmland prices go back to at least the 1960's, but these models have not performed well and are not widely used for forecasting. Overly complex models, poor proxy variables, and the high volatility and imperfect understanding of the forces driving the farmland market make forecasting of farmland prices difficult.

The objective of this study is to answer the question: Given a structural model that is relatively simple but generally consistent with economic logic and estimable with ordinary least squares (OLS), can forecasting performance be improved with more complex models that attempt to simulate structural changes in the farmland market? We first examine the price-forecasting performance of a farmland price model that researchers have routinely used to help develop U.S. Department of Agriculture forecasts. The model, estimated with OLS, assumes that the structure of the farmland market has not changed through time. We examine whether the assumption is reasonable from a statistical perspective and then compare the forecasting performance of the model with several alternative models, allowing for the possibility of structural shifts.

The alternatives we examined are three univariate models, a variable parameter model, and a state space model. The statistical properties of these models suggest that they may produce better forecasts because of sophisticated extrapolation of past behavior of farmland prices or because they simulate changes in the structure of the farmland market. Use of these models had been limited by difficult and laborious estimation procedures until recently when user-friendly automated estimation techniques became available.

Breaks in farmland price trends, including a near quadrupling of prices in the 1970's, a sharp decline in the 1980's, and the recovery toward the end of the decade, provide a unique opportunity for testing forecasting performance.

The results of this investigation show that forecasts are improved when an OLS-estimated model, which assumes a constant structure of the farmland market, is re-estimated with an automated procedure in which the parameters vary over time. Both the constant and variable parameter models outperformed three univariate models and a state space model. The accuracy obtained with the variable parameter model suggests further exploration of a number of variable parameter models.

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Introduction

Farmland constitutes the bulk of the wealth of the farm sector, accounting for 70 percent of the value of all farm assets in 1990 [*29*].[1] The price of farmland has been highly variable over the past two decades. U.S. average price per-acre nearly quadrupled from 1972 to 1982 and fell more than 25 percent by 1987. The importance of farmland in the farm economy and the volatility of farmland prices has generated demand for forecasts among private individuals and organizations. Federal and State agencies produce forecasts for private interests and public officials who ask how policy changes, such as changes in farm programs or interest rates, would affect farmland prices.

Nearly all forecasting of farmland prices is based on informal analysis of likely trends of the variables believed to influence farmland prices [*21, 28*] or on surveys of persons familiar with the farmland market [*11, 23*]. Econometric modeling of farmland prices goes back to at least the 1960's, but these models have not performed well. Pope, Kramer, Green, and Gardner re-estimated four early econometric models with 1970 data [*20*]. They found sign reversals of the coefficients and forecasts with higher root mean square errors than an autoregressive integrated moving-average (ARIMA) time series model. A single-equation model estimated by ordinary least squares (OLS) outperformed the ARIMA-based forecasts but also underwent changes in the signs of the coefficients when fitted over different periods. We are unaware of any econometric-based forecasts of the sharp rise of farmland in the 1970's or its fall in the 1980's. The volatility of farmland prices and imperfect understanding of the dynamics of the farmland market make forecasting of farmland prices difficult. However, overly complex models and poor proxies for the variables specified by economic theory have also contributed to the poor forecasting performance.

The objective of this study is to determine if forecasting performance can be improved by going from a relatively simple model, estimated by OLS, to more complex but fully automated approaches. Each of the forecasting methods we examine would have been implementable a few years ago, but would have required researchers to develop their own computer programs. Some of the methods would probably have required a team of statisticians, economists, and computer programmers to develop forecasts. But with the software now available, researchers can quickly use the forecasting methods on their own.

We treat all models alike. Each is estimated with all the available information up to the point at which a major break occurred in the farmland price series. We then ask how well the forecasts would have held up.

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[1]Italicized numbers in brackets refer to sources listed in the References.

We start with the structural model estimated by OLS. Compared with most earlier models, this model is simpler and the explanatory variables are more closely related to the variables required by economic theory. For example, three of the four models examined by Pope, Kramer, Green, and Gardner were simultaneous equation models, with as many as 12 variables and 5 equations. Knowledge of the farmland market is insufficient to support such detail. In three of the four models, returns to land are approximated as "net farm income," which is an aggregate measure of returns to the farm sector including returns to labor and management. The fourth model employs the ratio of prices received by farmers to the prices paid, a measure only indirectly related to returns to land. We employ "returns to farm assets," which are principally returns to farmland adjusted to exclude returns to certain land-intensive farms that account for only 2.4 percent of land in farms but 22 percent of gross farm income. While derived from a distributed-lag model developed by Burt, the model is robust in the sense that it is similar to a number of adaptive expectations and partial adjustment models [*3*]. Ability to accommodate alternative assumptions about market behavior is desirable when the causes for the high volatility of farmland prices are not fully understood.[2]

The forecast accuracy of the structural model is compared with three univariate models, a variable parameter model, and a state space model. Univariate models do not rely on economic relationships but attempt to extrapolate future farmland prices from their own history. The variable parameter model represents an effort to simulate the effect on the parameters of revised expectations that likely occur when there are sharp changes in the explanatory variables underlying farmland prices. In the state space model, structural change is simulated by continuous updating of the parameters of the estimating equation.

The near quadrupling of farmland prices from 1972 to 1982, the sharp decline from 1983 to 1987, and the upturn in 1987 indicate possible structural changes making forecasting especially difficult. These breaks in the trend provide an unusual opportunity to examine the long- and short-term performance of alternative forecasting procedures.

Brandt and Bessler suggest that the usefulness of forecasts is not so much in their statistical significance as in their value in decisionmaking [*2*]. In this spirit, we examine the accuracy of alternative forecasts when used by landowners to decide whether to retain their land or sell the land and acquire an alternative investment.

The historical trend in farmland prices is briefly described. This is followed by a derivation of the structural model and a description of the data series employed. Forecasts from the OLS model are presented next. The alternative forecasting models are described and the forecasts from these models are compared with OLS results in terms of forecast accuracy as well as in terms of their performance as a guide to investors.

Farmland Price Trends

Figure 1 shows average price per acre of U.S. farmland since 1910 (also see app. table 1). The figure shows a slowly rising series with a sharp upturn beginning in 1973, a sharp downturn beginning in 1983, and a mild upturn in 1988. The most stringent test of forecasting performance we could think of was the capability to forecast these three trend changes. Therefore, the ability to

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[2] Featherstone and Baker ascribe shocks in the farmland market to the presence of "quasi-rational agents," leading to speculative bubbles [*6*]. This view is challenged by Tegene and Kuchler [*26*]. Tweeten and Gertel stress sharp changes in real interest rates [*27, 7*], while Burt relates farmland prices movements solely to land returns [*3*].

