EXPLORING ALTERNATIVE MEASURES OF NET RENTS TO FARMLAND THROUGH THE ECONOMETRIC CAPITALIZATION FORMULA FOR FARMLAND PRICE

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APPROVAL

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ABSTRACT

Farmland prices began to diverge from farm income trends during the mid-1950's. Traditional capitalization theory is the accepted mechanism with which to value farmland. The central idea to this theory is that land values must derive from net rents to land. The divergence between the time path of farm income and land prices has focused economists' attention on the validity of traditional capitalization theory in explaining farmland prices, and the appropriateness of net farm income as a measure of net returns imputed to farmland.

This study explores three alternative measures of returns imputed to farmland. The measures are the United States Department of Agriculture (USDA) accounting data, cash rents, and gross revenue from corn and soybeans production. Each of these measures is fitted to essentially a second order non-stochastic difference equation framework; an economic capitalization formula for farmland price that is developed in a different study and is tested empirically using Illinois crop-share rent data as the measure of net rents to farmland.

Problems are encountered concerning two of the three measures explored; data problems for the USDA accounting data measure and a joint dependency problem with farmland prices for the cash rent measure. Encouraging results are encountered when gross revenue from corn and soybeans is explored. The regression results for this measure are similar to the results of the study that uses cropshare rents. An implicit capitalization rate cannot be computed from the estimated land price model. But it appears that the estimated model can be used for conditionally forecasting short to intermediate time periods.

Additional research on exploring other alternative measures or methods of imputing a net return to farmland is suggested, but the need for a good set of farm accounts data seems to be more pressing.

CHAPTER 1

INTRODUCTION

In 1960, Scofield (Doll, et.al., 1983) noted that farmland prices were sharply diverging from farm income trends. He concluded that it was paradoxical for farmland prices to increase without an accompanying rise in farm income, thus coining the term "land-price paradox." Historically, farmland prices are quite closely linked to net farm income, thus supporting Ricardo's classical argument that land values must derive from net rent to land. Divergence between income-price trends occurred in the mid-1950's, and has widened more after that. Real farm income has consistently declined since 1973, with farmland prices continuing to increase, then dropping slightly in 1981 and the subsequent two years.

Rising farmland prices are viewed by some with elation; landowners have benefitted from the increase in their wealth position from the rise. Some view it with concern; those that borrow to buy land have to pay a larger downpayment, and service the rest of the debt with decreasing funds from farm income. This cash flow problem makes it difficult for new farmers to get started, for the tenant farmer to become an owner-operator, or for smaller farms to finance additional land. Robison and Blake (1980) discuss the cash flow problem which emanates from the temporal disassociation of generated returns and the usual nominally amortized flat debt payment schedule. Cash flow may be confused with the returns resulting in a perceived discrepancy between returns and farmland prices.

Many believe that land prices have reached unrealistic levels before the drop in the early 1980's, and that they are overvalued in relation to farm earnings. This conclusion is reached through the use of the traditional capitalization formula, and the use of farm income as a measure of returns to farmland.

Statement of the Problem

The "unrealistic" levels of land prices have focused economists' attention on the applicability of traditional capitalization theory as a mechanism used to explain farmland prices. Some question the appropriateness of net farm income as a measure of returns imputed to farmland. This, in turn, leads to a host of new research studies, each purporting to have come up with new approaches to explain the high price levels of land. Some hypothesize that the traditional capitalization formula is too simplistic and have modified it, some consider net farm income inappropriate and have suggested other ways for imputing returns to farmland, while others offer new imputing returns to farmland, while others offer new theories that replace traditional capitalization theory. Very few of these new models are tested empirically.

The purpose of this study is to look at one approach that models the behavior of farmland prices within a traditional capitalization theory framework. This model is formulated by Burt (1986), then is tested empirically using annual data for Illinois, and produces encouraging results. The model is based on the idea that if returns are imputed correctly to farmland, then net rent to land will solely determine farmland price as stated in the traditional capitalization formula. Thus the main objective of this study is to further test empirically Burt's land price model. Since the measure of net rent to land used in Burt's study is available only for Illinois, an alternative measure of rent that may be derived from more commonly available data bases is needed.

Methodology

This study explores several alternative methods for estimating net returns to farmland. Burt (1986) models farmland prices through use of the capitalization formula. The measure of net returns to farmland that is used is a series published by Scott (1983) and is defined as "net returns in dollars to landowners on high quality crop-share grain farms in Illinois." This crop-share rent data originates from farm accounting data associated with the farm records program at the University of Illinois, and the uniform application of accounting procedures that is used in collecting the data throughout the period makes this type of data unique to the state of Illinois (Burt, 1986). Due to the uniqueness of the crop-share rent data that is used in Burt's analysis, there is a need for an alternative measure of net returns to farmland using data that is easily collected in any state. It will give Burt's model greater plausibility if the results reached in the Illinois study can be reproduced with a measure of rents that uses a more common data base.

Three alternative measures of net returns to farmland are explored in this study. First, United States Department of Agriculture (USDA) accounting data are used to impute a residual return to farmland. Second, cash rents are used as a proxy for net returns to farmland. The third alternative measure is gross revenue for the dominant cash crops for the state.

These measures are then fitted to essentially the same dynamic regression model that is developed by Burt (1986). The results of estimation are compared to regression results arrived at when crop-share rent data was used, thus using crop-share rent as the reference measure. Analysis is first done for Illinois, because of the opportunity for direct comparison. If encouraging results emanate from one extended from Illinois to other neighboring states in the Corn Belt region and comparisons made. The estimated equations in this last part of the study are then tested by evaluating their relative predictive performance via prediction errors.

Comparisons of results from the estimated equations using alternative net rent measures with Burt's (1986) estimation results are made with generous criteria of performance, and with no aspirations about getting as precise statistical results as when crop-share data are used. It is hoped that the same general dynamic structure would prevail when the alternate measures of net returns are used, and that such a model would do reasonably well in conditionally forecasting within short to intermediate time periods.

This thesis is organized as follows. Chapter 2 summarizes major works that are relevant and pertain to agricultural land prices. Chapter 3 describes the farmland price model and theory of the estimation used plus a section on data compilation. Chapter 4 delineates empirical results. A summary of the findings of the study plus some thoughts on their relevance towards the fulfillment of the objectives of this study are presented in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

Fisher, in his Theory of Interest (1967), stated that "the value of any property, or rights to wealth, is its value as a source of income and is found by discounting that expected income" (p. 12). This is the basis for traditional capitalization theory. This approach has its roots in basic intertemporal choice analysis. The analysis starts out by assuming that human nature prefers "goods" now as opposed to later, say one time period into the future. So people basically have a positive time preference. This positive time preference translates into "goods" being worth more now relative to the future. The interest rate r, in this case, is a special price; a premium that reflects the extra worth of "goods" now instead of a period into the future, or its time value. Let V_0 denote the value of "goods" now (time period 0) and V_1 denote the value of "goods" one time period later. Then,

$$V_0(1+r) = V_1 \qquad (2.1)$$

reflects this extra worth of V_0 over V_1 which equals rV_0. Another way to look at equation (2.1) is:

$$V_0 = \frac{V_1}{(1+r)} \qquad (2.2)$$

which transforms the value of a dollar one period in the future into an equivalent value for a dollar received immediately. This is called discounting a future value to the present, or said another way, the present value of a future worth.

According to Fisher's concept of value, the traditional capitalization formula is represented as

$$P_0 = \sum_{t=1}^{\infty} R_t/(1 + i_1)(1 + i_2) \ldots (1 + i_t) \qquad (2.3)$$

where

P_0 = price of farmland at time zero (current price);

R_t = returns occurring at the end of time period t;

i_t = discount rate at time t.

If returns and discount rates are assumed constant into perpetuity, i.e., R_t = R and i_t = i for all t = 1, 2, ..., ∞, the equation reduces to

$$P_0 = \sum_{t=1}^{\infty} R/(1 + i)^t \qquad (2.4)$$

with a closed form solution of

$$P_0 = \frac{R}{i} . \qquad (2.5)$$

Equation (2.5) with current returns and discount rates is what is commonly used to evaluate the current value of land. Use of (2.3) requires knowledge of all future earnings and discount rates.

When land price and farm income trends began to diverge in the mid-1950's, equation (2.5) was still commonly used to evaluate farmland value. During this time people concluded that land was being overvalued in relation to farm income. When (2.5) was used, land prices were lower than the actual prices. However, equation (2.5) is, by assumption, the long-run equilibrium capitalization formula under restrictive assumptions. Thus this equation should be used to estimate the equilibrium value of farmland associated with constant rents and constant interest rates, and not short-term farmland prices where economic variables are subject to continuing perturbations.

Research in the 1960's and the early 1970's focused on the apparent land price divergence. It was claimed that net farm income did not fully explain rising farmland prices, and researchers sought other variables that might.

Reynolds and Timmons (1969) hypothesized that there were factors other than net farm income, that could be contributing to the change in farmland prices and thus causing the divergence between the time paths of income and prices. Net farm income, though, was still believed to be the major determinant of land prices. The other factors considered were government farm programs, technological advancements, farm enlargement, transfers of farmland, pressure from increasing population, and capital gains. These factors were modeled through a recursive cobweb model

(Ezekiel, 1938), where on the demand side, farmland price was determined by the current quantity of farmland ownership transferred plus other variables determined exogenously in the market including expected net farm income, government payments, expected capital gains, rate of return on common stock and farm enlargement. On the supply side, the current quantity of farmland transferred was a function of expected capital gains, ratio of farm to nonfarm earnings, a measure of technology, ratio of farm mortgage debt to equity, and change in the number of farms. The model was estimated using two stage least squares for the years 1933-1965. A cross-sectional analysis was also included as an alternative approach to time series analysis, although the authors acknowledged the coefficient estimates are not directly comparable.

A similar study done by Klinefelter (1973), in which land prices in Illinois were modeled through a single equation model, involved factors hypothesized to affect land prices that were very similar to those used in Reynolds' and Timmons' study (inflation, expected net rents, government programs, technology, farm enlargements, farmland transfers, and expected capital gains). Due to multicollinearity between variables in the proposed model, the final equation was reduced only to include net rent, average farm size, number of voluntary farmland transfers, and expected capital gains as explanatory variables. Net rent, in this study, was defined as the remaining amount of the landlord's share of gross farm income from production (including inventory change) after all of his costs are subtracted out (Reiss, 1969). It was assumed that landowners based the earning potential of farmland on an average of recent past trends. Thus the net rent variable was a three-year moving average of net rents for the previous three years.

Pope et al, (1979) evaluated the structural credibility of the above two models in explaining recent data and tested their predictive ability, along with Herdt and Cochrane's (1966) simultaneous equation model and Tweeten and Martin's (1966) five equation recursive model of the farmland market. When these models were re-estimated to include recent data, there were numerous sign reversals and lack of statistical significance of the re-estimated equation coefficients. The modified Klinefelter model (Pope et al, 1979) had the least problem with sign changes and statistical insignificance, so this equation was chosen as the econometric model to be tested against a Box-Jenkins time series equation of land prices only for relative predictive performance. Results were that a time series model provided as good or better short run forecasts than Klinefelter's modified econometric model.

Melichar (1979) provided some insight into the land price paradox phenomenon when he proposed that comparing the USDA index of farm real estate value with operator net farm income, the common measures of land prices and net returns to land, was erroneous. It was like comparing apples with oranges. First, an aggregated return component is compared to the unit price of a single asset (land) with net farm income imputed to real estate alone exclusive of the other productive assets. Second, operators' net farm income, as traditionally computed by the USDA, is not an appropriate measure of return to land, or of returns to productive assets. To obtain a valid measure of returns to farm production assets, Melichar suggested that net rent to non-operator landlords and interest paid on farm debt be added to operators' net farm income. Also, the part of net income imputed to farm dwellings is not a part of productive farm assets. This adjusted component is not only a return to productive assets, but also a return to management and operator labor; so these last two return components must be subtracted out. Melichar then compared the time path of this residual return to productive assets with the time path of its value. Since the 1950's the return to farm productive assets had been growing at a faster rate than the value of these assets, but with relatively parallel trends. And since farm real estate makes up a major portion of farm productive assets, Melichar concluded that the upward pressure caused by returns to productive assets on the value of these assets should also be felt by farm real estate values.

In the second part of his paper, Melichar examined parallel relationships found in the asset-pricing model with the key assumption of constant growth in earnings (returns). Through this analysis, he showed that the total rate of return to productive assets is made up of the rate of current return to productive assets plus the rate of capital gains on these assets. He also showed that the steady-state rate of capital gains equals the growth rate of current returns, assumed to be a constant geometric rate. Melichar then tested this last result empirically, and concluded that capital gains and the growth rate of returns for the past twenty-five years, on the whole, supported this result. Because of the dominant position of farm real estate in the makeup of farm productive assets, Melichar also compared historical data of capital gains from real estate assets to growth rates of current returns to productive assets, and found that real estate capital gains were, in a sense, fully explained by the growth exhibited by current returns to productive assets.

In summation, Melichar's analysis showed that as asset earnings are expected to grow, then these expected earnings will translate more into real capital gains rather than to current returns. He concluded that

> ... according to asset-pricing theory, a farm economy characterized by rapid growth in the real current return to assets will tend to experience large annual real capital gains and a low rate of current returns to assets--which corresponds to actual experience in most years since the mid 1950's. (p. 1085)

Asset returns if properly measured would seem to fully explain asset values, at least within the framework in which Melichar chose to make his comparisons.

But there were those that were not fully convinced by Melichar's explanation. "There is a fundamental link between general price inflation and the relative price of land that deserves particular attention," argued Feldstein (1980). He explained that the combination of inflation and the tax laws will raise the return to land, and eventually the price of land will have to adjust itself upward during inflationary times. Feldstein incorporated the land market into his model from a speculative viewpoint. He went on to derive price equations for land and for reproducible capital (business capital) in an explicit portfolio-choice framework. Feldstein then looked at comparative statics results of the effects of inflation on the price of land and the price of reproducible capital. Results of comparative statics analysis pointed to the inappropriateness of assuming that the effect of inflation on land prices is neutral (Feldstein, 1980).

