THEORY AND MEASUREMENT OF DETERMINANTS OF FARMLAND PRICE AND THE RATIO OF RENT TO FARMLAND PRICE

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INTRODUCTION

Overview

Farmland is a durable asset which tends to be a residual claimant on farm income. Changes in land values resulted in major real wealth gains to owners in the 1970s and wealth losses in the 1980s.

Land is one of the most important factors in agriculture. Land is not only a primary input in agriculture but also is collateral to secure loans for many farmers. Such loans may be utilized for investment or operating funds. Thus land indirectly is a source of capital and funding for production inputs. The amount of loan which can be obtained from financial institutions usually depends on the value of the farmland. Since the early 1930s the nominal land value has trended upward until recently when its value in some regions either declined or stabilized. This phenomenon is puzzling many economists and the people who are involved in the farming business.

The USDA publication "Economic Indicators of the Farm Sector" shows that real estate comprises the largest share of farm assets for most regions (USDA, 1984). Nationally, U.S. farm real estate, valued at $818.9 billion, comprised three-fourths of the value of total farm assets in 1983 (USDA, 1983). The data also indicate that real estate debts from 1979 to 1983 increased for most states. Declining real estate values in the 1980s imply capital losses as opposed to capital gains from real estate in previous decades. The lender hesitates to extend credit because of shortfalls in loan security. The situation creates problems for many farmers expecting to use their real estate as collateral for operating funds. In this and other ways farm real estate value causes financial hardship for many farmers.

Land tends to be the most durable and immobile of farm resources. Its basic properties either do not change over time or change so slowly that land is considered to have an infinite life. Land is so fixed to agriculture that its value over much of the nation is determined endogenously by its earning power in producing crops and livestock. This is unlike other inputs whose value is determined mostly by industries outside of agriculture. However, it has been suspected that anticipated capital gains from holding farmland, farm programs, population pressure and some other factors outside the agricultural sector caused the increases in farmland price in the 1970s. Recently, the direction of farmland price has changed as shown in Table I. The value of farmland started to decline in 1982, especially for the Lake States, Corn Belt, and Southeast. For many other regions and states, farmland value started to decline in 1983. In the Northeast and Southern Plains, farmland value for most states did not decrease. Nevertheless, the overall acreage of farmland values for 48 states started to decline in 1982. Farmland value averaged $795 per acre in 1981, but decreased to $739 per acre in 1984. A major purpose of this research will be to estimate the contribution of factors to the change in farmland value and rent in the U.S.