Figure 1
U.S. average value per acre of farmland

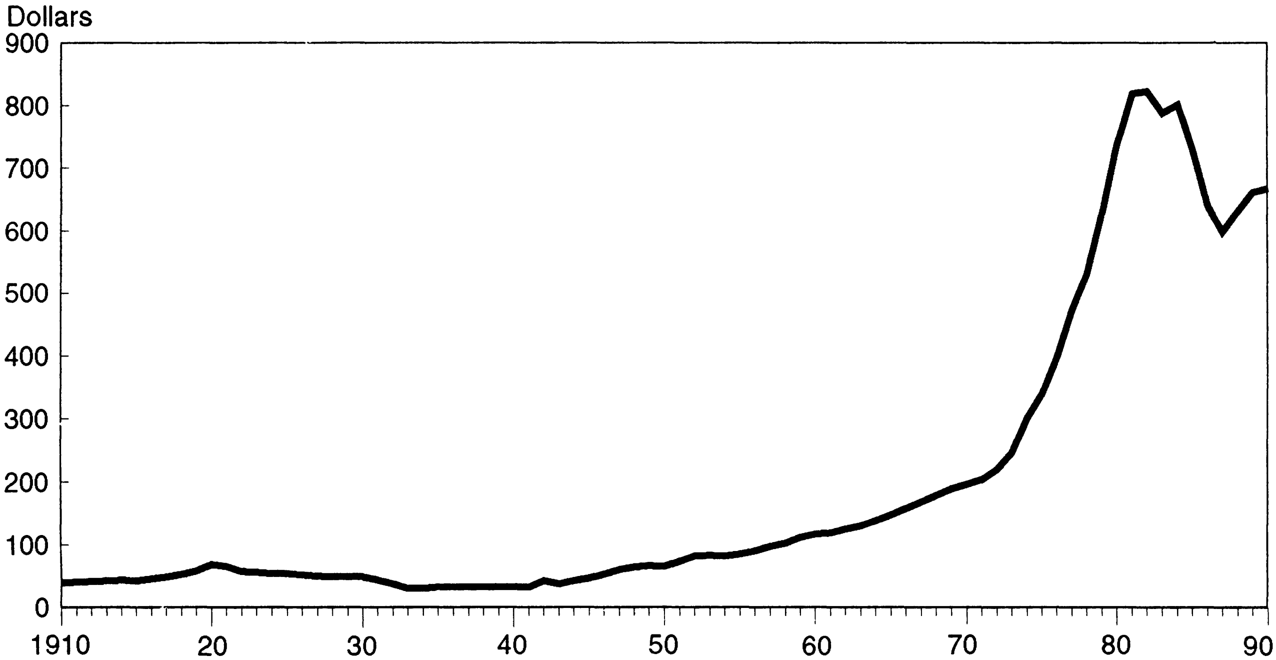
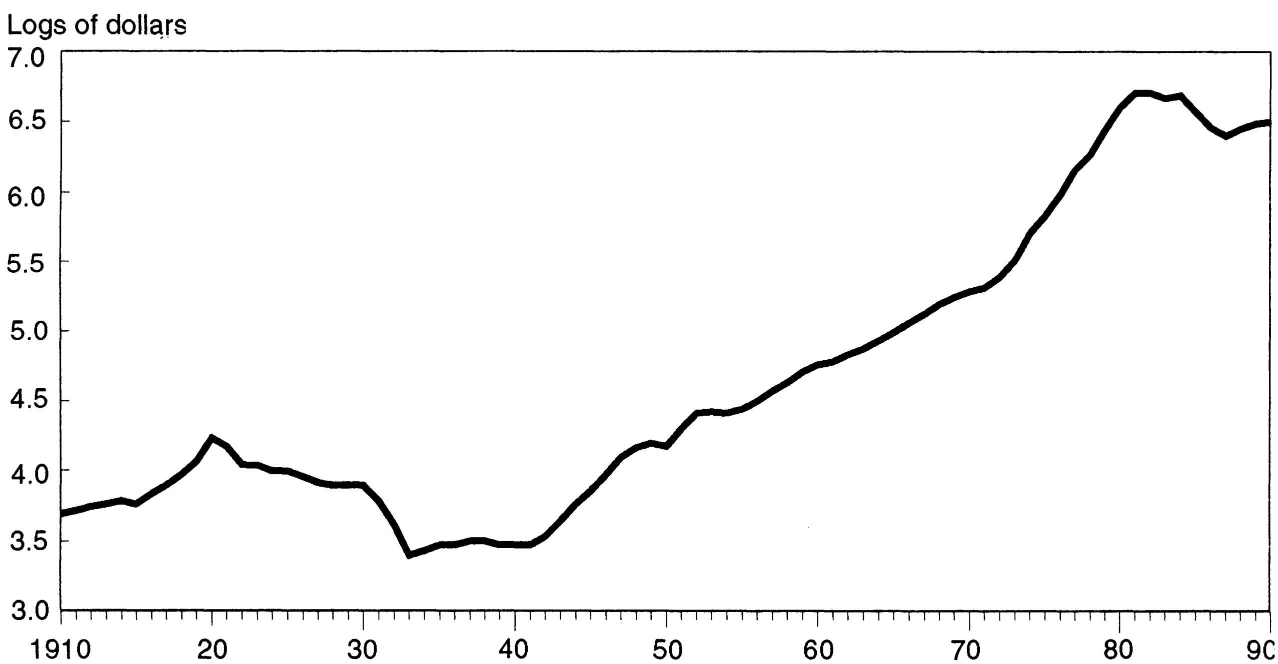


Figure 2
U.S. average value per acre of farmland in natural logs



forecast these three major breaks in the trend of the series is highlighted in the test of forecasting performance.

Figure 2 shows farmland prices transformed into natural logarithms: equal distance on the vertical scale represents equal percentage changes. Large percentage changes in farmland price in the early part of the century are obscured in figure 1, because the change was relatively small when expressed in natural numbers. From figure 2, one sees that the boom and bust of the past two decades had an antecedent in the decades of the 1920's and 1930's. The database of our structural model does not contain this earlier decline since the data series of the explanatory variables begins in 1940.

Structural Model

As a capital good, the price of land is the sum of the expected future net returns to the land discounted to an equivalent present value. Let P be the price per acre of land at the beginning of the year, X the net return at the end of the year, and R the real interest rate at the beginning of the year. Then, assuming that future returns and interest rates are constant and known:

$$P=\sum_{i=1}^{\infty}\frac{X}{(1+R)^i}. \tag{1}$$

The right side of equation 1 becomes a geometric series which sums to the capitalization formula:

$$P=\frac{X}{R}. \tag{2}$$

We drop the assumption that future returns and interest rates are known. Instead it is assumed that farmland participants form expectations of the average level of future returns and future interest rates. Moreover, the expected average level of future returns and interest rates is periodically revised resulting in periodic changes in farmland prices. Equation 3 then becomes:

$$P_t=\frac{X_t^*}{R_t^*}, \tag{3}$$

where X_t^* is returns expected in year t and R_t^* is the expected interest rate. Price and returns are in real terms at the price level at the beginning of year t.

Hicks defined the relationship in equation 3 as "equilibrium over time" [*12*]. Equation 3 represents equilibrium values in successive time periods. Farmland prices are in equilibrium with expected returns and expected interest rates, not necessarily with respect to existing returns and interest rates. It is assumed that changes in expectations and changes in farmland prices occur at the same time. This seems a reasonable approximation of reality since no delays, such as production processes, are necessary to revise farmland values in response to changed expectations. Volatility in the farmland market is likely to occur when market participants change the way in which they form their expectations. Falk has suggested that sharp changes in returns may induce farmland participants to place more weight on recent returns [*5*]. We would extend this hypothesis to sharp changes in real interest rates.

Since expected returns are unobservable, an expectations model is necessary in which expected values are functions of observed values. As a first step in deriving an estimable model, equation 3 is transformed into logs. This is consistent with the multiplicative relationship in equation 3 in which the price of land changes by the same percentage as the percentage change in returns and interest rates. Also, transforming the data into logs reduces the chances of heteroscedasticity of the residual terms by reducing the range of the data, since, often, the larger an independent variable, the larger the variance of the associated disturbance. The chances of heteroscedasticity are increased in the model of farmland prices because of the wide range in returns per acre, increasing more than tenfold over the sample period. Adding a residual term u to allow for the stochastic relationship between farmland prices, returns, and interest rates results in:

$$LogP_t = LogX_t^* - LogR_t^* + Logu_t. \tag{4}$$

Expected returns and expected real interest rates are modeled as a distributed lag in which expected values are assumed to be a weighted mean of past observed values with weights generally declining from more recent to earlier observations. The particular lag form selected is the rational lag which we adapted from a model employed by Burt [*3*]. This type of function was developed by Jorgeson who has shown that any distributed lag can be expressed as the ratio of two polynomials [*16*]. The rational lag model employed is:

$$LogP_t = \frac{B_3 LogX_{t-1} + B_4 LogR_t}{1 - B_1 L - B_2 L^2} + Logu_t. \tag{5}$$

P_t is the nominal price per acre at the beginning of the year t and B_1, B_2, B_3, and B_4 are structural parameters. The expected sign of B_3 is positive and the expected sign of B_4 is negative. The term L is a lag operator such that $LP_t = P_{t-1}$ and $L^2P = P_{t-2}$. Since returns for the year t are not known at the beginning of the year, and were found to be not significant, returns in the preceding year are employed. Multiplying both sides of equation 5 by $1-B_1L-B_2L^2$ gives:

$$LogP_t - B_1 LogP_{t-1} - B_2 LogP_{t-2} = B_3 LogX_{t-1} + B_4 LogR_t + Logu_t - B_1 Logu_{t-1} - B_2 Logu_{t-2}. \tag{6}$$

Transposing from the left side of the equation gives:

$$LogP_t = B_1 LogP_{t-1} + B_2 LogP_{t-2} + B_3 LogX_{t-1} + B_4 LogR_t + v_t. \tag{7}$$

where $v_t = Logu_t - B_1 Logu_{t-1} - B_2 Logu_{t-2}$. The residual is a combination of the current and preceding two residuals and may result in first- and second-order serial correlation of v_t. Therefore, the Durbin h test and the asymptotic Breusch-Godfrey tests were employed to check the residuals from equation 7 for first- and second-order serial correlation.

The expected value of the sum of the coefficients for returns and lagged land prices is 1.0, and the expected value of the coefficient of the interest rate is equal and opposite in sign to the coefficient for returns. These relationships are derived from equation 5 when all the explanatory variables are static and $X_t = X_{t-1} = X_{t-2}$, $R_t = R_{t-1} = R_{t-2}$, and $P_t = P_{t-1} = P_{t-2}$. Therefore, the lag operators in equation 5 can be eliminated so that equation 5 becomes:

$$LogP = \frac{B_3 LogX + B_4 LogR}{1 - B_1 - B_2}. \tag{8}$$

According to equation 2, a change in X (returns to land) results in a proportionate positive change in P (the price of land). A change in R (the interest rate) results in a proportionate negative change in P. Therefore:

$$\frac{\partial LogP}{\partial LogX} = \frac{B_3}{1 - B_1 - B_2} = 1, \tag{9}$$

and

$$\frac{\partial LogP}{\partial LogR} = \frac{B_4}{1 - B_1 - B_2} = -1. \tag{10}$$

From equation 9:

$$B_3 = 1 - B_1 - B_2 \text{ that is } B_1 + B_2 + B_3 = 1, \tag{11}$$

and from equation 10:

$$B_4 = -1 + B_1 + B_2 \text{ that is } B_1 + B_2 - B_4 = 1. \tag{12}$$

Subtracting equation 12 from equation 11 gives $B_3+B_4=0$; that is, the coefficients for returns and interest rates are equal in magnitude but opposite in sign.