The study by Castle and Hoch (1982) discussed the farmland market from an investor's point of view. A prospective investor starts out by forming expectations about future land prices. If expected price exceeds actual current price then he will want to buy, but if actual current price exceeds expected price then he will want to sell or at least be discouraged from buying. Castle and Hoch hypothesized that this expected price is made up of two components. The first component in land price, labeled the earnings component, takes into account the effect of the capitalized value of the "pure" return obtained from real estate assets. This is the familiar capitalized value of earnings concept for assets of infinite life. This concept was extended by Castle and Hoch to include another component that measures the effect that is determined by "all the forces which cause real estate prices to change relative to the general price level" (p. 8). A subsidiary part of the second component measured the effect of inflation on land prices. Castle and Hoch offered a fairly complicated description of their expectations model for farm real estate prices based on the traditional capitalization formula; two components in addition to net return were capital gains and farm real estate debt under inflation. This latter component emanates from the lag between interest rates and inflation rates so that existing long-term farm debt has value because the loan rates tend to be less than market interest rates. Equations for each of the three components were developed and tested empirically. Predicted values for each of the value components were added up to produce a predicted value for land. Comparisons between actual and predicted land prices were made. Castle and Hoch concluded that the results of the empirical testing show that the capitalized value of net return to real estate assets used in farm production explains only about one half of real estate values.

Shalit and Schmitz (1982) offered a "the other side of the coin" approach to farmland market analysis. Their paper focused on the derived demand for farmland generated through agricultural production, and did not consider speculative "motives" as did Castle and Hoch (1982). The paper first derived an individual farmer's derived demand function for agricultural land through lifetime utility maximization rather than profit maximation. Then from these individual derived demands, the authors developed an aggregate derived demand model for farmland, which the authors note was just a more general and dynamic extension of traditional capitalization theory. Lastly, the aggregate model was empirically tested for the U.S. for the 1950-78 period. The net return used in their model is a series compiled by Hottel and Evans (1979), which "consists of residual income to real estate equity obtained by deducting imputed returns to labor, management, and dwellings from the operator's total net farm income" (Shalit and Schmitz, 1982, p. 717).

The analysis resulted in Shalit and Schmitz concluding that "the price of farmland is determined not only by the profit it generates (agricultural income and capital gains) but also by the debt it can carry" (p. 718), and also that, "the expansion and contraction of credit importantly affects the pace at which land prices increase or decrease" (p. 718).

Melichar's conventional hypothesis of explaining growth in land prices solely from expected growth in returns to land has been widely accepted. However, rapid growth in land prices has also been associated with rapid inflation (Alston, 1986). Feldstein was able to formulate a plausible theoretical mechanism to model the effect of inflation on land prices. Alston (1986) combined the two competing hypotheses generated from Melichar's and Feldstein's papers into a simple model of land prices. Alston mentioned that both hypotheses had been previously tested with results that reject inflation as a cause of land price movements and favor Melichar's more conventional explanation.

A price equation for land which incorporated net returns and rate of inflation was initially derived using the traditional capitalization approach. Then a regression equation that incorporated expected inflation as a separate independent variable was derived. Analysis was done for eight midwestern states, and cash rent data were used to measure the net return variable. Estimation of the regression equation for the eight states gave a statistically significant negative net effect for inflation (contrary to Feldstein's hypothesis) on land prices, although empirically small.

There seemed to be major differences in the approach taken by researchers in explaining the recent trend of farmland prices. In addition to this, there is yet no agreement on the exact definition of net returns imputed to farmland. Alston (1986) and Castle and Hoch (1982) used USDA accounting rent data (plus some adjustments) for the return variable in their respective models. Comparison of time series plots of cash rents and farmland prices (by state) indicate that there were years when cash rents seemed to lag land prices. Cash rents are somewhat sticky in their adjustment path because of the renegotiation process that must be experienced whenever a change is needed to account for changed commodity prices and production costs. Recently past land prices could become a factor in determining the new renegotiated cash rent amount, thus making cash rent a non-exogenous variable. All of this could add up to the possibility of cash rents being jointly determined with land prices; the exogenous variable(s) that effect land prices may also determine cash rents as well.

Some agreed that operator's net farm income is a valid starting point from which to impute a residual return to farmland (Melichar, Phipps, Shalit and Schmitz). Melichar's adjustments to operator's net farm income to produce a measure of return to total farm productive assets was fairly straightforward. But to impute a return to one part of total farm productive assets, namely farmland, can become much more difficult and much more arbitrary.

For example, Phipps (1984) used a similar approach to the one Melichar developed to estimate a net return to farmland. First, Phipps subtracted out "an implicit return to non-land durable productive assets" (p. 427) from operator's net farm income. He used the USDA's definition of depreciation on non-land durable assets plus the opportunity cost of investment as the measure of the return to the non-land component. He also subtracted out the opportunity cost of a farm operator's time, evaluated at 85% of the non-farm wage rate. Shalit and Schmitz subtracted returns imputed to management, labor, and dwelling from operator's net farm income to arrive at a return to farm real estate (1982).

Furthermore, recent literature used traditional capitalization theory as the springboard to launch and develop a more involved model for farmland prices. These models usually involved variables other that the return component, making them arduous to follow and comprehend

(Castle and Hoch, Shalit and Schmitz). There is a need for a much simpler model for farmland prices, because according to traditional capitalization theory, returns to an asset should fully justify its value.

Burt (1986) modeled farmland prices in a dynamic regression framework that is tied back eventually to the traditional capitalization formula. The model was tested empirically using annual Illinois data, producing empirical results that were encouraging. The following chapter is devoted to a more in-depth discussion of Burt's farmland price model, as the model is central to this study.

CHAPTER 3

MODEL DEVELOPMENT

This chapter presents a short discussion on distributed lag theory before summarizing the formulation of the econometric capitalization formula for farmland price developed by Burt (1986). Lastly, a section discussing sources of data compilation is included.

Distributed Lags

Oftentimes an economic phenomenon is best described by a dynamic system consisting of variables that affect one another, where more than one time period is needed to measure the full effect a variable has on another. In comparison, a static system consists of variables that affect one another where the effect(s) are fully realized contemporaneously (during one time period). Relating to this study, for example, the time adjustment between a change in rents and its effect on land prices may not occur instantaneously because of uncertainties in the land market. A dynamic system is modeled using a distributed lag structure. This structure could be finite or infinite depending on whether one variable will have the "ripple" effect on another variable over a finite or infinite length of time.

A finite distributed lag model would have the form

$$Y_t = \alpha + \delta_0 X_t + \delta_1 X_{t-1} + \ldots + \delta_k X_{t-k} + \mu_t \quad (3.1)$$

where X_t is an exogenous variable that has a distributed lag effect on Y_t and μ_t is an unobservable error term. Equation (3.1) indicates that the order of lag coefficients higher than δ_k are assumed to be zero, so that the independent variable X does not affect Y beyond k time periods.

Examples of finite distributed lag structures are arithmetic lag, inverted V-lag, and Almon polynomial lag. A basic disadvantage to using the finite lag structure is in deciding what lag k should be, thus a priori specifying when the distributed lag effect will be fully realized. Since there is little theoretical basis and/or specific knowledge of the industry to identify the length of the distributed lag period, specifying k becomes arbitrary. A further problem with the finite distributed lag model is due to the fact that economic time series are usually slow to change. This often results in multicollinearity among the lagged independent variables, leading to estimation problems (Theil, 1978). Precision in the estimation of the distributed lag coefficients is lost due to the increase in the standard errors of the coefficient estimates. Another problem that may arise is the loss of degrees of freedom due to the number of parameters estimated (degrees of freedom equals total number of sample data points minus total number of parameters to be estimated including the intercept).

Assuming an infinite lag structure will not necessarily alleviate having to arbitrarily assign k in equation (3.1) as it arbitrarily sets $k = +\infty$. Infinite lag structures include the geometric lag, Pascal, and Jorgensen's (1966) rational lag. A geometric lag model assumes a lag structure that takes on a geometric series structure. This lag structure is specified as

$$Y_t = \alpha + \beta X_t + \beta\lambda X_{t-1} + \beta\lambda^2 X_{t-2} + \dots + \mu_t \qquad (3.2)$$

where δ's are assigned weights equal to $\delta_j = \beta\lambda^j$, $j=0, 1, 2, \dots$, and λ lies in the interval of $0 < \lambda < 1$. Notice that only three parameters (α, β, and λ) are needed to describe the infinite lag structure. The equation in this form is unestimable due to an infinite series required on X. A Koyck transformation (Theil, 1978) on (3.2) will produce

$$Y_t = \alpha(1-\lambda) + \beta X_t + \lambda Y_{t-1} + \mu_t - \lambda\mu_{t-1} \qquad (3.3)$$

which is estimable because of the finite lag structure. The difference equation parameter λ determines the time path of adjustment of the dependent variable Y due to a change in the independent variable X. Higher values of λ indicate a slower time rate towards the adjustment, while lower values of λ indicate a faster time rate of adjustment in Y. Note also that due to Koyck's transformation, the error term in (3.2) has an additional moving average error (MA) component in (3.3).

A lag structure with geometrically declining weights may not be appropriate for describing the dynamics of land prices. The distributed lag effect could be hypothesized as having a "peak" (inverted V-lag structure) or several "peaks" at certain lag periods similar to the path that a polynomial function would take. The general form of this type of distributed lag structure is the rational lag developed by Jorgensen (1966). This model is specified as

$$Y_t = W(L)X_t + \mu_t \tag{3.4}$$

with the rational generating function W(L) defined as W(L) = B(L)/A(L), where L is the lag operator such that $L^j x_t = x_{t-j}$. Jorgensen defines B(L) and A(L) as

$$B(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_m L^m$$

$$A(L) = 1 - \lambda_1 L - \lambda_2 L^2 - \ldots - \lambda_n L^n$$

where λ_0 is usually normalized to equal one for identification purposes. B(L) is an m^{th} order polynomial lag on the independent variable X, while A(L) is an n^{th} order polynomial lag structure on the dependent variable Y. A(L) also determines the order of the difference equation and correlation structure of the error term. Multiplying equation (3.4) through by A(L) yields

$$Y_t = \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_m X_{t-m} + \lambda_1 Y_{t-1} + \lambda_2 Y_{t-2} + \ldots + \lambda_n Y_{t-n} + \mu_t - \lambda_1 \mu_{t-1} - \ldots - \lambda_n \mu_{t-n}. \tag{3.5}$$

Equation (3.5) is an n^{th} order difference equation with an n^{th} order moving average disturbance term if μ_t is white noise.

The roots of a difference equation determine the shape of the distributed lag pattern through time. The rational lag allows for real and/or complex roots if the order of the polynomial A(L) is at least 2. In a second-order difference equation, for example, real roots can imply a unimodal lag structure that dampens off after reaching the "peak" lag, while complex roots allow for an oscillatory pattern in the distributed lag structure.

Jorgensen (1966) showed that the rational lag model can approximate any arbitrary lag structure which has an asymptote of zero.

A Pascal distributed lag model is a special case of the rational lag in that the roots are constrained to be positive and equal. With the Pascal model, B(L) is of order zero while A(L) is of order r with equal roots such that the equation looks like

$$Y_t = \frac{\beta_0 X_t}{(1-\lambda L)^r} + \mu_t. \qquad (3.6)$$

The geometric lag model is a special case of the Pascal when r=1, thus making the geometric lag a special case of the rational lag model.

Farmland Price Model

Burt (1986) begins by pointing out that "with quantity of farmland fixed, the demand equation entirely determines price" (p. 11). With the assumptions of competition among buyers (potential and realized alike) and a world of certainty, farmland price is explained through use of the traditional capitalization formula. So the basic model for farmland prices would be

$$P_O = \sum_{t=1}^{\infty} R_t/[(1 + r_1)(1 + r_2)\ldots(1 + r_t)] \qquad (3.7)$$

where

P_O = price of land in year 0;

R_t = net returns to land in year t;

r_t = real discount rate in year t.

Returns and prices are thought of as occurring at the end of the year. If discount rates are assumed constant, then (3.7) reduces to

$$P_O = \sum_{t=1}^{\infty} R_t/(1 + r)^t. \qquad (3.8)$$

Letting net returns and the rate of capitalization be constant into perpetuity produces the long run equilibrium land price equation

$$P_* = \alpha R_* \qquad (3.9)$$

where

P_* = equilibrium price of land;

R_* = equilibrium (fixed) annual net returns to land;

$\alpha = 1/r$ = reciprocal of the real capitalization rate.

The dynamic regression equation for farmland price to be developed is constrained to have an equilibrium structure of (3.9), with α an unknown parameter.

The dynamic regression equation is specified with a multiplicative distributed lag on rents, since it is more likely that land market participants consider percentage changes rather than absolute changes in this variable. Random shocks in the economy emanating from discrepancies of the constant capitalization rate implicit in the model and measurement errors on land prices would also impact in a proportional, rather than in an additive way. From these assumptions, the dynamic regression equation for farmland prices is specified as

$$P_t = (\alpha R_t^{\beta_0} R_{t-1}^{\beta_1} R_{t-2}^{\beta_2} \ldots)\mu_t \qquad (3.10)$$

where μ_t is a random disturbance term; β_0, β_1, ... are unknown parameters; and (3.10) is considered to be homogeneous of degree one ($\beta_0 + \beta_1 + \ldots = 1$). Equation (3.10) after a natural logarithmic transformation becomes

$$\log P_t = \log \alpha + \sum_{j=0}^{\infty} \beta_j \log R_{t-j} + \log \mu_t \qquad (3.11)$$

where $\log \mu_t$ is assumed to follow an autoregressive-moving average (ARMA) process of unknown order and $E(\log \mu_t) = 0$.