TABLE I

FARM REAL ESTATE VALUE: AVERAGE VALUE PER ACRE OF LAND AND BUILDINGS BY STATE, GROUPED BY FARM PRODUCTION REGION

State	1976	1977	1978	1979	1980	1981	1982	1983	1984
					Dollars				
Northeast									
Maine	375	414	464	538	579	612	636	649	691
New Hampshire	625	696	787	919	988	1,045	1,087	1,109	1,181
Vermont	496	533	584	660	710	751	781	797	849
Massachusetts	1,044	1,138	1,261	1,443	1,552	1,641	1,707	1,741	1,854
Rhode Island	1,650	1,821	2,045	2,370	2,548	2,696	2,804	2,860	3,046
Connecticut	1,645	1,780	1,960	2,227	2,395	2,533	2,634	2,687	2,862
New York	553	587	600	670	708	749	786	770	793
New Jersey	2,106	2,211	2,386	2,701	2,926	2,998	3,118	3,056	3,148
Pennsylvania	820	994	1,115	1,273	1,404	1,447	1,332	1,279	1,381
Delaware	1,114	1,250	1,350	1,500	1,755	1,843	1,659	1,659	1,692
Maryland	1,280	1,353	1,579	1,800	2,251	2,556	2,416	2,174	2,239
Lake States									
Michigan	609	778	877	975	1,082	1,232	1,192	1,109	1,109
Wisconsin	496	598	718	856	980	1,105	1,073	1,019	958
Minnesota	529	672	761	901	1,061	1,231	1,197	1,065	990
Corn Belt									
Ohio	846	1,099	1,224	1,483	1,678	1,727	1,474	1,297	1,245
Indiana	888	1,188	1,357	1,589	1,833	1,972	1,715	1,492	1,477
Illinois	1,062	1,458	1,625	1,858	2,013	2,133	1,940	1,727	1,692
Iowa	920	1,259	1,331	1,550	1,811	1,941	1,802	1,568	1,396
Missouri	456	548	641	726	878	941	872	759	759
Northern Plains									
North Dakota	236	274	300	347	399	423	436	414	414
South Dakota	163	194	227	256	273	290	291	271	263
Nebraska	363	420	412	525	600	660	626	563	495
Kansas	342	398	418	501	573	590	585	544	528
Appalachian									
Virginia	633	701	774	930	1,009	1,080	1,040	1,050	1,040
West Virginia	393	430	459	592	704	751	829	829	804
North Carolina	676	759	830	1,051	1,215	1,331	1,284	1,297	1,362
Kentucky	514	619	715	861	955	991	996	966	927
Tennessee	528	618	736	860	953	1,024	972	923	951
Southeast									
South Carolina	515	600	653	773	879	930	918	863	846
Georgia	507	581	685	777	868	915	842	817	801
Florida	763	861	981	1,149	1,352	1,507	1,432	1,461	1,490
Alabama	425	477	527	639	792	935	922	876	858
Delta States									
Mississippi	408	461	567	681	825	1,047	1,000	920	966
Arkansas	475	542	606	770	921	1,061	1,104	983	944
Louisiana	575	665	818	1,001	1,288	1,519	1,511	1,481	1,481
Southern Plains									
Oklahoma	345	394	450	512	604	662	696	661	661
Texas	274	299	337	386	448	492	576	593	646
Mountain States									
Montana	134	157	176	196	229	239	254	236	241
Idaho	386	454	515	585	669	717	753	700	700
Wyoming	98	110	121	144	153	164	170	162	165
Colorado	219	256	273	322	376	412	419	411	423
New Mexico	86	101	112	143	190	203	211	200	204
Arizona	122	138	154	199	264	282	294	279	285
Utah	227	271	308	400	530	567	590	561	572
Nevada	98	112	140	191	253	271	282	268	273
Pacific States									
Washington	438	535	602	692	725	854	888	888	915
Oregon	294	342	414	504	556	605	611	580	574
California	711	759	914	1,186	1,426	1,735	1,905	1,925	1,925
48 States	397	474	531	628	725	795	789	743	739

[1]These values are based on land-value benchmarks obtained from the Census of Agriculture. For intercensal years, interpolations and extrapolations are made using the indexes in table 1. For some years, the dollar values show changes that differ from the changes shown in table 1

Source: U.S. Department of Agriculture, 1984a.

Study Objectives

Many econometric studies have analyzed sources of farm land price changes in the past. Most models, however, did not show whether systematic regional and state differences were apparent in determining land value models.

The specific objectives of this study are:

1. To examine the factors that influence farmland value and the ratio of rent to farmland price.
2. To use econometric models to evaluate elements which affect farmland value and ratio of rent to farmland price in each state.
3. To test whether or not models developed in (2) have the same structure across states.
4. To test the structural stability of models in (2) over time.
5. To examine the impact of expected inflation on the structure of the model developed in (2).

Hypotheses

Hypotheses to be tested include:

1. Farmland price at the state level is determined by factors both inside and outside the agricultural sector.
2. No differences exist among states in the economic structure determining farmland models.
3. The economic determinants of farmland price do not vary over time.
4. Changes in anticipated inflation have no impact on farmland models.

Overview of Research Procedure

To investigate sources or factors which influence farmland value for each state in the U.S., an econometric model is useful to express farmland price structure. To estimate coefficients for the studied model, time series data from 1950 to 1982 will be used. Variables to be included in the model will be selected based on theory and previous empirical studies. The ordinary least squares procedure is used to estimate coefficients in the models.

The test for structural stability will be performed across states and time periods by segmenting data and by introducing dummy variables into the model.

Outline of Thesis

The remainder of this study is divided into five chapters. The conceptual framework and literature review will be presented in Chapter II. The statistical tests procedure to be used in this study will also be illustrated in this chapter. Data will be defined and their sources identified in Chapter III. In Chapter IV, the econometric models for each state will be estimated by using the relationships in Chapter II and the data in Chapter III. The structural test for parameter changes across time periods and states will be performed in Chapter V. The hypothesis that inflation has no real impact on farmland price will also be tested in this chapter. Finally, Chapter VI will contain the summary and conclusion of the study as well as recommendations for further study.