The logic of the expected value of the coefficients can be seen by expressing equation 7 in exponential form. Omitting the stochastic error term, equation 7 becomes:

$$P_t = P_{t-1}^{B1} P_{t-2}^{B2} X_{t-1}^{B3} R_t^{B4}. \tag{13}$$

According to equation 2, returns and interest rates have equal but opposite effects on farmland prices. Therefore, the expected value of $B_4=-B_3$. Hence, equation 13 can be written as:

$$P_t = P_{t-1}^{B1} P_{t-2}^{B2} \left(\frac{X_{t-1}}{R_t}\right)^{B3}. \tag{14}$$

In equations 7 and 14, price per acre is a weighted geometric mean of past land prices and the capitalized value of past returns. The first and second terms of the right side of the equations are price per acre, 1 and 2 years earlier, weighted by B_1 and B_2, respectively. The third term is the capitalized value of last year's returns weighted by B_3. The expected value of the sum of weights $B_1+B_2+B_3=1.0$.[3]

Equations 4 and 5 do not contain a constant term since the capitalization model in equation 3 has an implied constant term of 1, which assumes a value of zero in logs.

Data

Once the theoretical model was developed, data that could be used to empirically estimate the model were specified. Data specification involved modifying an existing series on returns to farm assets and selecting the most appropriate series on interest rates.

Current Net Returns to Farmland

The proper measure of returns, theoretically, is net returns to farmland. Net returns to farmland is defined as gross farm income minus the sum of production expenses and returns to unpaid labor. The historical data necessary to construct a net returns series, however, are not available. To construct such a series, analysts would need to know how interest charges are attributed to land versus other

[3] The interpretation given in the text assumes that the coefficients for P_{t-1}, P_{t-2}, and X_{t-1} are positive. Empirically, the coefficient of P_{t-2} is often negative. In such cases, the interpretation is in terms of ratios. For example, this year's price P_t, is equal to last year's price adjusted by the ratios of P_{t-1}/P_{t-2}. For a fuller explanation, see [3, p. 22].

assets. Returns to farm assets are often used as a proxy, since land and buildings account for over 70 percent of all farm assets [*29*]. Moreover, using returns to farm assets avoids the need to separate interest charges attributed to land from interest charges attributed to other assets. The basic data series used in this report is returns to assets as published in *Economic Indicators of the Farm Sector: National Financial Summary* [*29*]. The authors modified that series in several ways, however, to represent more closely the workings of the farmland market.

First, the series was adjusted to account for the hypothesis that trends in farmland prices are more closely related to returns to expansion buyers who add acreage to existing farmland, than to average returns to all farm operators. Johnson's study of returns to land and Hottel and Reinsel's study of returns to equity capital show that in any given year the average return is a composite of a wide range of positive and negative values [*13, 14*]. Bid prices in the farmland market are likely to be set by expansion buyers and other buyers with below-average expense schedules. From 1989 to 1991, nearly 60 percent of total acres of farmland purchased were to expand an existing farm [*28*]. Accommodating that hypothesis requires the analyst to modify the net returns series to reflect the lower production expenses of an expansion buyer rather than those of a new farm buyer.

Expansion buyers buy farmland to better use their resources, such as family labor, farm machinery, and farm buildings. In cases where machinery and buildings are the slack resource, the additional depreciation resulting from the expansion unit is assumed to be proportionately less than that associated with operating an entire farm. Nevertheless, the marginal depreciation on an expansion unit is not zero, even in the short run. To account for the differential depreciation on such potentially slack resources available to expansion buyers, only half the normal depreciation in production expenses was included. Because the added labor needed to operate newly purchased land is likely to have an opportunity cost, the cost of labor was kept as a production expense.

Second, the return-to-asset series was adjusted to account for possible shifts in the proportion of aggregate returns attributable to land-extensive and land-intensive agricultural enterprises by removing returns to assets for such enterprises from the U.S. total. The *1987 Census of Agriculture: U.S. Summary and State Data* reported that five Standard Industrial Classification (SIC) farms accounted for approximately 22 percent of gross income [*30*]. The five categories of farms were animal specialty, fruits and nuts, horticultural, vegetable, and poultry and eggs. As a group, however, the five categories accounted for only 2.4 percent of land in farms. Returns to assets in these five SIC's were deducted from the U.S. total. Somwaru provided the basic data on income and expenses [*24*].

Third, total returns to assets were divided by acres of land in farms to produce per-acre statistics. This step was taken to conform to customary reporting procedures. Farmland prices are usually reported and discussed on a per-acre basis, while aggregates of income and expenses are reported and discussed as totals. Per-acre returns to assets are given in appendix table 2.

Interest Rates

The real interest rate was calculated from the Farm Credit System rate on new real estate loans minus the inflation rate as measured by the gross national product (GNP) deflator. The Farm Credit System rate was used since it was the principal lender on farm real estate for most of the period examined. Real interest rates are given in appendix table 2.

Ordinary Least Squares

The most stringent test of forecasting performance that we could conceive was to test the capability to forecast the three trend changes in farmland prices that have occurred since 1970. Accordingly, the

OLS model was fitted over three sample periods: (1) from 1942 to 1972 to see if the sharp upturn in farmland prices beginning in 1973 is predicted, (2) from 1942 to 1982 to see if the severe decline that began in 1983 is predicted, and (3) from 1942 to 1987 to see if the upturn that began in 1988 is predicted.

The statistical profile of fitting equation 7 to OLS is given in table 1. For the 1942-87 sample period, the Durbin h test shows no significant first-order serial correlation of the residuals, and the Breusch-Godfrey test for the 1942-87 period shows no significant first- and second-order serial correlation ($R^2=0.04$ for the regression of the residuals on the lagged residuals and independent variables) [*15*]. The Goldfeld-Quandt test did not indicate heteroscedasticity; fitting the model for the first 20 observations and the last 20 observations gave an F ratio of 1.52 for the error variance. The characteristic roots indicate a stable dynamic equilibrium. That is, if the equilibrium price per acre is disturbed by a change in returns or interest, price per acre will move to a new stable equilibrium rather than follow an explosive path. The coefficients are significant at the 95-percent level or higher, except for returns from 1942 to 1972, and have similar values over the three sample periods. This result suggests that there may be permanent values for the key parameters that determine farmland prices. Breaks in price trends may be due to sharp but temporary changes in the value of these parameters.

Coefficients for returns and interest rates are approximately equal but of opposite sign as expected and the sum of the coefficients relating to returns and lagged land prices is close to 1. When fitted with a constant term, the value of the intercept is not significant (t=-0.25).

Table 1--U.S. average price per acre of farmland related to lagged farmland prices, returns to assets, and the real interest rate, estimated by OLS[1]

Coefficient	Sample period		
	1942-87	1942-82	1942-72
Price of land Lagged by 1 year	1.4279 (12.41)[2]	1.2804 (9.46)	1.2919 (8.64)
Price of land Lagged by 2 years	-.4676 (-4.24)	-.3178 (-2.39)	-.3173 (-2.12)
Returns to assets Lagged by 1 year	.0389 (2.77)	.0474 (3.66)	.0267 (1.43)
Real interest rate	-.0421 (4.62)	-.0388 (-4.48)	-.0317 (-3.10)
Standard error of regression	.0408	.0359	.0320
Sum of coefficients relating to returns and lagged land prices	.9992	1.0100	1.0013

[1]Coterminous United States. All variables in natural logs.
[2]Numbers in parentheses are t-values.

The R^2 for the three periods examined is 0.99, but high R^2's are not unusual when lagged values of the dependent variable are included as explanatory variables. Maddala notes that the usual R^2 is based on the naive alternative estimator of the mean of the dependent variable [*18*]. He recommends Harvey's relative R^2 to judge the usefulness of the model. In Harvey's R^2_D, the alternative estimator is a random walk with drift:

$$R_D^2 = 1 - \frac{RSS}{\sum [\Delta y_t - mean \Delta y_t]^2}, \tag{15}$$

where RSS represents the residual sum of squares of the model divided by the degrees of freedom. The denominator is the sum of squares of the deviations of the first differences from their mean, divided by the degrees of freedom. For a sample of T observations there will be T-1 differences and T-2 degrees of freedom. R^2_D can be positive or negative. A model with a negative R^2_D explains less of the variation of the dependent variable than a random walk with drift. Maddala recommends discarding models with negative R^2_D's. The R^2_D for the 1942-87 period is 0.64. This amounts to a nearly two-thirds reduction of the residual error variance from a random walk with drift.

Following the procedure of Pope, Kramer, Green, and Gardner, forecasts were made by using the historical values realized for the exogenous variables of returns and real interest rates [*20*]. Forecasts of lagged farmland prices were generated by the model. Use of historical values for the explanatory variables serves to identify faulty models. Models that fail to forecast trend changes, given accurate values of the explanatory variables, are considered unsatisfactory.