The form of equation (3.11) cannot be estimated when a finite data set is used because of its infinite lag structure (thus an infinite number of unknown parameters to be estimated), so an approximation is needed. The technique chosen is a second-order rational lag approximation of the general lag in equation (3.11) which was proposed by Jorgensen. Burt describes this rational lag as "... a parsimonious and flexible form in which a second order specification is sufficiently flexible" (p. 13), which allows for relatively few unknown parameters to be estimated. The number of potentially estimable unknown parameters is crucial when working with annual data. Therefore, (3.11) is approximated by

$$\log P_t = \log \alpha + \frac{(\gamma_0 + \gamma_1 L) \log R_t}{(1 - \lambda_1 L - \lambda_2 L^2)} + \log \mu_t \qquad (3.12)$$

where L is a lag operator such that $L^j x_t = x_{t-j}$. Multiplying both sides of (3.12) by $(1 - \lambda_1 L - \lambda_2 L^2)$ yields

$$(1 - \lambda_1 L - \lambda_2 L^2)\log P_t = (1 - \lambda_1 L - \lambda_2 L^2)\log \alpha$$

$$+ \gamma_0 \log R_t + \gamma_1 \log R_{t-1} + (1 - \lambda_1 L - \lambda_2 L^2)\log \mu_t \quad (3.13)$$

or equivalently

$$\log P_t = (1 - \lambda_1 - \lambda_2)\log \alpha + \gamma_0 \log R_t + \gamma_1 \log R_{t-1} +$$

$$\lambda_1 \log P_{t-1} + \lambda_2 \log P_{t-2} + \log \mu_t - \lambda_1 \log \mu_{t-1} -$$

$$\lambda_2 \log \mu_{t-2} \qquad (3.14)$$

Grouping terms produces

$$\log P_t = (1 - \lambda_1 - \lambda_2)\log a + \gamma_0 \log R_t + \gamma_1 \log R_{t-1} + \lambda_1(\log P_{t-1} - \log \mu_{t-1}) + \lambda_2(\log P_{t-2} - \log \mu_{t-2}) + \log \mu_t \quad (3.15)$$

Equation (3.15) can be transformed into a second-order difference equation in expected values,

$$\log P_t = \delta + \gamma_0 \log R_t + \gamma_1 \log R_{t-1} + \lambda_1 E(\log P_{t-1}) + \lambda_2 E(\log P_{t-2}) + \log \mu_t \quad (3.16)$$

where $E(\log P_{t-j}) = \log P_{t-j} - \log \mu_{t-j}$ and $\delta = (1 - \lambda_1 - \lambda_2)\log \alpha$. Equation (3.16) is a second-order nonstochastic difference equation (Burt, 1980).

If at equilibrium, $\log R_t = \log R_{t-1} = \log R_*$, then land prices will approach a steady-state such that $E(\log P_*) = E(\log P_t) = E(\log P_{t-1}) = E(\log P_{t-2})$. Transposing the disturbance term in (3.16), we can write

$$E(\log P_t) = \delta + \gamma_0 \log R_t + \gamma_1 \log R_{t-1} + \lambda_1 E(\log P_{t-1}) + \lambda_2 E(\log P_{t-2}) \quad (3.17)$$

For the equilibrium state, like terms can be grouped to get

$$E(\log P_*) = \log \alpha + \frac{(\gamma_0 + \gamma_1)\log R_*}{(1 - \lambda_1 - \lambda_2)} . \quad (3.18)$$

The homogeneity constraint, $\beta_0 + \beta_1 + \ldots = 1$, which was imposed initially can be combined with (3.18) to produce

$$\gamma_0 + \gamma_1 = (1 - \lambda_1 - \lambda_2). \quad (3.19)$$

Notice that if (3.19) is true, then (3.18) is the result of a natural logarithmic transformation of (3.9). It was noted that $E(\log P_*)$ is interpreted as $\log P_*$.

The approach taken in specifying the farmland price model is to assume that the sources of dynamic behavior in farmland prices are "confounded," and not try to separate them out. These sources of dynamic behavior are grouped into two components. Sources that affect net returns to land (input price, commodity price, and technology) will affect expectations of net returns, and will eventually affect expectations of what land prices are going to be. The other component consists of sources of dynamic adjustments in land price itself.

An example of the latter component occurs in the Shalit-Schmitz model. When there is considerable uncertainty about future rents, lending institutions would practice capital rationing and "focus more on market value of collateral, rather than on prospective net rents" (Burt, 1986, p. 12), thus producing a cyclical adjustment path for farmland prices. Researchers frequently try to separate out these sources of dynamic behavior in land prices and formulate hypotheses on the forms that they take. The specification of these "price expectations" and "dynamic adjustments" components are then tested empirically, usually using time series data. When the criterion used to evaluate the estimation results are variable coefficients with significant t-ratios and the "right" sign, time series data usually would not contain enough information to reject the a priori specified mechanisms in the price of farmland. Burt concludes that

> if statistical estimation of the general model yields precise estimates of unknown parameters, then an attempt can be made to justify one or more plausible structures for the formation of expectations about rents and capital gains. (p. 12)

In specifying the model, the implicit rate of capitalization is assumed constant over time. One could argue against this assumption on the point that it is unrealistic. Tanzi (1980) believed that the real rate was associated with the position of the economy in the business cycle or that it depended on the inflation rate as hypothesized by Feldstein (1980). The classical theory of interest, originated by Fisher, came to the conclusion that the equilibrium real rate of interest remains fairly constant over time, because in the long run this rate mainly depends on intertemporal consumer preferences along with changes in productivity. Darby's study (1984) produced results that seem to support an almost constant rate of change in productivity for the past few decades. The rational expectations hypothesis discussed by Sargent (1973) implies short run evidence that supports the assumption of a constant capitalization rate. Intuitive support for this assumption would be that due to the long term investment characteristics of the farmland market, participants are more likely to use longer term real rates of interest to capitalize farmland values. In summation, Burt states that

> the empirical question is whether farmland investors take account of these year-to-year movements in their decisions or think of a longer run equilibrium. (pp. 12-13)

The traditional capitalization approach and thus the model developed here does not explicitly take into account the influence of tax rates on farmland prices. Burt explains that there are "... many devices available for delaying payment of capital gains taxes, even to the next generation ..." (p. 13) and that

> changes in tax rates, especially effective rates on farmers and owners of farmland, occur infrequently and in an evolutionary way as new loopholes are discovered and then lost with new I.R.S. rulings and legislation. (p. 13)

Burt then points out that because of taxes correlating weakly with rents, the "would-be independent variables associated with tax rates over time can be compounded into the disturbance term if the form of the regression equation is such that these variables enter in an additive way with the disturbance" (p.13).

Net rent data used to estimate the model is Scott's crop-share rent data mentioned previously. The land price data are constructed from the USDA land value index for all agricultural land in Illinois. Burt (1986) adjusts this index into a land value series for high quality grainland in Illinois. Estimation of the model using the

Scott data not only resulted in statistically credible land price equations, but also an estimated homogeneity constraint near one and an implicit capitalization rate near 4%. A study by Watts and Johnson (1985) empirically estimated this rate at 4.5%.

When inferior measures of net returns are used, one would expect estimation results not quite as encouraging as above. The land price equations estimated from less reliable rent data may have some statistical credibility, but it might be asking too much from the data to produce an estimated homogeneity constraint coefficient equal to one. It would not be surprising if an "unrealistic" implicit capitalization rate is estimated using this inferior data.

One method to be explored in this study is a per acre gross return measure (price x yield) for the dominant cash crops of the state. One could posit that the "true" net rent measure is nearly proportional to the gross measure so that in the logged model, the proportionality constant is separated from the gross measure and combined in the constant term of the regression equation. Because the constant term has this extra component added (log of the proportionality constant), this term cannot be interpreted as an implicit capitalization rate. This phenomenon may be reflected in a potentially "unrealistic" capitalization rate resulting from estimation using an inferior measure of net rents to farmland.

Dynamic regression equations for farmland price are estimated using the program DYNEREG developed by Burt, Townsend, and LaFrance (1986). This program is for estimation of distributed lag models and/or regression models with time series error term. Written in FORTRAN 77 language, the computational algorithm is nonlinear least squares, specifically Marquardt's compromise (Draper and Smith, 1981).

Data Compilation

Almost all of the data compiled for this study are collected and published by the USDA.

The components used to calculate Returns to Total Agricultural Asset, plus data for Total Agricultural Asset Value, Agricultural Real Estate Value, and Land in Farms are collected from Economic Indicators of the Farm Sector: National Financial Summary, 1984. Land Value index series for the U.S. are collected from various issues of Farm Real Estate Market Development: Outlook and Situation (which changed its name to Agricultural Land Values and Markets: Outlook ... in 1985). For deflating purposes, the Personal Consumption Expenditure Index (PCEI) is used; this index is supplied by Burt but can be found in the yearly issues of The Economic Report of the President. All data collected above are for the years 1942-84, and are used when (USDA) accounting data is explored as an alternative measure of net rents to land.

Data sources cited below are used when cash rents and/or gross revenues are being explored. The deflators used in this part of the study, PCEI and inflation rate plus unity, are supplied by Burt but can be found in the yearly issues of the Economic Report of the President. Illinois land price data is supplied by Burt, as it is constructed from Scott's (1983) data by Burt for use in his 1986 research paper. Cropshare rent data originate from Scott's 1983 paper, while cash rents are compiled by Alston for use in his doctorate dissertation research, and thus originate from his PhD. thesis. Statewide index of land values (Illinois, Iowa, Indiana, and Ohio) are compiled from various issues of Farm Real Estate Market Developments publications (cited in the previous paragraph). Per acre real estate tax are collected from various issues of Farm Real Estate Taxes, while the index of prices paid by farmers (for production of all commodities) originate from various issues of Agricultural Statistics.

Direct government payments originate from Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1984. Components used to compute Gross Income from Farming (excluding dwelling) and Production Expense are collected from Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1984.

Finally, data for the value of production for corn (for grain) and for soybeans originate from various issues of Field Crops (discontinued in 1979) and Crop Values (from 1980 onward). Data for total acres harvested for corn (for grain) and for soybeans are compiled from various issues of Crop Production (Annual Summary).

After data are compiled and the three alternative measures of net rent to farmland are computed, then each alternative net rent measure is explored by fitting them to a farmland price equation similar to the dynamic regression equation for land price developed by Burt (1986). Estimation results for the alternative measures being explored are presented in the following chapter.

CHAPTER 4

EMPIRICAL RESULTS

This chapter presents and discusses empirical results for the three alternative measures of net rents to farmland being explored in this study. Therefore, the chapter is divided into three parts. The first section explores the use of USDA accounting to impute a residual return to farmland, the second section explores cash rents as a viable measure of net rents, while the third section is devoted to exploring gross revenues also as a viable measure of net rents to farmland.

USDA Accounting Data Measure

This method uses returns to agricultural assets to indirectly model the behavior of farmland prices. Returns to Agricultural Assets are computed by subtracting Production Expenses from Gross Income from Farming Excluding Dwelling (Watts and Johnson, 1985). Production Expenses are defined as total production expense (excluding operator households) minus both net rent to all landlords and interest payments (both non-real estate and real estate excluding operator households), and with costs of operator labor added. Gross Income from Farming Excluding Dwelling is defined as gross income from farming minus gross rental value of dwellings (including operator households). Other data collected are total agricultural asset values, agricultural real estate values, land in farms, and index of land values.

All value and return data (other than the index of land values) are deflated by PCEI into constant 1982 dollars, then is deflated into a per acre measure by the land in farms series. The index of land values series is only deflated by PCEI, since it is already a per acre measure. The index of land values are collected early in the calendar year. Farmers should base their estimates of current land values on recent information that could very well go back into the previous year. The rest of the data are accounting data and are heavily weighted towards the latter part of the year. This is partly due to data being collected after the harvest and mainly due to the accrual accounting method used to collect the data makes its inventory adjustments at the end of the year (Burt, 1986). The accounting data are adjusted by deflating them for one year's inflation to make them more commensurate with the land value index data by deflating them with the following year's PCEI measure.

A direct measure of returns to farmland is unavailable with the accounting data. Therefore, the land price model and the dynamic regression equation for farmland prices is modified to account for this. Let

A = total agricultural assets value

O = agricultural non-real estate assets value

P = agricultural real estate value

TR = return to total agricultural assets

In equilibrium, the farmland price model is defined as

$$P = \frac{1}{r}(TR - rO) \tag{4.1}$$

where (TR - rO) equals the returns to real estate (farmland) with the assumption that the rate of return to non-real estate assets is equal to that of real estate assets. Note that (4.1) can be rewritten with the term O on the right hand side,

$$P + O = A = \frac{1}{r} TR \tag{4.2}$$

indicating an equilibrium capitalization equation for determining the value of total agricultural assets.

Following a similar logical progression as that used to arrive at equation (3.19), the modified dynamic regression equation for farmland is represented as

$$P_t = [\alpha(TR_t - rO_t)^{\beta_0}(TR_{t-1} - rO_{t-1})^{\beta_1} \ldots]\mu_t \tag{4.3}$$

with μ_t as a multiplicative random disturbance; β_0, β_1, ... are unknown parameters, $\beta_0 + \beta_1 + \ldots = 1$, and recall that $\alpha = 1/r$. Taking the natural logarithm of (4.3) results in

$$\log P_t = \log \alpha + \sum_{j=0}^{\infty} \beta_j \log (TR_{t-j}) + \log \mu_t \tag{4.4}$$

Approximation of (4.4) by a second order rational log then produces

$$\log P_t = \delta + \gamma_0 \log (TR_t - r0_t) + \gamma_1 \log (TR_{t-1} - r0_{t-1})$$
$$+ \lambda_1 E(\log P_{t-1}) + \lambda_2 E(\log P_{t-2}) + \log \mu_t \qquad (4.5)$$

which is similar to (3.16), with $\delta = (1 - \lambda_1 - \lambda_2)\log \alpha$ and $E(\log P_{t-j}) = \log P_{t-j} - \log \mu_t$.

This model is explored by searching over a few values of r and getting a rough approximation to the least squares solution; i.e., an r that produces an estimated equation of (4.5) with the smallest residual sum of squares. A priori specification of r results in computation of returns to farmland as $R_{t-j} = (TR_{t-j} - r0_{t-j})$, j=1,2,... and (4.5) having a similar structure as (3.16). But there is not a strong a priori basis for imposing the constraint that the rate of return on real estate assets be equal to the rate of return on non-real estate assets.

It is not clear that assuming a constant rate of return on non-real estate assets is as easily justifiable as imposing this constraint on real estate assets. These two classes of assets do not have much in common. Farmland (real estate) is fixed in supply and of infinite life (durable asset), while non-real estate assets is an aggregation of very heterogeneous capital (machinery, livestock, inventories, financial assets, etc.) as well as having a fairly elastic supply function and are short-lived.

Assuming an additive distributed lag structure on net returns (and error structure) enables r to be estimated as a free parameter. An additive form of the dynamic regression equation for farmland price approximated by a second order rational lag is represented as

$$P_t = \alpha_1(TR_1 - \beta O_t) + \alpha_2(TR_{t-1} - \beta O_{t-1}) + \lambda_1 E(P_{t-1}) + \lambda_2 E(P_{t-2}) + \mu_t \qquad (4.6)$$

with μ_t a white noise error term and β a more consistent notation for the parameter r. The additive distributed lag assumption enables the dynamic regression equation to be specified in levels (rather than in logged form) so that the variable O_t can be separated out, thus estimating its coefficient as a free parameter. At the equilibrium state, $TR_t = TR_{t-1} = TR_*$, $O_t = O_{t-1} = O_*$, $P_t = P_{t-1} = P_{t-2} = P_*$; so that (4.6) becomes

$$E(P_*)\ (1 - \lambda_1 - \lambda_2) = \alpha_1(TR_* - \beta O_*) + \alpha_2(TR_* - \beta O_*)$$

$$E(P_*) = \frac{(\alpha_1 + \alpha_2)}{(1 - \lambda_1 - \lambda_2)}\ (TR_* - O_*) \qquad (4.7)$$

As shown, specifying the dynamic regression equation (4.6) in levels and without an intercept forces the homogeneity constraint. Equation (4.7) interprets the reciprocal of the capitalization rate as

$$\frac{1}{r} = \frac{(\alpha_1 + \alpha_2)}{(1 - \lambda_1 - \lambda_2)} \qquad (4.8)$$

An easily estimated form of (4.6) is

$$P_t = \alpha_1 TR_t + \alpha_2 TR_{t-1} + \gamma_1 O_t + \gamma_2 O_{t-1} + \lambda_1 E(P_{t-1}) + \lambda_2 E(P_{t-2}) + \mu_t \quad (4.9)$$

where $\gamma_1 = \alpha_1\beta$ and $\gamma_2 = \alpha_2\beta$. With the estimation of (4.9), the implicit capitalization rate $r = (1 - \lambda_1 - \lambda_2)/(\alpha_1 + \alpha_2)$ is estimated, and the hypothesis that the rate of return to farmland is equal to the rate of return of other assets ($\beta = r$) can be checked. In the event that the distributed lag structure on TR_{t-1} is negligible so that $\alpha_2 = \gamma_2 = 0$, equation (4.9) reduces to

$$P_t = \alpha_1 TR_t + \gamma_1 O_t + \lambda_1 E(P_{t-1}) + \lambda_2 E(P_{t-2}) + \mu_t \quad (4.10)$$

and the problem of estimating redundant parameters (α_2 and γ_2) is eliminated so that the least squares estimate of r becomes $\beta = \gamma_1/\alpha_1$.

Equation (4.9) is estimated for the United States (U.S.) using a sample period of 1942-1984, but the estimated equation turns out to be unstable. The next step taken is to shorten the sample period to 1951-1972 for the purpose of trying to locate a more "stable" period in which to re-estimate (4.9); but it still results in an unstable estimated equation. The deflating method used on the variables is redefined so as to possibly make the variables more commensurate in terms of time with respect to each other, but instability still persists. When land value index is used in place of the accounting measure, estimation of (4.9) produces an unstable equation. One encouraging note is that in all of the trial estimations, the estimated coefficients for the non-real estate value variable always has the opposite sign of the estimated coefficients for returns to total assets thus qualitatively corroborating the structure of (4.6) (with respect to the signs on non-real estate and return to assets variables).

The poor results from estimating (4.9) with the underlying assumption of an additive distributed lag on net returns prompt a return to estimation of (4.6) based on a multiplicative distributed lag structure on net returns. Returning to the originally proposed model means that a way must be found to structure (4.6) so as to reflect net returns with one variable instead of two. A priori determining r (rate of return to non-real estate assets) as distinct from $\alpha = 1/r$ would be a way to fulfill this and alleviate the necessity to modify the DYNREG program needed to estimate (4.6) in its original form.

An r of 3.5% is looked at so that net returns could be calculated for each year, and such that equation (4.6) can be estimated with the structure of (3.16). The years 1950-52, 1974-75 are dummied out such that the year's effect of farm returns is excluded from the distributed lag structure and that its effect on land prices is fully realized contemporaneously. The years 1950-52 are associated with the Korean War, while the years 1974-75 are associated with years following the quadrupling of crude oil prices and Russia buying up the surplus stocks of grain in the U.S. During these years, U.S. grain prices were extremely high, thus feeding into extremely high levels of farm income. The extremely high levels of income are considered aberrations due to a one-time violent shock from outside the system. The sample period is cut off at 1983 because at the time the data was being collected, the 1984 levels were preliminary measures subject to revisions. For comparison purposes, equations are estimated using both the accounting and index data for the land price variable.

Estimation of (4.6) produced results that suggest a first differenced model for both accounting and index measures, although both estimated equations are unstable. The first differenced models are estimated with and without imposing the homogeneity constraint, with results reproduced in Table 1. Equations 1 and 2 are estimated using accounting data for the land price variable while equations 3 and 4 are estimated using the land price index series. An implicit capitalization rate can not be estimated because the intercept is subtracted out when the model is differenced. A second order non-stochastic difference model (in first differences) with a second order lag on the rent variable is also estimated. But only the estimated coefficients from the first order lag on rent and land price are significant, thus only regression results from estimation of the first order model are presented.

Table 1: Regression results for final U.S. land price model using USDA accounting data (sample period 1942-83)[a]

Equation No. :	1	2	3	4
$Rent_t$	.0395 (.0163)	.0425[b] -	.0485 (.0329)	.0915[b] -
$E(P_{t-1})$	.8801 (.2686)	.9575 (.0157)	.6138 (.3647)	.9085 (.0279)
AR(1) error	.8189 (.0885)	.8487 (.1542)	.1399 (.1528)	.2731 (.1543)
Linear homogeneous	no	yes	no	yes
Adj. R^2	.4681	.4793	-.0472	-.0632
Std. Error est.	.0321	.0318	.0608	.0639
Error Sum sq.	.03498	.03540	.12561	.14294
Durbin Watson	1.78	1.79	2.01	2.07
Degrees of Freedom	34	35	34	35

[a]In first differences and with the years 1950-51 and 1974-75 dummied out

[b]Standard error not computed

One important observation from the results in Table 1 is that returns have no explanatory value when the index of land values are used (equations 3 and 4). This means that the results from equations 1 and 2 are spurious with respect to a measure of the relationship between residual return to farmland and land prices. It also demonstrates that land prices derived from accounting data are not a reliable measure of per acre land prices if we assume that the index of land values is reliable. Some of the correlation observed in equations 1 and 2 are probably due to the ineffective removal of "other assets" from the "total assets" measure by use of (TR_t - rO_t).

The next step is to disaggregate to the state level to see if the analysis would have similar, or even more encouraging results compared to the results arrived at the national level. But accounting data compiled for the U.S. level does not guarantee a reproduction for the state level. Data needed to calculate gross income from farming excluding dwelling can be found, but data needed to calculate production expenses are only compiled for measures that included households (measures that excluded households were needed). Net rent to all landlords and operator labor measures are not collected also.

The "missing" data at the state level can lead one to question the validity of the same type of data that was not "missing" at the national level. Aside from that, there are questions as to the type of accounting methods used to collect the data, and also if these methods are applied somewhat uniformly across the sample area. Measurement of economic depreciation for non-real estate assets is nearly impossible, causing the accounting data to be only a crude measure at best. Add to these the high probability of aggregation problems inherent in the data and it is relatively easy to see how poor estimation results could be produced.

Cash Rent Measure

The second alternative measure uses cash rents as a proxy for net returns to farmland. A cash rent lease has the amount of rent (paid to the landlord) specified as either a fixed amount per acre or a fixed lump sum. Under a cash lease, the landlord furnishes the land and buildings while the tenant receives all of the income generated, and typically pays all expenses except property taxes, insurance, and major repair costs to buildings and improvements (Kay, 1981).

In comparison, a crop-share lease specifies that the landlord is to receive a certain share of the crops produced with the proceeds from the sale becoming the rent (Kay, 1981). This type of lease is more popular in the midwest and other areas where cash grain farms dominate. Many crop-share leases have the landlord pay part of the variable costs in the same proportion as the share of production to be received (as rent). Since the reference measure is crop-share rent used in Burt (1986), the analysis begins by using Illinois data. Although cash rent leases are few in number in Illinois, this will not affect its predictive ability if cash rent adjustments follow closely those of crop-share rent and imputed returns to land in owner-operator situations. If cash rents provide as good a measure of net rents to farmland as the crop-share rent data in Burt (1986), this can be a start towards a more common (easily collectible) measure of net returns to farmland.

Cash rents tend to be inflexible in their adjustments, and thus slow to change because landlord and tenant have to renegotiate the contract whenever a change is made to reflect new economic conditions. The renegotiation process takes time and effort translating into a cost for both parties so that leases are negotiated less frequently. Pressure from changes in prices of commodities, resource prices, and technology will induce either (both) landlord or (and) tenant to renegotiate. But by the time a cash rent lease is renegotiated, recent changes in farmland prices can possibly affect the decisions made in the renegotiation process; especially on the part of the landlord wanting a higher rent because land has become more "valuable." So there is a joint dependency between farmland prices and cash rents in that changes in the level of one affect the level of the other and vice versa.

Regressing land price on cash rents will produce coefficient estimates on cash rents that are biased and inconsistent, because cash rents are correlated with the error term as a result of its joint dependency with land prices. The method of instrumental variables alleviates the problem of biased and inconsistent estimates. This method involves choosing a variable that is highly correlated with the endogenous "independent" variable, and at the same time uncorrelated, in the limit, with the error term. For this analysis,a special case of the method of instrumental variables is used, namely two stage least squares regression. This method specifies cash rents as a function of the exogenous variables in the system. Regressing cash rents on these exogenous variables produces predicted values of cash rents that are uncorrelated with the error term in the land price equation. And these values are highly correlated with the original values for cash rent, thus fulfilling the two conditions specified by the method of instrumental variables.

The first stage of the analysis is producing a suitable equation for the instrument for the cash rent variable. Crop-share rent is probably be the "best" exogenous variable with which to explain cash rents as it is also a net rental payment for the leasing of farmland.

These two measures follow similar adjustment paths, although crop-share rent is more sensitive to market signals since it is a function of commodity yield and price. Comparison of time series plots of cash rents with crop-share rents indicates that, with respect to adjustments, the former seem to lag the latter. All of this plus its strength in explaining land prices indicate crop-share rents to best explain cash rents.

Regression of cash rents on crop-share rents within a second order non-stochastic difference equation similar to (3.16) results in crop-share rent explaining 96% of the variation in cash rents. The deflation process that is used on the variables is similar to the one used by Burt, with the cash rent data originating from Alston (1986). This data is collected from a survey that asks farmers what cash rents are in the surrounding area for that year. Since crop-share rents seem to explain a major portion of variations in cash rents, regressing crop-share rents on potential exogenous variables would be a logical first step in trying to locate exogenous variables that affect cash rents. Both crop-share rents and cash rents are sums paid to the landlord by the tenant for use of the landlord's farmland, so the factors which affect usage of this land (which is production) would affect determination of these rents. These factors are imputed through two components, return and cost of production. The two rents are basically the net amount of returns minus the cost of production.

Several proxies for the return and cost components are explored. The proxies are either Gross Revenue from Corn and Soybeans or Gross Income from Farming (excluding dwelling) for the return variable, and Production Expense for the cost variable. Recall that the gross income and production expense measures are from accounting data explored in the previous section. Corn and soybeans are the dominant cash crops in Illinois with a major part of Illinois farmland going to crop production. Since a measure of production expense that excludes households is not collected at the state level, a method that prorates the components of production expense (including households) with the ratio of each production expense component excluding households with the same component that includes households (at the national level) and adding all components up (except interest expense and net rent to all landlords) is used to construct this measure. Operator labor is also constructed through a prorating method, and added on to produce the final Production Expense measure. Gross Income from Farming and Production Expense are deflated to a per acre measure by the land in farms measure described in the previous section. Gross revenue from corn and soybeans is computed as a weighted average of the number of acres harvested for each.

The regression equation for crop-share rent is formulated as

$$SR_t = \alpha + \beta GR_t + \delta C_t + \mu_t \qquad (4.11)$$

with SR representing crop-share rent, GR representing one of the two measures of gross returns, and C representing costs. Different combinations of the cost and return proxies, and also the return proxies alone are used to explain crop-share rent. Gross Revenues from corn and soybean production by itself performs statistically better than the other combinations as it explains 78% of the variation in crop-share rent, and has the lowest standard error of the estimate and sum of squared error.

Cash rents are then regressed on the above cost and return proxies. In addition, the index of prices paid by farmers is included as an alternative proxy for the cost variable with the hope that production costs at the state level are proportional to this national index and follow similar adjustment paths. Combinations of cost and return proxies are explored in order to find a set that can explain cash rents relatively better than the others and thus produce a set of exogenous variables in the equation of the instrument for cash rent. First and second order non-stochastic difference equations with lags of t and t-1 or t-1 and t-2 on the explanatory variables (with white noise error term) are the basic structures for the equations explored.

Regression results are varied and not encouraging, because the structures that are estimated are counterintuitive and implausible on a priori grounds. Detailed results of these regression runs are not reported, but an attempt is made to summarize these results in a rather descriptive way.

The proxies for cost of production do not do well as a group regardless of their combination with gross returns. Estimates of the coefficients for this variable either have the wrong sign (should be negative), or have the right sign and not be statistically significant. The proxies for the return variable perform only slightly better. When gross income from farming is used in conjunction with production expense, the estimated coefficients for the return variable are statistically significant. Also some equations estimated with this equation are unstable, which made these accounting measures somewhat suspect. Gross revenues from corn and soybeans production produces coefficient estimates with the right sign (positive), but which are not statistically significant.

For further information concerning the appropriateness of cash rents as an alternative measure of net rents, farmland prices are then regressed directly on to cash rents. Cash rents are also regressed on land prices to see if there is evidence to support joint dependency between the two variables. Initial regression results for the two models indicate a need for differencing the data. These equations are reestimated without imposing the homogeneity constraint. Scott's (1983) "... dollars per acre for high quality grainland in Illinois ... and adjusted with the USDA land price index" (p. 797) that was reconstructed by Burt (1986) are used as land value data. The cash rent data is from Alston's study (1986) found in the same publication as that of the land price index and is measured the same way (survey), therefore no adjustment (for inflation) is needed.

Regression results from land prices regressed on cash rents are presented in Table 2. The estimated coefficients for the difference parameters are relatively small. This may indicate that lagged values of cash rents do not have much explanatory capacity. If cash rents are an exogenous variable able to explain the dynamic behavior of land prices, then these lagged values should have substantial explanatory capacity.