As shown in figure 3, the OLS model did forecast a rise in the upward trend of farmland prices beginning in 1973, the first forecast year, but the rate of increase in the trend was underestimated. The downturn beginning in 1983 is similarly anticipated but greatly underestimated (fig. 4). The mild recovery from 1988 to 1990 is forecast as a bottoming out of the decline (fig. 5). Thus given accurate

Figure 3
U.S. average value per acre realized and forecast by OLS from 1973

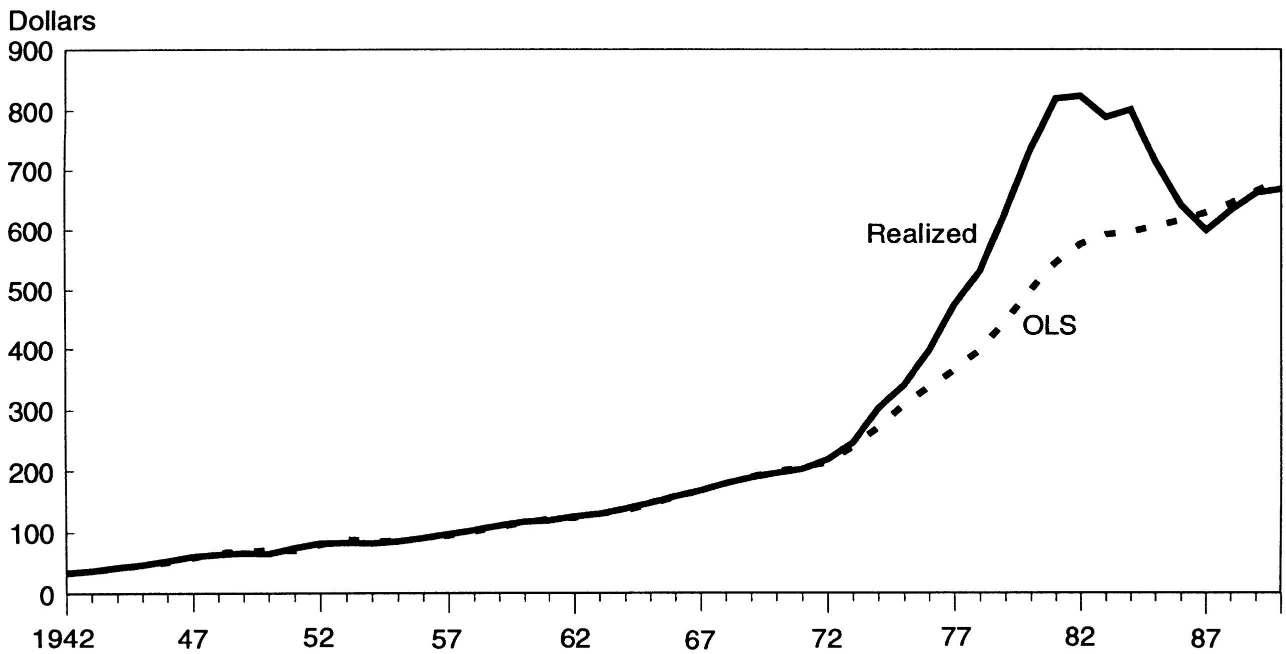


Figure 4
U.S. average value per acre of farmland realized and forecast by OLS from 1983

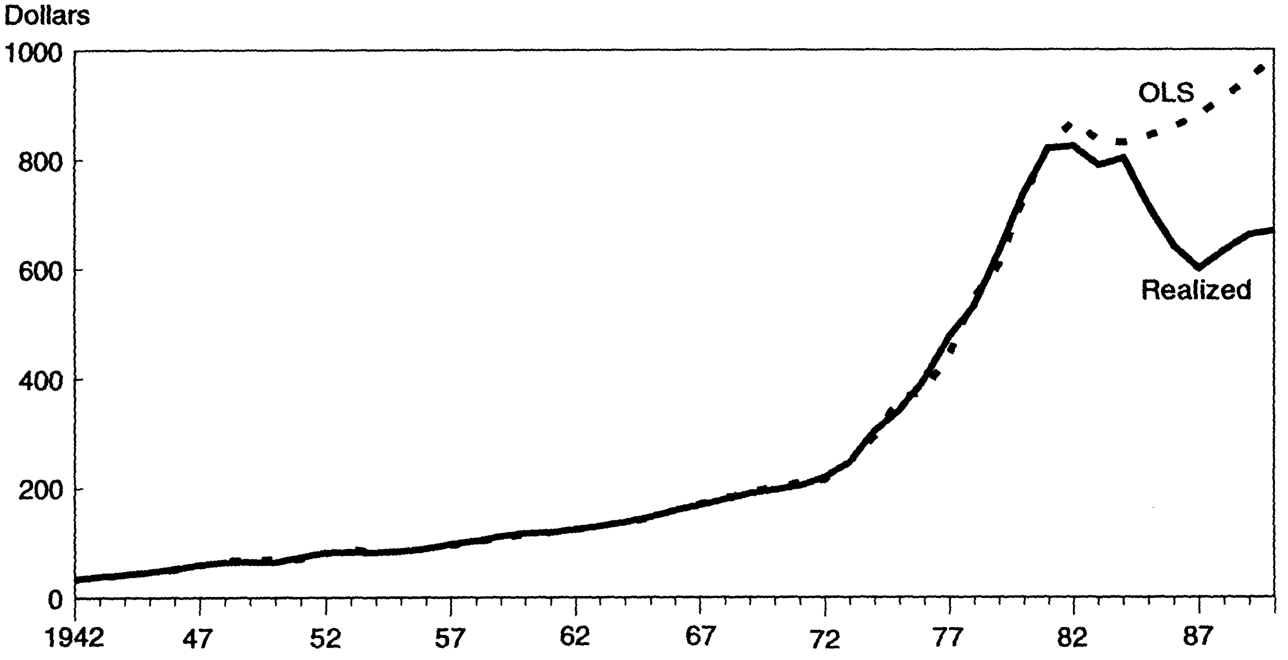
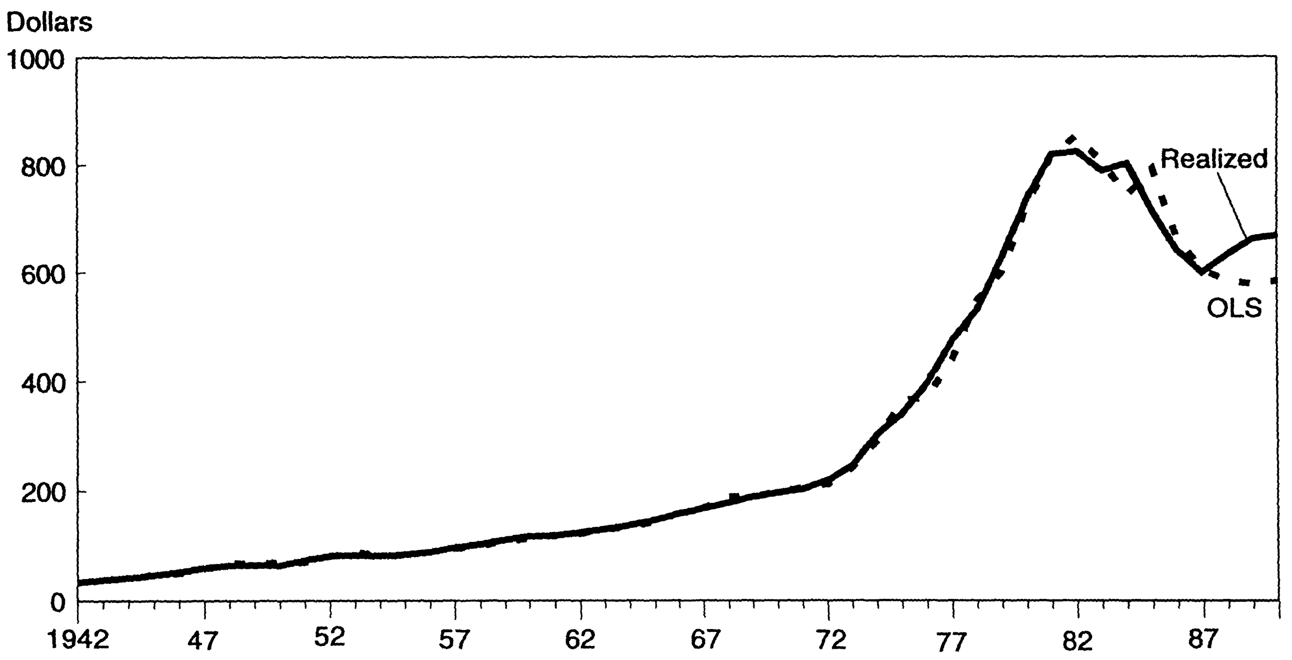


Figure 5
U.S. average value per acre of farmland realized and forecast by OLS from 1988



forecasts of the explanatory variables, the OLS model can predict trend increases and trend reversals, but underestimates them. Understatement of trend changes is due to the heavy weight the parameters place on lagged farmland values. When trend changes occur, parameter values have probably changed from their long-term average, putting greater weight on currently observed returns and interest rates.