Burt's results using crop-share rents produced estimated difference equation parameters that are far more significant than the rent variable estimates indicating that lagged values of rent have a more important role in explaining land prices than current year rents. Taking equation 1 (or 2) as the unrestricted (general) model and equation 4 as the restricted model, the F-statistic computed is not statistically significant at the 25%

Table 2: Regression Results for Land Prices Regressed on Cash Rents for Illinois (sample period 1961-83)[a]

Equation No.:	1	2	3	4	5
$Rent_t$	.9243 (.2423)	.9149 (.2325)	.9210 (.2259)	.9447 (.2302)	
$Rent_{t-1}$	-.0597 (.7779)	.0045 (.6244)	.3178 (.2282)		.1792 (.2931)
$E(Price)_{t-1}$	.40171 (.8108)	.3023 (.5706)			
$E(Price)_{t-2}$	-.1076 (.2862)				
AR(1) error	.4654 (.1846)	.4547 (.1857)	.4480 (.1864)	.4632 (.1848)	.6855 (.1518)
Adj. R^{2b}	.5507	.5824	.5959	.5816	.2242
St. error est.	.0556	.0546	.0536	.0548	.0690
Error sum sq.	.05558	.05661	.05750	.06307	.10009
Durbin Watson	2.06	2.07	2.04	2.14	2.10
Degrees of freedom	18	19	20	21	21

[a]In first differences

[b]Exclusive of autoregressive (AR) disturbance

level. Looking at equation 3, the t-ratio for the estimated coefficient for the rent variable lagged one period is not significant at conventional levels of 5% and 10%. Only contemporaneous rents show statistical significance with t-ratios that are relatively consistent in all of the estimated equations (around 4.0).

These results suggest that a static model with only contemporaneous rents as the explanatory variable does as good or better job of explaining the variations in land prices than when dynamics are incorporated. Also note that inclusion of a distributed lag structure into the regression does not affect the autoregressive error estimates which remained fairly constant and statistically significant throughout.

Regression results of cash rents regressed on land prices are presented in Table 3. They are somewhat similar to the results from the previous regression model. A similar F-test is conducted between equations 1 (or 2) and 4, with the computed F-statistics indicating that lagged values of land price are even less significant in explaining cash rents. Comparison of equation 3 from Table 2 and from Table 3 indicates that cash rents lagged one period are relatively more significant (in explaining land prices) than land prices (in explaining cash rents). Comparison of equation 5 for the two tables suggests

Table 3: Regression Results for Cash Rents Regressed on Land Prices for Illinois (sample period 1961-83)[a]

Equation No.:	1	2	3	4	5
$Price_t$	.4723 (.1250)	.4696 (.1222)	.4752 (.1191)	.5011 (.0975)	
$Price_{t-1}$	-.1334 (.3844)	-.1077 (.3835)	.0507 (.1247)		.3453 (.1328)
$E(Rent)_{t-1}$	.3677 (.7133)	.3414 (.6956)			
$E(Rent)_{t-2}$	.0249 (.2399)				
AR(1) error	.2064 (.2040)	.2060 (.2040)	.1970 (.2044)	.2082 (.2040)	.1634 (.2057)
Adj. R^{2b}	.4947	.5257	.5594	.5816	.2388
St. error est.	.0400	.0390	.0383	.0375	.0501
Error sum sq.	.02885	.02886	.02935	.02959	.05268
Durbin Watson	2.02	2.02	2.02	2.03	2.04
Degrees of freedom	18	19	20	21	21

[a]In first differences

[b]Exclusive of AR disturbance

otherwise. But the magnitude of these differences are fairly trivial from a statistical point of view, and are also of little practical importance.

Regression results from Tables 2 and 3 indicate that any dynamics involved in the relationship between cash rents and land prices are extremely weak, and that basically only contemporaneous levels are needed to explain the variation of one variable by the other. This is an indication of a phenomenon known as "third variable spurious regression." What is happening is that a third exogenous variable (or set of variables), namely lagged values of crop-share rents, is (are) separately explaining both cash rents and farmland prices. This produces the mirage effect of joint dependency between the two variables that are, in reality, being simultaneously determined by the third variable. These results lead to the conclusion that cash rent, as a measure of net returns to farmland, is not useful in explaining the movements of farmland prices.

Gross Revenue Measure

The third alternative measure of net returns to farmland explored in this study is gross revenue from production of dominant crops. Regression of crop-share rents on the different cost and return to production proxies briefly mentioned in the preceding section suggests the use of this measure. Results of the regressions are that gross revenue from corn and soybean production (in Illinois) does a relatively better job of explaining Illinois crop-share rents than when cost proxies are included, or when Gross Income from Farming Excluding Dwelling (Watts, Johnson, 1985) together with the cost proxies are used. Crop-share rents explain farmland prices rather well (Burt, 1986). So this gross revenue measure is a likely candidate as an alternative to crop-share rents. A major portion of Illinois farmland is delegated to crop production, and among these crops, corn and soybeans are dominant. Gross revenues from the two crops reflect a major portion of the return to farmland in Illinois, albeit a gross rather than a net measure.

Gross revenue from corn and soybean production is a value of production measure of corn for grain and of soybeans. This value of production series is defined as the season average price received by farmers for the crop ($/bu.) that is applied to the crop's production estimates (bu.). Each value of production estimate is deflated to a per acre measure by the total acreage harvested for the crop. Land value data is a series constructed by Burt (1986) from Scott's "... dollars per acre for high quality grain land in Illinois for comparable and paired sales in 1961, 1967, and 1981 and adjusted with the USDA land price index" (1983, p. 797). The land price index is published as a series for March 1 before 1976, February 1 for 1976-81, and April 1 for 1982 and onward. The indices are based on surveys that ask farmers to estimate the average value of farmland in the surrounding area.

Land value indices are used as land value data for comparison with dollar value land price levels. Since these surveys occur early in the year, it is conceivable that farmers base their estimates of land prices on recent information that could go back into the previous year. Gross revenue is heavily weighted by revenues received at the end of the year, during harvest time. Thus gross revenue from corn and soybeans should be deflated for one year's inflation to be commensurate with the land value data. As usual, both land value and revenue data are deflated to a base year dollar measure (1982) by the PCEI.

Initially, land prices are regressed on gross revenue and a cost variable. A proxy for the cost variable is Production Expenses (Watts and Johnson, 1985) defined in the first section of this chapter. Although this measure is a cost imputed to all agricultural assets, costs imputed to farmland should follow a similar time path since farmland is a major component of total agricultural assets. But regression results suggest that this is not so, because the estimated coefficients for the cost variable reflect a total distributed lag effect on land prices that are positive when it theoretically should be negative.

These coefficients are also not statistically significant, so the cost variable is dropped from the model.

Land prices are then regressed on gross revenues alone, within a structure equivalent to (3.16) and also a structure that is similar to (3.8) except that the rent variable is lagged at t-1 and t-2. The equations are estimated with and without the long-run homogeneity constraint imposed. The regression results are presented in equations 1-4, Table 4. One notices instantly that the estimated coefficients on the difference equation parameters (λ_1, λ_2) of equations 1 and 2 are very close to Burt's estimated coefficients (equation 1, Table 5). Only one of Burt's estimated equations is reproduced for comparison purposes as all of the regression results for his estimated equations are similar. When the two equations are estimated with the homogeneity constraint, the estimated difference equation parameters become unstable. An F test is conducted to test the statistical importance of the homogeneity (h=1) constraint. Computed F-statistics under the null hypothesis of restricting the model (h=1) are 68.47 and 37.75 both with 1 and 19 degrees of freedom. The F-statistics indicate rejection of the null hypothesis, thus favoring non-restriction of the model.

Table 4: Initial Regression Results for Illinois Land Prices Using by Gross Revenue from Corn and Soybeans (Sample Period 1960-83)

Equation No.:	1	2	3	4
Intercept	-.0831 (.0392)	-.5473 (.0410)	.2068 (.0193)	.0512 (.0292)
$Rent_t$	-.0175 (.0263)		.0053[a] -	
$Rent_{t-1}$	.2130 (.0359)	.2137 (.0304)	.1426 (.0519)	.4470[a] -
$Rent_{t-2}$		-.0418 (.0475)		-.4329 (.0628)
$E(Price)_{t-1}$	1.6214 (.0440)	1.6808 (.0502)	1.8149 (.0326)	1.9430 (.0203)
$E(Price)_{t-2}$	-.7638 (.0405)	-.8090 (.0421)	-.9628 (.0262)	-.9872 (.0172)
Linear homogeneous	no	no	yes	yes
Adj. R^2	.9908	.9910	.9637	.9752
St. error est.	.0339	.0338	.0708	.0569
Error sum sq.	.02179	.02167	.10032	.06473
Durbin Watson	1.41	1.31	.43	.70
Degrees of freedom	19	19	20	20

[a]Standard error not computed

Table 4: Continued

Equation No.:	5	6	7	8
Intercept	-.6371 (.0507)	-.5411 (.0720)	-.0785 (.0381)	-.6260 (.0416)
$Rent_t$	-.0097 (.0269)			
$Rent_{t-1}$	.2169 (.0369)	.2367 (.0307)	.1895 (.0089)	.2037 (.0091)
$Rent_{t-2}$		-.0575 (.0482)		
$E(Price)_{t-1}$	1.6266 (.0431)	1.6900 (.0475)	1.6400 (.0345)	1.6367 (.0338)
$E(Price)_{t-2}$	-.7629 (.0398)	-.8114 (.0402)	-.7786 (.0342)	-.7710 (.0335)
Linear homogeneous	no	no	no	no
Adj. R^2	.9920	.9925	.9912	.9924
St. error est.	.0345	.0337	.0333	.0337
Error sum sq.	.02260	.02160	.02227	.02274
Durbin Watson	1.45	1.40	1.34	1.42
Degrees of freedom	19	19	20	20

The two models are then estimated using land value indices with results presented in equations 5 and 6. Overall, the regression results are not much different from the results of equations 1 and 2. Long-run elasticities of land price estimated from equations 1, 2, 5, and 6 are 1.37, 1.34, 1.52, and 1.48, respectively. This suggests that forcing the homogeneity constraint imposes an implausible constraint in the model. Gross revenue from corn and soybeans may do a better job of forecasting for the short-term than for the longer term. The long-term forecasts overshoot the true values of land price for that period. Consistency in the regression results using the two kinds of land value data indicate the usefulness of gross revenue in explaining high quality grain land as well as other farmland.

Attempts to fine tune the land price model results in a model similar to (3.16) but with only one rent variable at lag t-1. The estimated coefficients for the rent variables at lag t and lag t-2 are not statistically significant at conventional levels of significance, so both variables are dropped from the final model. Results for this now model are presented in equations 7 and 8, Table 4, with equation 8 using the statewide land value index. Long-run elasticity coefficients estimated for equations 7 and 8 are 1.38 and 1.52 respectively, further indicating that the data suggest using a model without the homogeneity constraint.

Equations 1-8 are also estimated with and without the inflation adjustment on the rent data discussed earlier, but only regression results with the adjustment are presented in table 4. This is because equations estimated with the adjustment have lower standard errors of the estimate than equations estimated without the adjustment. Since the inflation adjustment on rents produces a better fit to land prices, this adjustment is incorporated and assumed from here onward.

There is a problem with using the gross revenue measure because it is a return to the factors of production with farmland being only one component of it. Therefore, gross revenue is adjusted in this study to reflect a return to farmland alone.

Most crop-share leases in Illinois provide the landlord receiving 50% of the crops produced, which translate to one-half of revenue received for the crops. The rent data is then adjusted to include only 50% of original revenue estimates. Real estate tax is a cost borne by the landlord, and is subtracted out. What is left is a more precise estimate of returns imputed to land, but is still a gross measure since other costs paid by the landlord are left out (primarily the landlord's share of fertilizer and chemicals).

The adjusted rent data is run through a similar estimation process to that described previously. This results in a model with only one rent variable at lag t-1. Regression results for the final estimated model are presented in Table 5, equations 2 and 3, with equation 3 using land value indices. Comparing these two equations with equations 7 and 8 (Table 4) indicate that almost all (except the intercept) estimated coefficients changed little, but that the fit is improved when adjusted gross revenues are used. This is shown by the reduction in the standard errors of the point estimates.

An implicit capitalization rate cannot be computed from the final farmland price equations estimated in this study, as is done in Burt's (1986) study. Costs imputed to farmland and proportional to gross revenue are imbedded in the rent variable; this proportional cost amount becomes confounded into the intercept term when the logarithm transformation is done on the land price equation. So the estimated intercept coefficient does not have the same meaning for the land price model estimated in this study as that estimated in Burt's study.

The study here digresses a little in order to explore the potential for direct government payments to strengthen the explanatory value of final estimated land price models. Direct government payments are deflated to a per-acre

Table 5: Regression Results for Final Illinois Land Price Model Using Gross Revenue from Corn and Soybeans (Sample Period 1960-83)

Equation No.:	1	2	3
Intercept	.4091 (.0268)	.0780 (.0318)	-.4688 (.0335)
$Rent_t$	.0708 (.0164)		
$Rent_{t-1}$	.0563 (.0238)	.1905 (.0086)	.2050 (.0089)
$E(Price)_{t-1}$	1.6317 (.0325)	1.6105 (.0329)	1.6062 (.0322)
$E(Price)_{t-2}$	-.7588 (.0255)	-.7515 (.0324)	-.7431 (.0317)
Linear homogeneous	yes	no	no
Adj. R^2	.9952	.9917	.9929
St. error est.	.0241	.0321	.0325
Error sum sq.	.01049	.02064	.02108
Durbin Watson	2.59	1.45	1.54
Degrees of freedom	18	20	20

measure by the total number of acres harvested for both corn (for grain) and soybeans.

Equations are estimated within a distributed lag framework similar to (3.16) using the two types of land price data. Government payments treated as a similar exogenous variable produces a smaller standard error of the estimate for its estimated land price equations compared to when these payments are summed up with gross revenue. The estimated coefficients for government payments have relatively low t-ratios and are not statistically significant at conventional levels of significance (5% or 10%). This result is caused by the fact that data used for government payments are not only for the crop production sector, but also include payments for the livestock and dairy sectors. It also indicates that since the rent variable is a gross measure, government payments do not contribute much in the way of explaining land price movements as it is such a small part of gross returns.

Given the encouraging results in using gross revenues from corn and soybean production to explain Illinois land prices, the analysis is then broadened to include the surrounding states in the corn belt region, namely Indiana, Iowa, and Ohio. It is thought that these states have similar farmland characteristics (a major portion used for crop production, and a large portion leased with crop-share leases dominating) as in Illinois. Only the adjusted statewide index of land values are used in this stage of the analysis as the dollar value land prices are constructed only for Illinois. Previous results indicate that there is basically no difference in the regression results between using the two land value measures. The analysis for these three states progresses in similar fashion as was done for Illinois. Final model regression results for the three states are presented in Table 6.

Analysis with Iowa, Indiana, and Ohio data result in the same estimated equation structure as with Illinois data, namely a second order non-stochastic difference equation with one rent variable at lag t-1.

Comparisons between equations, one estimated with adjusted and the other estimated with unadjusted gross revenue (corn and soybeans production), indicate similar regression results for all three states. Only the results using adjusted revenue data (50% of gross revenue and real estate taxes deducted) are presented.