Selected Modeling Alternatives

Several alternatives to the OLS model were explored to compare and test their performance. The emphasis was on techniques not requiring a large amount of user intervention or expertise within existing statistical software packages.

Univariate Methods

We first explored univariate time series models of the land price series; that is, techniques that attempted to predict the future of the series from its history rather than from a relationship with explanatory variables. Three univariate models were examined: two trend models and one autoregressive integrated moving-average (ARIMA) model.

The first trend model was obtained using the Stepar option of the Proc Forecast procedure in SAS Institute Inc. SAS/ETS User's Guide ®[22].[4] In this model, the data are first detrended using an OLS regression. The residuals from the trend are fitted to an autoregressive process in which the lags are selected in a stepwise procedure. Forecasts are generated using the estimated trend and the stepwise autoregressive estimation of the residuals.

The second trend model uses the Expo option of Proc Forecast. This is a standard method in which forecasts are a moving average of weighted past prices, with earlier prices given exponentially declining weights. The third univariate model is an ARIMA model that follows the Box-Jenkins technique of time-series analysis. ARIMA models also forecast the future of a series based on its history, using the autocorrelation structure of the data to identify a model. Determining the appropriate structure for such a model and estimating its parameters can be quite complex. The Automatic Forecasting System Inc. Autobox software package we used accomplishes this task in an automated way [*1*].

Table 2 shows some forecasting results from the two extrapolation techniques (with the stepwise autoregressive method labeled "trend") and the ARIMA model and compares them with the OLS forecasts and observed values. Three forecast years were selected to highlight the sizeable forecast errors resulting from failure to forecast trend changes. The first was 1982, the year in which farmland prices peaked following the trend change in 1972. When fit with data through 1972, the univariate models were unable to predict the boom beginning in 1973 and underestimated farmland prices in 1982. When fit for the period 1942-82, they similarly missed the decline beginning in 1983 and severely overestimated values for 1987. When fit for the period 1942-87, the ARIMA model failed to forecast the upturn that occurred. The trend and exponential smoothing models did detect the upturn, but the level of farmland prices was greatly overestimated with the exponential smoothing model.

None of the univariate models consistently outperformed OLS, but the trend model appeared the least ineffective and was therefore included in graphic comparisons and short-term forecasts. Enlarging the

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[4] SAS™ is a registered trademark of SAS Institute, Inc., Cary, NC.

Table 2--Univariate forecasts of farmland price per acre

Method	1982[1]	1987[2]	1988[3]	1989[3]	1990[3]
			Dollars		
Trend[4]	407	900	637	713	809
Exponential smoothing[5]	475	1,356	1,031	1,131	1,243
ARIMA[6]	415	1,447	569	542	518
OLS	574	881	583	578	583
Observed	823	599	632	661	668

[1]The year 1982 was the peak of the boom beginning in 1973.
[2]The year 1987 was the bottom of the decline beginning in 1983.
[3]The years 1988-90 saw an upturn following the low point in 1987.
[4]SAS Stepar method of proc forecast, a trend model with modeling of residuals from trend.
[5]SAS Expo method of Proc Forecast, exponential smoothing.
[6]Autobox method of forecasting.

sample by fitting the univariate models from 1910 to include the peak of 1920 and the low of 1933 did not change the conclusions.

Modeling OLS Residuals

Although no significant first- and second-order serial correlation of the residuals was found, the possibility exists of a more complex interrelationship among the residuals. We therefore investigated the forecasting of the OLS residuals as described by Pindyck and Rubinfeld [*19*]. The residuals were modeled by two methods available from SAS: stepwise autoregressive method (labeled trend) and exponential smoothing. Forecasts of the residuals obtained by these methods were added to the forecasts generated by OLS. The third method employed was state space regression, available from the Forecast Master Plus software package [*10*]. The state space regression derives OLS estimates and applies state space techniques to the residuals (see Multivariate State Space section below for a description of the state space approach). It adjusts the OLS forecasts by adding the forecasts of the residual.

The results for the three methods are given in table 3. Adjusting the OLS estimates by modeling the residuals resulted in only minor adjustments. We also attempted to apply ARIMA techniques to forecast the OLS residuals. However, a look at the autocorrelations of the residuals using both the Autobox and a more manual approach in SAS Proc ARIMA indicated that there was not enough structure left over to work with. There are apparently no gains from modeling of OLS residuals when no significant serial correlation of the residuals from the regression has been detected.

Variable Parameter Regression

Returning to the structural model, it appears reasonable that one or more of the parameters may be time varying rather than constant, consistent with structural changes in the farmland market. A variable parameter model does not attempt to model various types of structural change. Instead it is hoped that modeling the parameters, as following an autoregressive process with a disturbance term, will simulate the actual effects of structural change on the parameters.

Table 3--Forecasts of price per acre with modeling of OLS residuals

Method	Sample period, forecast year				
	1942-72		1942-87		
	1982[1]	1978[2]	1988	1989	1990[3]
			Dollars		
Trend[4]	576	883	585	580	585
Exponential smoothing[5]	576	881	574	568	572
State space[6]	576	899	582	575	576
OLS	575	881	583	578	583
Observed	823	599	632	661	668

[1]The year 1982 was the peak of the boom beginning in 1973.
[2]The year 1987 was the bottom of the decline beginning in 1983.
[3]The years 1988-90 saw an upturn following the low point in 1987.
[4]SAS Stepar method of proc forecast, a trend model with modeling of residuals from trend.
[5]SAS Expo method of proc forecast, exponential smoothing.
[6]Forecast Master Plus. A multivariate state space model option in which forecasts of the explanatory variables are provided by the user.

A variable parameter regression (VPR) procedure to fit a model whose regression coefficients change over time is available in the Forecast Master Plus Software package [*10*]. We used VPR to estimate equations corresponding to the OLS model discussed earlier, where the coefficients for returns and interest rates followed autoregressive processes. The data are fitted iteratively to maximize the log likelihood function. Table 4 shows the estimation results for the variable parameter model. The regression coefficients in table 4 are the expected values of the regression coefficients calculated from the stationary autoregressive model:

$$b_{t+1}=ab_t+D+e_t, \qquad (16)$$

where b_{t+1} and b_t are the values of the regression coefficients at time t and time t+1, a is the autocorrelation coefficient, D is a constant and e is a random error with mean zero. With estimates of a and D provided by Forecast Master, the expected values of the regression coefficients were calculated as b=D/(1-a). The coefficients of the variable parameter model are similar to those estimated by OLS and shown in table 1.

Multivariate State Space

Multivariate state space (MSS) is a flexible forecasting approach that includes a number of models as special cases including OLS, ARIMA time series models, Baysian forecasting, and models with time-varying parameters. The appeal of MSS for forecasting the volatile farmland price series is the continuous updating of the forecasting equation and the capacity of MSS to incorporate a "returns to normality" model in which the coefficients are stochastic about a fixed mean [*17*, p. 810]. Such a model may accommodate shocks in the land market, sharp changes in returns, and interest rates that induce temporary changes in the parameters.

The MSS program provided by Forecast Master requires the transformation of all variables to stationarity. This is not a general requirement of state space, nor is it needed to implement MSS regression, which applies state space techniques to the OLS residuals [*9*]. Transformation of the

Table 4--U.S. average price per acre of farmland related to lagged farmland price, returns to assets, and the real interest rate, estimated by variable parameter regression[1]

Coefficients	Analysis period		
	1942-87	1942-82	1942-72
Price of land Lagged by 1 year	1.3192 (6.08)[2]	1.2102 (3.87)	1.3135 (4.29)
Price of land Lagged by 2 years	-.3492 (-1.64)	-.2445 (-0.78)	-.3412 (1.11)
Returns to assets[3] Lagged by 1 year	.0279 (NA)	.0340 (NA)	.0262 (NA)
Real interest rate[3]	-.0377 (NA)	-.0408 (NA)	-.0321 (NA)
Standard error of forecast	.0463	.0430	.0385
Sum of coefficients relating to returns and lagged land prices	.9701	.9658	.9723

[1]Coterminous United States. Forecast Master Plus variable parameter program. All variables in natural logs.
[2]Numbers in brackets are t values.
[3]Expected value of the coefficients, standard errors unavailable, NA is not available.

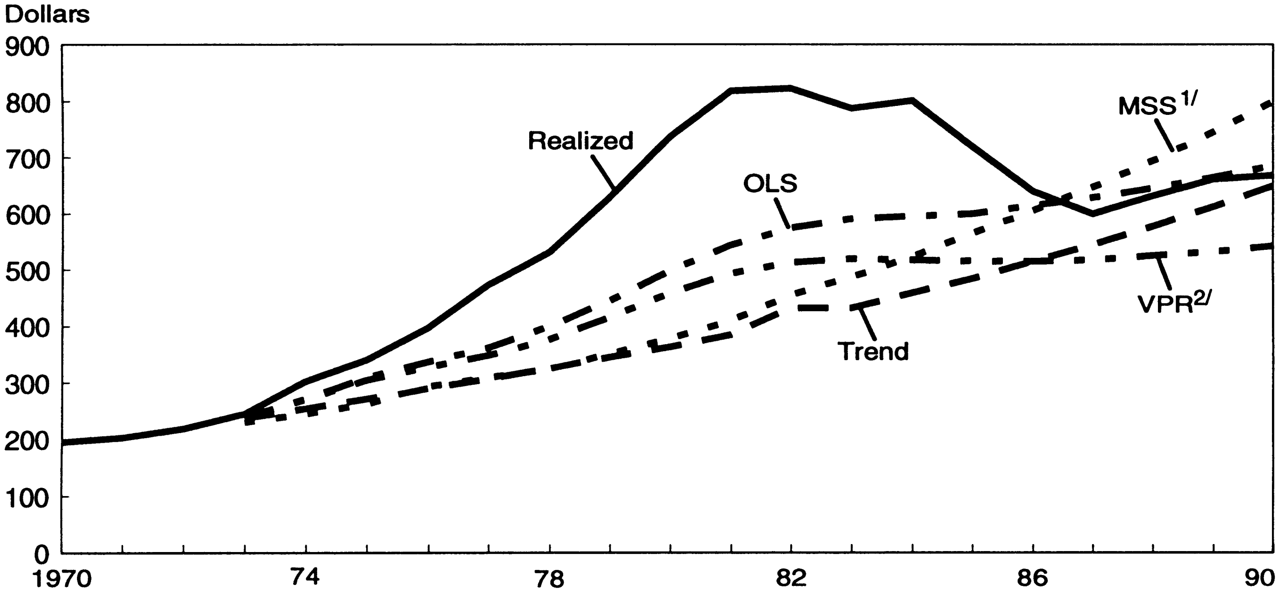
variables to stationarity, when feasible, is easily accomplished with Forecast Master. At the option of the user, the program will either generate forecasts of the explanatory variables or accept the user's forecasts of the explanatory variables. Using historical data for returns and interest rates, we selected the option in which the user provides the forecasts of the explanatory variables.

Figures 6-8 compare the forecasts from OLS, VPR, MSS, and the univariate trend extrapolation procedure with the values actually realized. For 1973-90 out of sample forecasts, the OLS model outperformed all alternatives. For 1983-90, VPR did best. For 1988-90, the VPR again outperformed OLS, but not by much. The trend model gave the clearest sign of a turnaround in the land market, but it overestimated the robustness of the recovery. The average absolute percentage error and the root mean square error of the forecast from 1988 through 1990 are approximately the same for the OLS and the trend models.

In table 5, results are given for 1- and 2-year forecasts from 1973 to 1988. To ensure representative results during 1973-87, we drew a stratified random sample from eight strata, each consisting of 2-year periods. From each subperiod, 1 year was selected to be the year to which the model was fitted. For example, 1972 was selected from the first subperiod. Therefore, the model was fitted from 1942 to 1972 and 1- and 2-year forecasts were generated for 1973 and 1974. In short-term forecasting, the VPR model performed better than OLS, whereas the MSS and the trend models came in a poor third and fourth.

Figure 6

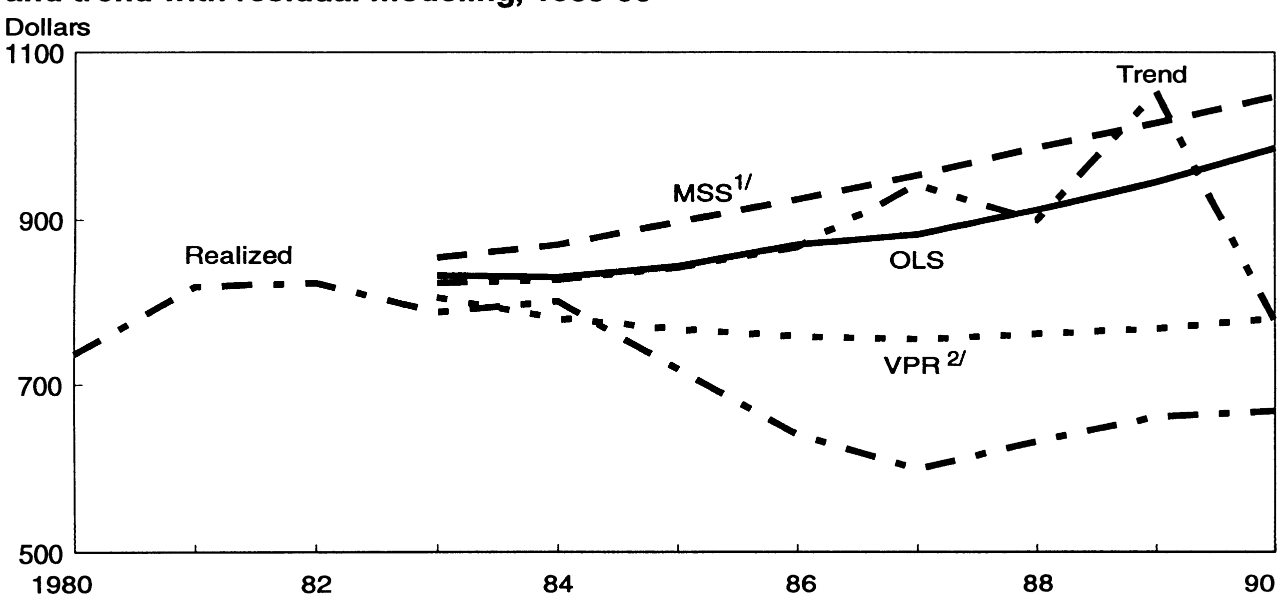
U.S. average value per acre of farmland realized and forecast by OLS, VPR, MSS, and trend with residual modeling, 1973-90



1/ MSS is multivariate state space.
2/ VPR is variable parameter regression.

Figure 7

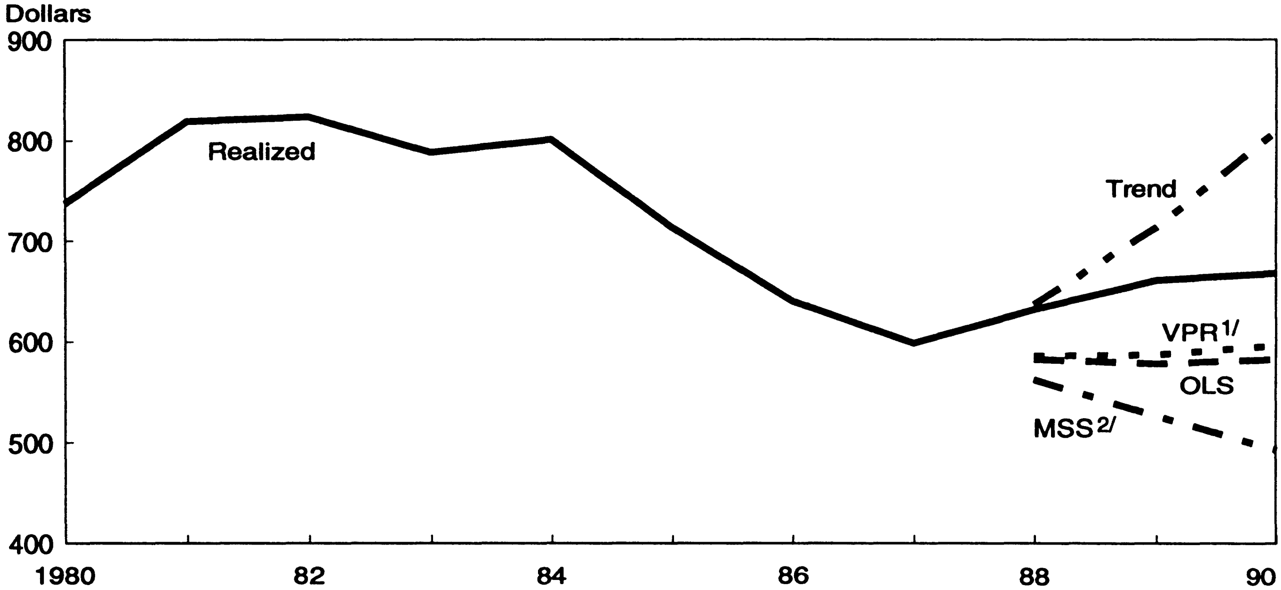
U.S. average value per acre of farmland realized and forecast by OLS, VPR, MSS, and trend with residual modeling, 1983-90



1/ MSS is multivariate state space.
2/ VPR is variable parameter regression.

Figure 8

U.S. average value per acre of farmland realized and forecast by OLS, VPR, MSS, and trend with residual modeling, 1988-90



1/ VPR is variable parameter regression.
2/ MSS is multivariate state space.