The low Durbin-Watson statistic from final equation estimates for Indiana and Ohio (equations 2 and 4) indicate the presence of positively autocorrelated errors. So the equation was reestimated for the two states with an AR(1) error structure with the results presented in equations 3 and 5 in Table 6. The t-ratios for the estimated coefficients of the AR(1) error term for the two states are

Table 6: Regression Results for Final Land Price Model for Iowa, Indiana, and Ohio, using Gross Revenue from Corn and Soybeans (Sample Period 1960-83)

State:	Iowa	Indiana		Ohio	
Equation No.:	1	2	3	4	5
Intercept	-.2866 (.0336)	-.2113 (.0387)	-.1796 (.0592)	-.2079 (.0652)	-.1054 (.1015)
$Rent_{t-1}$	.1802 (.0084)	.1832 (.0099)	.1788 (.0147)	.2163 (.0206)	.1869 (.0261)
$E(Price)_{t-1}$	1.7380 (.0348)	1.6468 (.0381)	1.6819 (.0497)	1.5557 (.0702)	1.6655 (.0769)
$E(Price)_{t-2}$	-.8514 (.0355)	-.7788 (.0384)	-.8167 (.0493)	-.7161 (.0666)	-.8203 (.0733)
Linear homogeneous	no	no	no	no	no
AR error	--	--	.587 (.1689)	--	.748 (.1385)
Adj. R^2	.9924	.9863	.9836[a]	.9755	.9679[a]
St. error est.	.0383	.0437	.0390	.0560	.0443
Srror sum sq.	.02928	.03826	.02737	.06276	.03537
Durbin Watson	1.55	.93	1.57	.72	1.71
Degrees of freedom	20	20	18	20	18

[a]Exclusive of AR disturbance

3.48 and 5.4, indicating that they are statistically significant at conventional levels of significance.

Comparison between regression results for these three states with that of Illinois (equation 3, Table 4) produces some interesting results. Not only are the estimated coefficients for the difference equation parameters quite similar, but that of the rent variable remains fairly constant throughout the analysis within the four states. The estimated coefficients for the intercept have the same negative sign, and are fairly close. Computation of the long-run elasticities for the three states results in coefficients between 1.20 and 1.60, indicating that the homogeneity constraint assumption is violated.

Gross revenue from production of principal crops is explored as an alternative to revenue from corn and soybean production in the analysis for Ohio. It is thought that corn and soybeans are not as dominant in this state as in the other three states. But the fit is statistically better when revenues from corn and soybean production are used.

Additional analysis is also done on two plains states: Kansas and North Dakota. Wheat is the dominant crop in these two states, so gross revenue is estimated from wheat production. Gross revenue from production of principal crops is also explored for comparison purposes. The regression results for the two states are not encouraging and thus not presented.

The practice of summer fallowing is important in Kansas and North Dakota, so that summer fallow acres should have been included with the harvested acreage before deflating gross revenue to a per acre basis. But the USDA does not publish an annual series for summer fallowed acres. Exclusion of the summer fallow acreage distorts the per acre amount of returns to farmland such that the regression results for Kansas and North Dakota are much different from the results for the cornbelt states.

Distributed lag land price response elasticities with respect to gross returns are then computed for the estimated models for Illinois (equation 2, Table 5), Iowa, Indiana (equation 3, Table 6), Ohio (equation 5, Table 6), and for Burt's estimated equation (equation 1, Table 5). These elasticities are partial derivatives defined in natural logarithms as

$$Y(T) = \partial Y_{t-T}/\partial X_t = \partial Y_t/\partial X_{t-T} \qquad (4.12)$$

where X and Y are logarithms of gross returns and land prices, respectively. Y(T) measures the effect on current land prices from a change in rents T period(s) back, or similarly the effect of current rents on land price T period(s) into the future. Cumulative (intermediate-run) response elasticities are also computed, and these are defined as

$$e(T) = \sum_{j=0}^{T} Y(j) \qquad (4.13)$$

where e(T) is the total cumulative effect on current land price from a change in rents T periods back. The computed elasticities are reproduced in Tables 7 and 8 only for T=0, 1, 2, ..., 20, with T=20 reflecting the long-run (or equilibrium) response.

The computed elasticities in Table 7 indicate that the distributed lag response of land prices to rents for the estimated models using gross revenues are similar to Burt's estimated model using cropshare rents. The distributed lag response (using gross revenues) follows a similar dampened cyclical path indicative of a second order difference equation with complex roots as that of Burt's estimated model. Turning points in the time paths of Y(T) occur at similat lag periods, except for Iowa, which is one period off. One difference is that the computed elasticities for estimated models using gross revenues are relatively larger than the ones when cropshare rents were used. This is reflected in the intermediate and long-run cumulative elasticities e(T).

The estimated relationship between farmland price and gross revenue is further tested via prediction errors. Final estimated regression equations for Illinois, Iowa, Indiana, and Ohio (equations 2 and 3, Table 5, and all

Table 7: Distributed lag land price elasticities (Y(T))

T	Crop-share Rent Illinois	Gross Revenue (Corn and Soybeans) Illinois	Iowa	Indiana	Ohio
0	.0708	.0000	.0000	.0000	.0000
1	.1718	.1905	.1802	.1788	.1869
2	.2266	.3068	.3132	.3007	.3113
3	.2394	.3509	.3909	.3598	.3651
4	.2187	.3346	.4127	.3595	.3528
5	.1752	.2752	.3845	.3108	.2880
6	.1199	.1917	.3169	.2291	.1903
7	.0627	.1020	.2234	.1316	.0807
8	.0113	.0201	.1184	.0341	-.0217
9	-.0291	-.0442	.0157	-.0500	-.1023
10	-.0561	-.0863	-.0736	-.1120	-.1526
11	-.0694	-.1058	-.1413	-.1476	-.1703
12	-.0707	-.1055	-.1827	-.1567	-.1584
13	-.0627	-.0904	-.1976	-.1430	-.1241
14	-.0487	-.0663	-.1876	-.1126	-.0768
15	-.0318	-.0389	-.1589	-.0725	-.0261
16	-.0150	-.0128	-.1147	-.0301	.1955
17	-.0003	.0087	-.0649	.0087	.0540
18	.0108	.0235	-.0152	.0392	.0738
19	.0179	.0314	.0289	.0588	.0787
20	.0211	.0329	.0632	.0669	.0705
200	.174E-12	.107E-12	-.307E-7	-.355E-9	-.991E-9

Table 8: Cumulative distributed lag land price elasticities (e(T))

T	Crop-share Rent Illinois	Gross Revenue (Corn and Soybeans) Illinois	Iowa	Indiana	Ohio
0	.0708	.0000	.0000	.0000	.0000
1	.2426	.1905	.1802	.1788	.1869
2	.4693	.4973	.4934	.4795	.4982
3	.7087	.8482	.8843	.8393	.8633
4	.9274	1.1183	.1297	1.1988	1.2161
5	1.1026	1.4581	1.1682	1.5096	1.5041
6	1.2225	1.6498	1.9984	1.7387	1.6944
7	1.2852	1.7517	2.2218	1.8703	1.7752
8	1.2965	1.7719	2.3402	1.9044	1.7535
9	1.2672	1.7277	2.3539	1.8544	1.6512
10	1.2113	1.6413	2.2823	1.7423	1.4985
11	1.1419	1.5355	2.1410	1.5948	1.3283
12	1.0712	1.4300	1.9581	1.4381	1.1699
13	1.0085	1.3396	1.7605	1.2951	1.0457
14	.9599	1.2732	1.5729	1.1825	.9689
15	.9281	1.2344	1.4150	1.1099	.9428
16	.9130	1.2216	1.3002	1.0799	.9624
17	.9127	1.2303	1.2353	1.0886	1.0163
18	.9236	1.2538	1.2202	1.1277	1.0902
19	.9415	1.2852	1.2491	1.1865	1.1689
20	1.0000	1.3511	1.5891	1.3264	1.2074

equations in Table 6) are re-estimated in a sequential post-sample forecasting format (see Burt, Townsend and LaFrance, 1986).

For each equation, the sample period is reduced one year at a time, then the equation is re-estimated and forecasts computed up until the end of the original sample period (in this case it is 1983). The step-by-step yearly reduction of the sample period is done for up to 13 years, thus back until 1970, as is also done in Burt's (1986) study.

These post-sample forecasts are presented in Tables 9-15. Although sample period reductions are done for up to 13 years, only post-sample forecasts for up to five years ahead are presented in the tables. Asterisks indicate prediction errors that are greater than twice the absolute value of the standard error, thus lying outside an approximate 95% confidence interval. Burt (1986) mentions that these "predictions are not ex ante in a realistic sense because known rents are used, but the primary purpose is to detect specification error" (p. 16).

Glancing at the post-sample forecasts for the six estimated land price equations, one major point of similarity arises. This point is that asterisked prediction errors follow two main diagonal paths, one for the year 1975 and the other for the year 1976. This indicates that 1975 and 1976 are outlier years. As

Table 9: Post sample forecasts of final estimated land price model equations (classic disturbance) for Illinois (Burt's land price data)

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.052 (.047)				
1960-81	-.048 (.049)	-.090 (.061)			
1960-80	.025 (.050)	-.028 (.065)	-.064 (.080)		
1960-79	.001 (.052)	.026 (.067)	-.027 (.085)	-.063 (.102)	
1960-78	.029 (.055)	.024 (.070)	.052 (.087)	.001 (.103)	-.036 (.116)
1960-77	.007 (.060)	.035 (.079)	.031 (.095)	.059 (.110)	.007 (.122)
1960-76	.148* (.048)	.145* (.062)	.190* (.074)	.179* (.082)	.186* (.088)
1960-75	-.016 (.053)	.131 (.074)	.126 (.093)	.171 (.104)	.162 (.106)
1960-74	-.115* (.035)	-.135* (.049)	-.021 (.065)	-.037 (.077)	.021 (.083)
1960-73	-.071* (.033)	-.165* (.039)	-.183* (.048)	-.059 (.058)	-.061 (.065)
1960-72	-.050 (.029)	-.113* (.039)	-.196* (.041)	-.198* (.048)	-.060 (.055)
1960-71	.055* (.023)	-.006* (.030)	-.091* (.036)	-.179* (.033)	-.205* (.035)
1960-70	.001 (.027)	.054 (.035)	-.007 (.043)	-.072 (.045)	-.180* (.036)
RMSE	.064	.096	.112	.122	.127
Mean	-.007	-.010	-.015	-.020	-.018

Table 10: Post sample forecasts of final estimated land price model (classic disturbance) for Illinois (land price index data)

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.055 (.048)				
1960-81	-.052 (.049)	-.096 (.061)			
1960-80	.025 (.051)	-.031 (.065)	-.070 (.081)		
1960-79	.001 (.052)	.026 (.068)	-.031 (.086)	-.069 (.103)	
1960-78	.031 (.055)	.025 (.070)	.054 (.087)	-.001 (.103)	-.040 (.117)
1960-77	.008 (.060)	.038 (.078)	.033 (.095)	.062 (.109)	.007 (.122)
1960-76	.156* (.046)	.153* (.059)	.202* (.071)	.191* (.078)	.199* (.084)
1960-75	-.011 (.051)	.144* (.070)	.140 (.088)	.188 (.098)	.179 (.100)
1960-74	-.108* (.035)	-.122* (.050)	.003 (.065)	-.012 (.077)	.047 (.082)
1960-73	-.065 (.034)	-.155* (.040)	-.169* (.050)	-.035 (.060)	-.038 (.067)
1960-72	-.048 (.030)	-.106* (.041)	-.184* (.043)	-.183* (.050)	-.037 (.058)
1960-71	.058* (.024)	.000 (.031)	-.061 (.037)	-.166* (.034)	-.189* (.037)
1960-70	.001 (.028)	.059 (.036)	.001 (.045)	-.060 (.047)	-.165* (.038)
RMSE	.064	.096	.111	.121	.125
Mean	-.005	-.005	-.007	-.009	-.004

Table 11: Post sample forecasts of final estimated land price model (classic disturbance) for Iowa

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.097 (.058)				
1960-81	-.082 (.059)	-.175* (.098)			
1960-80	.021 (.063)	-.061 (.087)	-.146 (.116)		
1960-79	.078 (.060)	.099 (.083)	.046 (.112)	-.011 (.143)	
1960-78	.022 (.060)	.096 (.081)	.122 (.107)	.073 (.136)	.017 (.164)
1960-77	-.045 (.066)	-.015 (.088)	.056 (.112)	.084 (.136)	.042 (.162)
1960-76	.141* (.058)	.086 (.078)	.122 (.094)	.135 (.109)	.164 (.121)
1960-75	-.036 (.063)	.098 (.093)	.036 (.120)	.076 (.132)	.141 (.135)
1960-74	-.136* (.033)	-.168* (.041)	-.066 (.053)	-.130* (.063)	-.066 (.068)
1960-73	-.056 (.034)	-.175* (.039)	-.200* (.045)	-.085 (.052)	-.136* (.060)
1960-72	-.004 (.038)	-.060 (.050)	-.178* (.052)	-.202* (.051)	-.086 (.056)
1960-71	.080* (.033)	.081 (.048)	.034 (.058)	-.103 (.053)	-.157* (.040)
1960-70	-.006 (.041)	.072 (.064)	.069 (.087)	.022 (.097)	-.113 (.083)
RMSE	.076	.110	.113	.112	.114
Mean	-.009	-.010	-.010	-.010	-.022

Table 12: Post sample forecasts of final estimated land price model (classic disturbance) for Indiana

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.130*				
	(.057)				
1960-81	-.141*	-.228*			
	(.049)	(.061)			
1960-80	-.014	-.151*	-.240*		
	(.050)	(.062)	(.078)		
1960-79	.008	-.009	-.145	-.233*	
	(.053)	(.064)	(.079)	(.095)	
1960-78	-.042	-.024	-.045	-.184	-.271
	(.057)	(.072)	(.086)	(.103)	(.117)
1960-77	-.077	-.113	-.110	-.137	-.275
	(.061)	(.083)	(.105)	(.122)	(.137)
1960-76	.016	-.061	-.092	-.086	-.113
	(.064)	(.092)	(.121)	(.145)	(.161)
1960-75	-.096	-.086	-.192	-.244	-.243
	(.058)	(.084)	(.113)	(.141)	(.160)
1960-74	-.128*	-.218*	-.234*	-.348*	-.391*
	(.049)	(.066)	(.086)	(.105)	(.119)
1960-73	-.140*	-.273*	-.380*	-.399*	-.493*
	(.038)	(.051)	(.062)	(.073)	(.081)
1960-72	.028	-.109*	-.238*	-.348*	-.371*
	(.035)	(.056)	(.069)	(.076)	(.082)
1960-71	.053	.084	-.036	-.167	-.292*
	(.033)	(.050)	(.072)	(.082)	(.080)
1960-70	-.085*	.170*	.249*	.162	.016
	(.032)	(.055)	(.082)	(.104)	(.104)
RMSE	.088	.150	.204	.251	.306
Mean	-.024	-.085	-.133	-.198	-.270