Table 5--Short-term forecasting performance of alternative models

Forecast year	1-year-ahead forecasts OLS[1]	VPR[2]	MSS[3]	Trend[4]	Forecast year	2-year-ahead forecasts OLS[1]	VPR[2]	MSS[3]	Trend[4]
	Percent error[5]					*Percent error*[5]			
1973	-2.8	-2.6	-6.4	-3.8	1974	-10.3	-10.4	-19.0	-15.7
1976	-6.8	-8.7	-7.5	-12.5	1977	-15.6	-18.9	-20.4	-27.1
1977	-7.3	-5.5	-5.3	-16.2	1978	-6.6	-4.3	-5.1	-24.1
1979	-3.8	-5.8	-4.6	-15.6	1980	-6.1	-10.9	-6.1	-27.3
1982	7.0	4.5	15.2	.6	1983	17.3	10.7	37.3	7.0
1983	5.8	2.3	8.3	4.4	1984	3.6	-2.7	8.5	3.3
1986	5.9	4.6	1.2	11.7	1987	11.0	9.5	.7	20.2
1988	-7.8	-7.2	-11.0	.8	1989	-12.6	-11.2	-20.4	7.7
Average absolute error[5]	5.9	5.1	7.4	8.2	Average absolute error[5]	10.4	9.8	14.7	16.6
Root mean square error	.0612	.0552	.0843	.1022	Root mean square error	.1129	.1084	.1842	.1882

[1]Ordinary least squares.
[2]Forecast Master Plus, variable parameter regression.
[3]Forecast Master Plus, multivariate state space.
[4]SAS Stepar, a trend model with modeling of residuals from trend.
[5](Predicted-actual)/actual.

In addition to the methods evaluated above, two models, attempted because they looked promising, caused problems in implementation. We pursued using transfer function methodology to apply time series analysis techniques to model the land value series as a function of its own past and the values of the independent input series of returns and interest rates. Problems encountered in the transition to a new version of the Autobox package caused this process to be less automatic than desired, and we left this for future research. We also examined the feasibility for an error correction model which provides parameters of long-term equilibrium and a short-term dynamic structure [*25*]. However, the returns per acre series failed to pass the unit root test for a difference stationary process.

Economic Performance Evaluation

As we pointed out in the introduction, forecasts of trends in farmland prices are crucial to participants in the farmland market. Hence, we compare the performance of alternative forecasts as a guide to a typical decision problem. We simulate the situation of a farmer who is retiring and using the forecasts to help decide whether to keep the land and rent it to a tenant, or sell the land and buy U.S. Treasury bonds. The decision to retain or sell the land is evaluated over 13 periods. Five periods extend from starting years (selected as in table 5) to 1982, when farmland prices peaked after a sharp upturn beginning in 1972. Eight periods extend from the starting years to 1990, the end of the sample period.

The decision to retain or sell the farmland is based on a minimum rate of land appreciation required for land retention. Prices of the farmer's land are assumed to follow the U.S. average and are compared with the rate forecast by alternative models. The required rate of return equals the rate of interest on 10-year U.S. Treasury bonds [*4*], less 4 percent for the expected net rate of return from renting the land, approximately equal to the estimated 3.9-percent net rate of returns to cash-rented farmland from 1962 to 1972 [*8*], plus a 3-percent allowance from the greater risk and cost of managing the lease.

By comparing the required rate of farmland appreciation to the rate of appreciation realized (table 6), one sees that the farmer should have retained his land for four out of the five evaluation periods ending in 1982 but should have sold his land in the 1-year evaluation period beginning in 1981. Using the forecasts generated by the OLS model and the VPR, the correct decision would have been made in all five evaluation periods. The MSS model would have led to one wrong decision, while the univariate trend model would have led to three incorrect decisions, because it was unable to anticipate the sharp uptrend of the 1970 decade. Forecasts leading to wrong decisions have been underscored in table 6.

For the eight periods ending in 1990, the realized rate exceeded the required rate only for the period beginning in 1972. For the remaining seven periods, the land should have been sold. The forecasts from the VPR led to the correct decision for all eight periods. The trend model led to one wrong decision, the OLS model to two, and the MSS model to four.

Overall, the variable parameter regression did best, leading to the correct investment decision for all 13 evaluation periods. Forecasts from the OLS model led to 11 correct decisions, the trend model to 9, and multivariate state space model led to 8 correct decisions.

Conclusions

The question posed was whether the forecasts from a structural model estimated by OLS can be improved with other techniques from widely available software packages. The answer for our

Table 6--Rate of farmland appreciation, required by investor, realized, and forecast by alternative methods

Period	Required[1]	Realized	Forecast			
			OLS[2]	VPR[3]	MSS[4]	Trend[5]
			Percent			
To 1982 from:						
1972	4.7	14.2	10.1	8.9	7.6	6.4
1975	5.6	13.5	10.1	8.2	7.7	3.3
1976	6.8	12.9	11.5	10.8	14.2	2.8
1978	7.0	11.6	11.8	8.6	13.8	1.5
1981	12.2	.5	7.6	5.0	15.7	1.1
To 1990 from:						
1972	4.7	6.4	6.5	5.2	7.5	6.2
1975	5.6	4.6	6.0	4.5	7.5	4.9
1976	6.8	3.8	6.8	5.4	14.2	4.5
1978	7.0	1.9	6.7	3.8	13.4	3.9
1981	12.2	-2.2	4.6	.8	13.2	3.5
1982	12.9	-2.6	2.3	-.7	3.1	3.1
1985	10.1	-1.3	2.5	-.8	-8.1	4.4
1987	7.4	3.7	-.9	-.1	-6.3	10.5

[1]The required rate of return is 1 percent below the interest rate on 10 year-U.S. Treasury bonds in the month and year of the simulated decision to retain or sell the land. Underscored forecasts are forecasts leading to wrong decision.
[2]Ordinary least squares.
[3]Forecast Master Plus, variable parameter regression.
[4]Forecast Master Plus, multivariate state space model, in which forecasts of explanatory variable are provided by the user.
[5]SAS Stepar, a trend model with modeling of the residuals from trend.

example, a model that is generally consistent with economic logic and with data that are generally consistent with the OLS assumptions, is yes. When the structural model was re-estimated to allow for variable parameters, there was a gain in accuracy for all but one of the forecasts examined.

Both the constant and variable parameter models generally outperformed a number of univariate models. A multivariate state space model did not do as well as either OLS or VPR. Modeling the OLS residuals resulted in forecast adjustments that were very minor. This is a logical result when there is no strong serial correlation of the residuals. The next step for improving the econometric forecasts is to look for models that are either more realistic or more efficient in extracting information from the residuals. Although usually applied to a larger database, the transfer function should be examined. This procedure, in which the structural parameters and the residuals are jointly estimated, could conceivably produce more accurate forecasts than our modeling of OLS residuals.

The gain in accuracy obtained with the variable parameter model suggests further exploration of the structure and forecasting performance of other variable parameter models in the hope that at least one of these will better capture the boom and bust cycles that periodically occur in the farmland market.

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Appendix

Appendix table 1--Price per acre of farmland and buildings, average, coterminous 48 States

Year	Price per acre	Year	Price per acre	Year	Price per acre
	Dollars		*Dollars*		*Dollars*
1910	40	1940	32	1970	196
1911	41	1941	32	1971	203
1912	42	1942	43	1972	219
1913	43	1943	38	1973	246
1914	44	1944	43	1974	302
1915	43	1945	47	1975	340
1916	46	1946	53	1976	397
1917	49	1947	60	1977	474
1918	53	1948	64	1978	531
1919	58	1949	66	1979	628
1920	69	1950	65	1980	737
1921	65	1951	74	1981	819
1922	57	1952	82	1982	823
1923	56	1953	83	1983	788
1924	54	1954	82	1984	801
1925	54	1955	85	1985	731
1926	52	1956	90	1986	640
1927	50	1957	97	1987	599
1928	49	1958	103	1988	632
1929	49	1959	111	1989	661
1930	49	1960	117	1990	668
1931	44	1961	119		
1932	37	1962	125		
1933	30	1963	130		
1934	31	1964	138		
1935	32	1965	147		
1936	32	1966	158		
1937	33	1967	168		
1938	33	1968	179		
1939	32	1969	189		

Appendix table 2--Net returns to assets per acre and the real interest rate on new farm real estate loans, United States

Year	Net returns per acre[1]	Real interest rate[2]	Year	Net returns per acre[1]	Real interest rate[2]
	Dollars	*Percent*[3]		*Dollars*	*Percent*[3]
1940	0.29	1.44	1966	9.62	2.42
1941	1.31	-2.07	1967	8.23	3.16
1942	2.86	-2.40	1968	8.43	2.26
1943	2.54	1.15	1969	10.22	2.57
1944	1.25	2.77			
1945	1.17	1.26	1970	10.39	3.31
1946	2.66	-19.37	1971	10.65	2.87
1947	3.11	-9.37	1972	15.73	3.26
1948	4.79	-2.93	1973	31.53	1.73
1949	2.52	4.67	1974	24.41	-.68
			1975	23.18	-.62
1950	3.69	-2.06	1976	18.66	3.45
1951	4.42	-2.79	1977	18.11	2.56
1952	3.87	-2.95	1978	24.56	-.95
1953	2.66	2.62	1979	30.97	-.52
1954	2.65	2.81			
1955	2.40	1.99	1980	21.50	1.21
1956	2.75	1.20	1981	33.81	1.64
1957	3.32	1.83	1982	31.59	5.80
1958	5.08	3.55	1983	21.21	7.79
1959	3.53	3.39	1984	40.69	7.98
			1985	38.01	8.96
1960	4.57	4.22	1986	38.91	9.01
1961	5.63	4.77	1987	41.69	7.90
1962	6.28	3.68	1987	41.69	7.90
1963	6.42	4.13	1988	40.74	6.80
1964	5.77	3.98	1989	45.71	6.80
1965	8.74	3.32	1990	46.80	6.60

[1]To simulate returns to an expansion buyer, the definition of return to assets was modified from the Economic Indicators series [*29*] as follows: (a) value of home consumption and non-operator dwellings were excluded from gross income, (b) one-half of the capital consumption was excluded from production expenses, (c) returns to operator's management was excluded from production expenses, (d) returns to operator labor from 1985 through 1990 were independently estimated because of a revision of operator's labor in the Economic Indicators series [*29*], (e) net returns to assets were removed for farms in five Standard Industrial Classifications: animal specialty, fruits and nuts, vegetables, horticultural, and poultry and eggs.

[2]Nominal rate on new farm real estate loans by the Farm Credit System less rate of inflation measured by the GNP deflator. To avoid negative numbers when transforming into logs, negative real interest rates, and rates less than 1 percent were given a value of 1.0. This is consistent with the view that market participants are unlikely to include negative numbers in their calculation of expected interest rates.

[3]For analysis, percentages were converted to decimal fractions, for example, for 1940 the real interest rate used was 0.0144.

U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Farm Real Estate Values Resume Climb, Historical Data Show

Number 22, May 1993

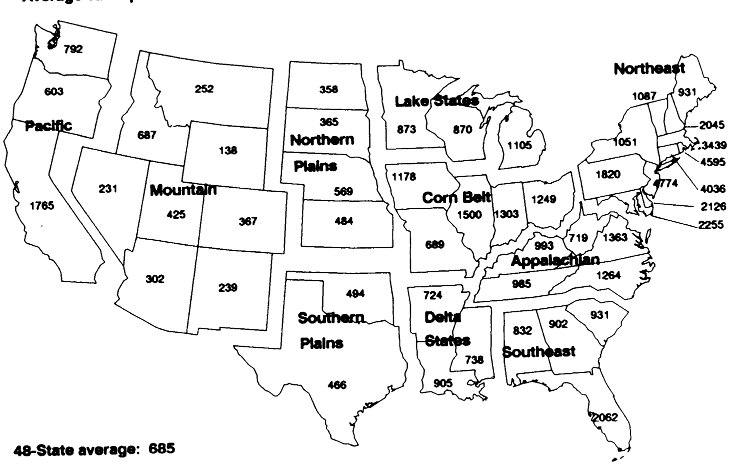
Contact: John Jones (202) 219-0428

The value of U.S. farmland rose by an average of 2.4 percent per year from 1987 to 1992, compared with a decrease of 6.6 percent per year from 1981 to 1986, according to the U.S. Department of Agriculture's *Farm Real Estate: Historical Series Data, 1950-92.*

Regional trends in the value of farmland generally mirror the national trend. From 1950 to 1982, the Southeast showed the highest rate of growth, while the Northern Plains showed the lowest. The decline in real estate value in the mid-1980's was most pronounced in the Corn Belt, while values actually increased in the Northeast. The present recovery in real estate prices has been most pronounced in the Northern Plains, while lagging in the Southern Plains.

Average farm real estate values in 1992 ranged from $138 per acre in Wyoming to $4,774 per acre in New Jersey.

Average value per acre of farm real estate, January 1, 1992



48-State average: 685

The area of land in farms has declined gradually every year since 1954, at an average rate under 1 percent per year. The number of farms has declined at an average annual rate of 2.3 percent. The average farm size, therefore, rose from 213 acres in 1950 to 467 acres in 1992.

United States: Selected statistics on farm real estate, selected years

Year	Farms	Farmland value per acre	Farmland and building value per farm	Total farmland and building value
	Thousands	-- *Dollars* --		*Million dollars*
1950	5,648	48	13,700	77,600
1960	3,955	86	34,600	136,771
1970	2,944	157	73,000	215,042
1980	2,435	636	313,495	763,285
1990	2,135	538	308,250	658,187
1991	2,100	556	317,950	667,504
1992	2,091	557	319,519	670,798

-- = Not available.
Excludes Alaska and Hawaii. Data for farms and land in farms are from "Farm Numbers," U.S. Department of Agriculture, National Agricultural Statistics Service.

To Order This Report...

Information presented here is excerpted from *Farm Real Estate: Historical Series Data, 1950-92*, SB-855, by John Jones and Patrick N. Canning. Cost is $12.00.

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT #AIB-682

Slow Turnover in Ownership of U.S. Farmland

September 1993

Contact: Gene Wunderlich, 202-219-0425

Only about 3.5 percent of farmland changes hands each year, according to a new report by USDA's Economic Research Service, *Acquiring Farmland in the United States.* Despite the relatively low turnover rate, the amount and value of land transferred each year is substantial. Twenty-nine million acres, valued at $21 billion, were transferred in 1988, according to the Census of Agriculture's Agricultural Economics and Land Ownership Survey (AELOS).

About half of the farmland transferred in 1988 was purchased from a nonrelative. Another 18 percent was purchased from relatives. The remaining 31 percent of farmland was transferred through inheritance, gift, and other methods.

Farm operators acquired a higher proportion of their farmland through purchase than did owners who are not farm operators. Women, who dominate the nonoperator-owner category, acquired more of their land through inheritance and gifts than did men. Method of farmland acquisition varies among racial groups. However, white owners hold 99 percent of the farmland.

Individuals and Families Own Most U.S. Farmland

By far, the largest class of farmland owners (86 percent) is individuals, including husband/wife combinations. But the population of owners is aging and the reduction in numbers is enlarging the average holding. If landownership patterns continue, the proportion of farmland held by older, nonoperator owners will grow, while the total number of owners declines. If the number of owners shrinks while the amount of farmland remains constant or decreases slowly, the average holding will increase.

Farmland is distributed among 2.9 million owners, according to AELOS. Farmland ownership is concentrated; less than 2 percent of the population own all U.S. farmland, which itself accounts for two-thirds of the Nation's private land. Four percent of farmland owners hold 47 percent of the farmland, while 30 percent hold only 2 percent. The distribution of farmland, however, has not changed appreciably since midcentury.

Method of acquisition by class of owner, 1988[1]
Market-driven land purchases were less frequent among nonoperators owners.

Method	Farm operator owners	Nonoperator owners
	Percent	
Purchase from nonrelative	67	48
Purchase from relative	32	23
Inheritance/gift	21	43
Other	5	5

[1] Respondent may have acquired land by more than one method.

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The information presented here is excerpted from ***Acquiring Farmland in the United States,*** AIB-682. The cost is $7.50.

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Detailed Data on Farm Operating and Financial Characteristics Available for 1990

Number 31, August 1993

Contact: Susan E. Bentley, 202/219-0931

An estimated 1.8 million farm operations represented by the 1990 Farm Costs and Returns Survey (FCRS) operated about 1 billion acres of land in 1990 (see table). Almost half of them rented or leased land from others (excluding public grazing lands), primarily through cash rent agreements. A new report, *Farm Operating and Financial Characteristics, 1990*, just released from the USDA's Economic Research Service, presents these and other detailed farm economic data and reliability measures for calendar year 1990. It includes data on the number of farms, land in farms, crop acreages and production, farm labor and wages, capital investments and improvements, farm business income and expenses, and farm business assets and liabilities. These data are summarized by sales class, region, production specialty, farm organization, acreage class, tenure, and operator age and major occupation.

Over one-quarter of farm operations reported removing some land from production in 1990 for summer fallow or government programs, which resulted in an estimated 56 million acres of cropland being removed from production.

Approximately 310,000 farms had gross sales of at least $100,000 in 1990. Farms of this size accounted for 18 percent of all farms, 49 percent of land owned, and 57 percent of land operated. Almost a quarter of all farms reported sales between $20,000 and $99,999 in 1990. Farms with sales of $40,000 to $99,999 reported operating, on average, nearly twice the acreage of farms with sales of $20,000 to $39,999. Farms with sales of less than $10,000 accounted for almost half of all farm operations, and they operated the smallest farms, averaging 123 acres.

Almost half of all farm operations were located in three regions: the Corn Belt, the Appalachian region, and the Southern Plains. However, only about 26 percent of all acres operated were in those regions, reflecting variation in farm size as the types of agricultural activities vary. Average acres operated ranged from 174 acres in the Appalachian region to 3,223 acres in the Mountain region.

Farms and land in farms, all classes, 1990
Nearly half of all farm operations rented or leased land from others.

Item	Total	Farms reporting	Average per reporting farm[1]
	1,000 acres	*Number*	*Acres*
Farms	1,752,125[2]	na	na
Land rented or leased from others[3]	342,011	797,474	429
Cropland removed from production	56,080	480,937	117
Total acres operated[4]	1,030,490	1,751,795	588

na=Not applicable.
[1]Average per reporting farm is defined as the mean per farm reporting a nonzero for the item in the sample. [2]Represents number of farms. [3]Excludes land rented or leased on an animal-unit-month (AUM) basis. [4]Defined as owned land plus land rented or leased from others (including AUM land) less land rented out.

To Order This Report...

The information presented here is excerpted from ***Farm Operating and Financial Characteristics, 1990,*** SB-860, by Susan E. Bentley. The cost is $15.00.

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