Table 13: Post sample forecasts of final estimated land price model (AR(1) disturbance) for Indiana

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.070				
	(.055)				
1960-81	-.135*	-.161*			
	(.046)	(.062)			
1960-80	-.016	-.146*	-.174*		
	(.047)	(.058)	(.078)		
1960-79	.024	-.001	-.127	-.150	
	(.049)	(.058)	(.071)	(.088)	
1960-78	-.017	.012	-.014	-.141	-.167
	(.053)	(.063)	(.074)	(.089)	(.106)
1960-77	-.084	-.082	-.062	-.091	-.215
	(.055)	(.073)	(.090)	(.101)	(.115)
1960-76	.064	-.030	-.010	.016	-.017
	(.053)	(.070)	(.083)	(.093)	(.098)
1960-75	-.030	.030	-.068	-.056	-.031
	(.059)	(.082)	(.107)	(.127)	(.139)
1960-74	-.150*	-.259*	-.293*	-.410*	-.467*
	(.055)	(.082)	(.113)	(.133)	(.162)
1960-73	-.149*	-.278*	-.380*	-.394*	-.485*
	(.039)	(.066)	(.102)	(.133)	(.142)
1960-72	.025	-.118	-.259*	-.378*	-.408*
	(.037)	(.060)	(.082)	(.109)	(.136)
1960-71	.091*	.160*	.073	-.129*	-.346*
	(.034)	(.056)	(.081)	(.092)	(.095)
1960-70	-.081*	.206*	.324*	.273*	.080
	(.031)	(.059)	(.094)	(.125)	(.120)
RMSE	.086	.153	.205	.247	.302
Mean	-.028	-.056	-.090	-.146	-.228

Table 14: Post sample forecasts of final estimated land price model (classic disturbance) for Ohio

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	-.150 (.076)				
1960-81	-.236* (.058)	-.327* (.074)			
1960-80	-.162 (.044)	-.365* (.060)	-.503* (.081)		
1960-79	-.049 (.046)	-.200* (.058)	-.419* (.083)	-.573* (.112)	
1960-78	-.010 (.050)	.057 (.065)	-.209* (.082)	-.432* (.115)	-.588* (.148)
1960-77	-.044 (.058)	-.055 (.083)	-.113 (.110)	-.272* (.134)	-.506* (.174)
1960-76	.108* (.044)	.075 (.059)	.095 (.073)	.057 (.087)	-.093 (.100)
1960-75	.009 (.054)	.118* (.091)	.088 (.095)	.110 (.113)	.073 (.128)
1960-74	-.176* (.031)	-.239* (.049)	-.231* (.072)	-.338* (.093)	-.356* (.108)
1960-73	-.073* (.024)	-.261* (.035)	-.342* (.048)	-.344* (.061)	-.444* (.071)
1960-72	.007 (.022)	-.066 (.036)	-.253* (.047)	-.334* (.055)	-.337* (.066)
1960-71	.022 (.022)	.028 (.033)	-.042 (.047)	-.234* (.053)	-.325* (.056)
1960-70	.009 (.029)	.033 (.044)	.042 (.064)	-.026 (.078)	-.222* (.076)
RMSE	.110	.191	.260	.317	.366
Mean	-.057	-.110	-.172	-.170	-.311

Table 15: Post sample forecasts of final estimated land price model (AR(1) disturbance) for Ohio

Sample Period	Number of Years Beyond the Sample 1	2	3	4	5
1960-82	.014 (.064)				
1960-81	-.178* (.058)	-.191* (.081)			
1960-80	-.153* (.045)	-.324* (.070)	-.417* (.113)		
1960-79	-.047 (.047)	-.189* (.061)	-.378* (.096)	-.488* (.148)	
1960-78	-.003 (.051)	-.049 (.066)	-.192* (.083)	-.383* (.126)	-.495* (.178)
1960-77	-.083 (.059)	-.080 (.088)	-.145 (.118)	-.291 (.149)	-.479* (.206)
1960-76	.105* (.039)	.025 (.055)	.059 (.062)	.011 (.075)	-.123 (.085)
1960-75	.054 (.037)	.140* (.042)	.054 (.062)	.094 (.066)	.047 (.079)
1960-74	-.149* (.034)	-.156* (.068)	-.120 (.095)	-.226 (.113)	-.214 (.138)
1960-73	-.082* (.026)	-.301* (.044)	-.447* (.088)	-.476* (.113)	-.574* (.120)
1960-72	.006 (.025)	-.075 (.041)	-.293* (.058)	-.441* (.096)	-.472* (.119)
1960-71	.021 (.025)	.028 (.039)	-.048 (.057)	-.265* (.068)	-.413* (.098)
1960-70	.015 (.035)	.041 (.057)	.056 (.084)	-.017 (.107)	-.243* (.106)
RMSE	.091	.166	.250	.320	.383
Mean	-.037	-.094	-.170	-.248	-.330

previously mentioned, this is due to a combination of high increases in oil prices and Russia buying out U.S. grain stocks, creating an aberration in U.S. agriculture in the form of extremely high grain prices translating into extremely high farm income for several years after 1974.

These two outlier years, if included in the sample period, throw off forecasts for later periods. This is shown especially in the two sets of post-sample forecasts for Ohio, where there is a group of prediction errors lying outside the approximate 95% confidence interval for the years beyond 1975 and 1976. Burt's (1986) post-sample forecasts also produce the 1975-76 outliers.

Another point to be noted from these sets of post-sample forecasts is that root mean squared error (RMSE) increases as the number of years forecasted beyond the sample increases. This indicates that the estimated land price equations do better with short term rather than long term forecasting as was hypothesized earlier in the chapter of this study. This is also consistent with the conclusion arrived at previously in this section. Because computed long-run elasticities of these estimated equations are greater than one, these equations will not do well forecasting for the long run.

This concludes the presentation and discussion of the empirical results for this study. A summary of the empirical results along with conclusions and suggestions for further study are presented in the following chapter.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Three alternative measures of net returns imputed to farmland were explored in this study. The three measures were returns estimated from aggregate accounting data, cash rents, and gross revenue from production of dominant crops (in this case, corn for grain and soybeans). Each rent measure was estimated within a second order rational lag framework similar to that of Burt's (1986) land price model. The performance of crop-share rents in explaining farmland prices (Burt, 1986) was used as a reference measure with which the performance of each alternative returns measure was compared against.

Returns to farmland computed from USDA accounting data did not do very well in explaining farmland prices. Regression results suggested that any correlation between returns and land prices were of a spurious nature. Since net returns imputed to farmland were computed indirectly by removal of returns to non-real estate assets from returns to total assets, it was thought that this procedure was ineffective in computing the true measure of net rent to land.

Analysis was initially done for aggregate U.S. data and was to proceed down to individual state data. If analysis at the state level (initial point being Illinois) produced similar regression results as at the national level, one could conclude that the indirect procedure of computing net rent to land was not useful. Unfortunately the data that was needed for the state level was not published.

Cash rents were the second alternative measure of net rents explored. It was thought that cash rents are jointly dependent with land prices, so the estimation procedure was done within an instrumental variable framework, specifically two stage least squares. But regression results using this approach were implausible.

Intuitively, cash rents would not be a good explanatory variable for farmland prices due to their rigidity caused by the renegotiation process that both parties must go through whenever a change (in response to new market conditions) is needed, and that cash rent contracts are usually for up to three years while crop-share rent contracts are for year-to-year. Farmland prices would respond to new economic conditions a lot faster than cash rents.

Cash rents were then regressed on current and lagged land prices, and also land prices were regressed on current and lagged cash rents. Regression results from both models suggested that both variables were responding to a "third" variable (or set of variables), namely the lagged values of crop-share rents. So it was concluded that the correlations between cash rents and farmland prices are spurious, and that each are ultimately responding to changes in this "third" variable mentioned above.

The last alternative measure explored was gross revenue from production. Since analysis was initiated in Illinois (so that direct comparison could be made with crop-share rents), the per acre value of production (yield x price) of corn for grain and soybeans were used as a measure of returns to farmland. A major part of Illinois agricultural land is used for crop production with corn and soybeans being its dominant crops.

The regression results indicated some promise for this measure of net rent. The estimated coefficients for the difference equation parameters were very close to those estimated using crop-share rents (Burt, 1986). Estimated coefficients for the rent variable were different from those in Burt's study. This would mean that gross revenue from corn and soybean production gave a distributed lag land price response pattern very close to that of crop-share rents, but general conclusions about predictive performance could not be made.

The estimated intercept could not be used to compute the estimated capitalization rate of farmland, as the return variable used a gross rather than a net return measure of returns to farmland. Landlord costs imputed to farmland that are proportional to gross returns were confounded with the intercept term, and thus prevented the computation of an implicit capitalization rate.

Analysis was then broadened to include other surrounding cornbelt states of Ohio, Iowa, and Indiana. The regression results also proved to be encouraging for these three states. Estimated coefficients for the difference equation parameters for the three states were very close to the Illinois analysis (using either gross revenue or crop-share rents). The only difference was that an AR(1) error structure on the estimated equations for both Indiana and Ohio came out statistically significant. Regression results for the four states proved to be consistent, with estimated coefficients for each variable (including intercept) not varying much across the states. Regression results also indicated that the homogeneity constraint was violated as the computed long-run elasticities were considerably greater than one.

Distributed lag response paths of land price to rents between Burt's estimated model using crop-share rents and final estimated models using gross revenues were then compared. The comparison indicated somewhat similar distributed lag response paths. Computed cumulative long-run distributed lag response (long-run response elasticities) for models estimated using gross revenues were all greater than one, suggesting that the estimated equations for farmland price using the gross revenue measure would only be useful for conditional short-term forecasting of land prices.

Finally, a set of post-sample forecasts were done for these final estimated farmland price equations. Results basically indicated that the estimated equations would forecast farmland prices better within a short-term time framework as was alluded to in the previous paragraph.

The results of this study indicate that in homogeneous agricultural areas, gross revenues from production (if properly computed) came close to approximating a good measure of returns to land. Analysis with the gross revenue measure seemed to have verified Burt's second order difference equation (with complex roots) land price model.

If a gross measure of revenue produced near similar regression results as when crop-share rents (a net measure) were used, it would not be unrealistic to expect that a net measure of revenues imputed to farmland will improve the fit produced by use of the gross measure.

Further research on farmland prices would either encompass finding a way to subtract costs imputed to farmland from gross revenues or to explore new alternative measures of returns to farmland that is a net measure.

It seems that we may be back to the old problem of finding a proper way to impute a net return to farmland.

But the need for a good set of farm accounts data for deriving a net return measure seems to be more pressing.

REFERENCES CITED

Alston, Julian M. "An Analysis of Growth of U.S. Farmland Prices: 1963-1982." American Journal of Agricultural Economics 68 (1986):1-9.

Barry, Peter J. "Capital Asset Pricing and Farm Real Estate." American Journal of Agricultural Economics 62 (1980):547-543.

Burt, Oscar P. "Econometric Modeling of the Capitalization Formula for Farmland Prices." American Journal of Agricultural Economics 68 (1986):10-25.

Burt, Oscar. "Estimation of Distributed Lags as Nonstochastic Difference Equations." Staff Paper No. 80-1, Department of Agricultural Economics and Economics, Montana State University, Bozeman, Montana, 1980.

Burt, Oscar, S. Townsend, and J. T. LaFrance. "Instruction Manual for DYNEREG: a Nonlinear Least Squares Algorithm for Distributed Lag Models and/or Regression Models with Time Series Error Terms." Staff Paper No. 86-4, Department of Agricultural Economics and Economics, Montana State University, Bozeman, Montana, August, 1986.

Castle, Emery N. and Irving Hoch. "Farm Real Estate Price Components, 1920-1978." American Journal of Agricultural Economics 64 (1982):8-18.

Darby, Michael R. "The U.S. Productivity Slowdown: A Case of Statistical Myopia." American Economic Review 74 (1984):301-322.

Doll, John P. and Richard Widdows. "Capital Gains Versus Current Income in the Farming Sector: Comment." American Journal of Agricultural Economics 63 (1981):729-733.

Doll, John P., Richard Widdows, and Paul D. Velde. "Research REview. The Value of Agricultural Land in the United States: A Report on Research." Agricultural Economics Research 35 (1983):39-44.

Ezekiel, Mordecai. "The Cobweb Theorem." Quarterly Journal of Economics (1938):255-280.

Feldstein, Martin. "Inflation, Portfolio Choice, and the Prices of Land and Corporate Stock." American Journal of Agricultural Economics 62 (1980):910-916.

Fisher, Irving. The Theory of Interest: As Determined by Impatience to Spend Income and Opportunity to Invest It. (reprint) New York: A. M. Kelley, 1967.

Harvey, A. C. The Econometric Analysis of Time Series. New York: John Wiley and Sons, 1981.

Herdt, Robert W., and Willard W. Cochrane. "Farmland Prices and Technological Advance." Journal of Farm Economics 48 (1966):243-263.

Hirshleifer, Jack. Price Theory and Applications. 3rd ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1984.

Hottel, J. B., and C. D. Evans. "Returns to Equity Capital in the U.S. Farm Production Sector." Balance Sheet of the Farming Sector, 1979 Supplement. Washington, D.C.: USDA ESCS Agr. Info. Bull. no. 430, 1979.

Jorgensen, Dale N. "Rational Distributed Lag Functions." Econometricia 32 (1966):135-148.

Kay, Donald. Farm Management: Planning, Control, and Implementation. New York: McGraw-Hill, Inc., 1981.

Klinefelter, Danny A. "Factors Affecting Farmland Values in Illinois." Illinois Agr. Econ. Res. 13 (1973):27-33.

Kmenta, Jan. Elements of Econometrics. New York: Macmillian Publishing Co., Inc., 1986.

Melichar, Emanuel. "Capital Gains versus Current Income in the Farming Sector." American Journal of Agricultural Economics 61 (1979):1085-1092.

Phipps, Tim T. "Land Prices and Farm-Based Returns." American Journal of Agricultural Economics 66 (1984):422-429.

Plaxico, James S. "Implications of Divergences in Sources of Resurns in Agriculture." American Journal of Agricultural Economics 68 (1979):1098-1102.

Pope, Rulon D., Randall A. Kramer, Richard D. Green, and B. Delworth Gardner. "An Evaluation of Econometric Models of U.S. Farmland Prices." Western Journal of Agricultural Economics 4 (1979):107-119.

Reinsel, Robert D. and Edward I. Reinsel. "The Economics of Asset Values and Current Income in Farming." American Journal of Agricultural Economics 61 (1979):1093-1097.

Reiss, Franklin J. "Landlord and Tenant Shares." University of Illinois Department of Agriculture AERR no. 102, 1969.

Reynolds, John E. and John F. Timmons. "Factors Affecting Farmland Values in the United States." Iowa Agr. Exp. Sta. Res. Bull. No. 566, 1969.

Robison, Lindon J., and John R. Brake. "Inflation, Cash Flows, and Growth: Some Implications for the Farm Firm." Southern Journal of Agricultural Economics (1980):131-137.

Sargent, Thomas J. "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment." Brookings Paper on Economic Activity (1973):429-480.

Scott, John T., Jr. "Factors Affecting Land Price Decline." American Journal of Agricultural Economics 65 (1983):796-800.

Shalit, Haim, and Andrew Schmitz. "Farmland Accumulation and Prices." American Journal of Agricultural Economics 64 (1982):710-719.

Tanzi, Vito. "Inflationary Expectations, Economic Activity, Taxes and Interest Rates." American Economic Review 70 (1980):12-21.

Theil, Henri. Principles of Econometrics. New York: John Wiley and Sons, 1971.

Tweeten, L. G., and J. E. Martin. "A Methodology for Predicting U.S. Farm Real Estate Price Variation." Journal of Farm Economics 48 (1966):378-393.

U.S. Congress, Joint Economic Committee. Economic Reports of the President. Washington: U.S. Government Printing Office (various issues).

U.S. Department of Agriculture. Agricultural Statistics. Washington: U.S. Government Printing Office (various issues).

.S. Department of Agriculture, Crop Reporting Board (Statistical Reporting Service). Crop Production (Annual Summary): Acreage, Yield, Production. Washington: U.S. Government Printing Office (various issues).

________. Crop Values: Season Average Prices Received by Farmers and Value of Production. Washington: U.S. Government Printing Office (various issues).

________. Field Crops: Production, Disposition, Value. Washington: U.S. Government Printing Office (various issues).

.S. Department of Agriculture, Economic Research Service. Economic Indicators of the Farm Sector: National Financial Summary, 1984. Washington: U.S. Government Printing Office, 1985.

________. Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1984. Washington: U.S. Government Printing Office, 1985.

________. Farm Real Estate Market Development: Outlook and Situation. Washington: U.S. Government Printing Office (various issues).

________. Farm Real Estate Taxes. Washington: U.S. Government Printing Office (various issues).

ıtts, Myles, and James Johnson. The Relationship of Inflation and Agricultural Income, Asset Values, and Firm Financial Analysis." Staff Paper 85-6, Department of Agricultural Economics and Economics, Montana State University, Bozeman, Montana, 1985.

APPENDIX

Original Data Set

Table 16: Sample data used for exploring USDA accounting data measure

Year	Deflator (PCEI)	Deflator (PCEI)	Ret. to Tot. Agr. Assets (million$)	Agr. Asset Value (million$)
1940	.141	.152	1733	42900
1941	.152	.168	3262	49600
1942	.168	.184	5428	59100
1943	.184	.194	5701	67800
1944	.194	.202	3989	74900
1945	.202	.220	4248	81800
1946	.220	.243	6831	91700
1947	.243	.257	7450	100800
1948	.257	.256	9493	106400
1949	.256	.262	5494	105800
1950	.262	.278	7133	122400
1951	.278	.284	8423	136000
1952	.284	.290	7378	133800
1953	.290	.291	5380	130400
1954	.291	.295	5325	134100
1955	.295	.301	4519	137800
1956	.301	.310	4763	146300
1957	.310	.316	5273	154400
1958	.316	.323	7625	170200
1959	.323	.329	5114	172900
1960	.329	.333	6249	174700
1961	.333	.339	7577	182600
1962	.339	.344	8210	190300
1963	.344	.350	8307	197900
1964	.350	.356	7504	205500
1965	.356	.367	10922	221400
1966	.367	.376	12291	234100
1967	.376	.393	10320	246100
1968	.393	.410	10443	259300
1969	.410	.429	12472	270500
1970	.429	.449	12834	280200
1971	.449	.467	13315	303100
1972	.467	.496	19136	341400
1973	.496	.548	36259	418900
1974	.548	.592	28631	442300
1975	.592	.626	27511	510100
1976	.626	.667	22472	590400
1977	.667	.716	22401	656700
1978	.716	.782	31834	783700
1979	.782	.866	38733	918100
1980	.866	.946	28979	1003200
1981	.946	1.000	39869	1005200
1982	1.000	1.039	37352	977800
1983	1.039	1.082	27576	956500

Table 16: Continued

Year	Agr. Real Estate Value (million$)	Land in Farms (million ac.)	Index of Land Values
1940	28900	1077	.0750
1941	31700	1093	.0750
1942	35200	1109	.0821
1943	41000	1125	.0893
1944	45900	1142	.1000
1945	52100	1145	.1107
1946	58400	1148	.1250
1947	62600	1152	.1392
1948	65100	1155	.1535
1949	65500	1202	.1571
1950	75900	1203	.1535
1951	83600	1204	.1749
1952	85100	1205	.1964
1953	84100	1206	.1964
1954	87500	1201	.1892
1955	92400	1197	.2035
1956	99900	1191	.2035
1957	105600	1184	.2178
1958	114200	1181	.2321
1959	120100	1174	.2535
1960	121800	1166	.2428
1961	127500	1157	.2642
1962	133000	1149	.2785
1963	140900	1144	.2749
1964	149300	1137	.2927
1965	160000	1130	.3070
1966	169100	1121	.3356
1967	179000	1113	.3570
1968	187900	1106	.3820
1969	194200	1102	.4034
1970	201300	1096	.4200
1971	216400	1092	.4300
1972	241800	1087	.5355
1973	297100	1084	.5300
1974	327000	1059	.6600
1975	381100	1054	.7500
1976	453500	1047	.8600
1977	507700	1044	1.0000
1978	600700	1042	1.0900
1979	704200	1038	1.2500
1980	779200	1034	1.4500
1981	780200	1027	1.5800
1982	745600	1024	1.5700
1983	736100	1019	1.4600

Table 17: Sample data for Illinois used for exploring cash rent and gross revenue measures

Year	Land Price (Burt's) ($/acre)	Statewide Index of Land Val. ($/acre)	Real Estate Tax ($/acre)	Gross Rev. from corn & Soybeans ($/acre)	Direct Gov't Payments ($/acre)
1958	511	18.6	3.79	135.05	3.11
1959	551	20.1	3.91	123.28	1.31
1960	551	20.1	4.03	125.30	1.20
1961	535	19.5	4.16	149.57	7.74
1962	534	20.2	4.30	159.13	7.89
1963	580	21.2	4.44	167.84	7.23
1964	607	22.2	4.69	156.95	8.78
1965	646	23.7	4.83	186.63	8.85
1966	726	26.7	5.29	175.33	7.43
1967	767	28.3	5.69	180.43	5.81
1968	797	29.4	6.60	176.02	9.61
1969	833	30.8	7.03	195.37	11.89
1970	823	30.4	7.07	191.28	9.95
1971	825	30.5	7.83	217.51	10.27
1972	882	32.7	8.30	329.12	14.56
1973	981	36.6	8.82	455.88	7.48
1974	1296	49.0	9.10	406.42	.53
1975	1548	59.1	9.34	480.92	2.04
1976	1906	73.5	10.15	461.63	.51
1977	2555	100.0	10.96	447.83	1.61
1978	2807	110.4	11.75	470.14	5.04
1979	3162	125.1	12.61	580.90	1.60
1980	3411	135.5	13.02	564.85	1.73
1981	3605	143.6	14.08	557.55	2.39
1982	3303	131.0	13.73	575.35	5.72
1983	2966	117.0	13.55	491.77	33.06

Table 17: Continued

Year	Crop-share rent ($/acre)	Cash rent ($/acre)	Production expense ($/acre)	Gross Inc. from farm ex. dwell. ($/acre)	Index of pr pd by farmers ($/acre)
1958	17	20.04	122.90	165.53	.8700
1959	17	19.44	117.15	139.42	.9300
1960	21	20.53	107.58	138.02	.9200
1961	23	20.75	114.75	161.21	.9300
1962	26	20.64	121.27	171.50	.9400
1963	29	22.16	116.10	167.62	.9500
1964	27	22.87	111.73	162.02	.9400
1965	30	24.33	103.19	159.49	1.0000
1966	33	27.79	114.28	184.61	1.0000
1967	29	29.69	114.51	163.43	1.0000
1968	34	33.44	120.04	171.85	1.0000
1969	30	34.47	125.52	184.16	1.0400
1970	33	35.56	126.11	180.91	1.0800
1971	34	36.71	123.08	172.23	1.1300
1972	48	36.57	118.96	216.13	1.2100
1973	85	39.38	115.34	275.45	1.4600
1974	107	48.72	155.65	316.89	1.6600
1975	80	56.47	163.81	278.86	1.8200
1976	103	68.04	188.64	327.83	1.9352
1977	89	81.00	200.96	291.76	1.9950
1978	95	85.00	196.75	330.56	2.1546
1979	110	92.00	206.66	341.22	2.4938
1980	108	99.00	234.26	389.84	2.7531
1981	93	105.80	248.61	374.06	2.9526
1982	90	112.80	242.30	372.56	2.9925
1983	102	111.40	236.15	371.07	3.0524

Table 18: Sample data for Iowa

Year	Deflator	Inflation Rate Plus Unity	Gross Revenue ($/acre)	Statewide Index of Land Price ($/acre)	Real Estate Tax ($/acre)
1958	.692	1.0206	124.85	66	2.65
1959	.706	1.0202	117.12	71	2.86
1960	.719	1.0184	115.91	73	3.06
1961	.726	1.0097	146.52	69	3.23
1962	.737	1.0152	147.24	72	3.37
1963	.748	1.0149	159.18	73	3.54
1964	.759	1.0147	160.14	76	3.71
1965	.772	1.0171	160.52	79	3.80
1966	.794	1.0285	183.49	89	4.24
1967	.814	1.0252	158.13	100	4.17
1968	.846	1.0393	177.59	105	4.63
1969	.884	1.0449	186.66	111	5.53
1970	.925	1.0464	199.15	114	5.87
1971	.965	1.0432	205.86	114	5.89
1972	1.000	1.0363	362.04	122	5.61
1973	1.057	1.0570	468.16	141	5.55
1974	1.164	1.1012	415.68	189	5.67
1975	1.253	1.0765	398.06	234	6.40
1976	1.317	1.0511	405.10	294	7.57
1977	1.393	1.0577	381.30	397	8.02
1978	1.491	1.0704	502.28	413	8.39
1979	1.625	1.0899	538.72	475	8.96
1980	1.790	1.1015	637.05	553	9.85
1981	1.945	1.0866	541.27	597	10.32
1982	2.060	1.0591	545.34	553	8.63
1983	2.136	1.0369	541.82	481	8.84

Table 19: Sample data for Indiana

Year	Deflator	Inflation Rate Plus Unity	Gross Revenue ($/acre)	Statewide Index of Land Price ($/acre)	Real Estate Tax ($/acre)
1958	.692	1.0206	126.73	64	2.09
1959	.706	1.0202	117.25	67	2.33
1960	.719	1.0184	124.28	69	2.42
1961	.726	1.0097	138.48	66	2.48
1962	.737	1.0152	151.34	68	3.01
1963	.748	1.0149	162.11	71	3.06
1964	.759	1.0147	142.68	76	3.20
1965	.772	1.0171	174.72	80	3.41
1966	.794	1.0285	167.96	92	3.75
1967	.814	1.0252	141.94	100	4.17
1968	.846	1.0393	166.05	106	4.51
1969	.884	1.0449	184.83	106	4.97
1970	.925	1.0464	191.71	104	5.43
1971	.965	1.0432	200.02	109	5.93
1972	1.000	1.0363	287.61	113	5.90
1973	1.057	1.0570	436.20	131	6.06
1974	1.164	1.1012	391.38	161	5.01
1975	1.253	1.0765	409.87	200	5.03
1976	1.317	1.0511	458.80	244	5.09
1977	1.393	1.0577	407.77	321	5.17
1978	1.491	1.0704	459.65	361	5.34
1979	1.625	1.0899	513.12	415	6.66
1980	1.790	1.1015	594.00	481	7.43
1981	1.945	1.0866	469.87	517	7.80
1982	2.060	1.0591	538.82	449	8.05
1983	2.136	1.0369	487.66	391	8.53

Table 20: Sample data for Ohio

Year	Deflator	Inflation Rate Plus Unity	Gross Revenue ($/acre)	Statewide Index of Land Price ($/acre)	Real Estate Tax ($/acre)
1958	.692	1.0206	127.96	69	1.92
1959	.706	1.0202	117.85	72	2.05
1960	.719	1.0184	119.37	73	2.21
1961	.726	1.0097	139.22	72	2.32
1962	.737	1.0152	138.05	75	2.44
1963	.748	1.0149	143.93	77	2.58
1964	.759	1.0147	132.65	83	2.75
1965	.772	1.0171	150.03	86	2.91
1966	.794	1.0285	184.50	93	2.98
1967	.814	1.0252	134.47	100	3.08
1968	.846	1.0393	163.08	106	3.32
1969	.884	1.0449	168.74	110	3.68
1970	.925	1.0464	188.38	115	4.31
1971	.965	1.0432	190.40	120	4.10
1972	1.000	1.0363	258.92	127	4.68
1973	1.057	1.0570	348.94	147	4.96
1974	1.164	1.1012	388.71	184	5.42
1975	1.253	1.0765	397.50	208	5.79
1976	1.317	1.0511	446.97	252	6.49
1977	1.393	1.0577	417.66	331	7.31
1978	1.491	1.0704	459.81	373	7.78
1979	1.625	1.0899	524.87	448	8.27
1980	1.790	1.1015	648.30	513	8.35
1981	1.945	1.0866	414.21	526	8.33
1982	2.060	1.0591	514.17	450	8.35
1983	2.136	1.0369	515.52	398	8.51