CHAPTER II

CONCEPTUAL FRAMEWORK AND METHODOLOGY

The purpose of this chapter is to present the conceptual framework used in this study. The important variables included in the model will be presented as well as the justification behind their inclusion. The hypothetical impact of independent variables on the dependent variable will be stated. In addition the econometric model for this study will be specified for use in later chapters.

Review of Past Econometric Models Explaining Farmland Value

Many studies have analyzed farmland value at both the regional and national level. Research on this topic peaked during the 1960s (Brake and Melichar, 1977). The large recent capital losses and financial stress caused by falling farmland value have prompted reexamination of causal economic forces.

Most econometric models developed to determine farmland value either utilized multi-equation or single-equation models. Three well known econometric models used simultaneous equations to explain the U.S. farm real estate market. These models were presented by Tweeten and Nelson (1966; see also Tweeten and Martin, 1966), Herdt and Cochrane (1966), and Reynolds and Timmons (1969). Because of the complexity of the multiple equation models, those models will be presented below in some detail.

The first model was developed by Tweeten and Nelson in 1966. This model utilized multi-equations to predict U.S. farm real estate price variation. The model was composed of 5 equations and was estimated empirically by recursive and ordinary least squares. The period under study was 1923 to 1963. The relationship of the variables is summarized as follows:

$$P = f(L_t, A_t, T_t; F_{t-1}, r_{t-1}, P_{t-1})$$

$$L = f(C_t, F_{t-1}, Lr_t, E_t, L_{t-1})$$

$$C = f(F_{t-1}, Lr_t, T2, C_{t-1})$$

$$A = f(JX_{t-1}, Cg_{t-1}, S_t, T2, A_{t-1})$$

$$T = f(JX_{t-1}, Cg_{t-1}, S_t, T2, T_{t-1})$$

where

A = number of farms;

C = cropland used for crops;

Cg = capital gains on farm real estate;

E = employment, national nonfarm;

F = net farm income;

JX = ratio of average earning per employed factory workers to the average income per farm worker;

Lr = land removed from production by government programs;

L = land in farms;

P = price index of U.S. farm real estate per acre;

r = rate of return;

S = stock of machinery;

T = transfers of farm real estate; and

T2 = dummy variable equal to 1 from 1942 to 1948 and to 0 otherwise.

Results from the above model indicate that the major source of increase in farmland price were capital gains and farm consolidation for agricultural factors and nonfarm employment for nonfarm factors. Pope, Kramer, Green, and Gardner (1977) updated the model by using more recent data (1946-1972). The results, however, showed a number of sign changes and lack of statistical significance for the reestimated coefficients. These contradictory or inconsistent results suggest that there were changes in variables or structure influencing farm real estate between these two periods.

The second multi-equation model was developed by Herdt and Cochrane (1966) to determine the impact of technology on farmland prices. The demand and supply model was as follows:

$$Ns = f(P, R, U, Lf) \qquad \text{(supply)}$$

$$Nd = f(P, R, T, Pr/Pp, Lu, G) \qquad \text{(demand)}$$

$$Nd = Ns \qquad \text{(market clearing relation)}$$

where Ns, Nd, and P were endogenously determined by the model. The variables were identified as follows:

Ns = number of farms supplied,

Nd = number of farms demanded,

P = price of farmland,

R = interest rate,

U = unemployment as a percentage of civilian labor force,

Lf = land in farms,

T = USDA productivity index

Pr/Pp = ratio of the index of prices received by farmers to the index of prices paid by farmers,

L_u = urban land, and

G = general price level (wholesale price index).

Their research indicated that the expectation of rising income from technological advance in conjunction with farm price supports was important in explaining the rise in farmland prices. They also concluded that technological advance benefited not the farm operator but the farm land owner.

The Herdt and Cochrane model was reestimated using more recent data (1946-1972 compared to 1913-1962) by Pope et al. (1977). This model also did not perform well when estimated with more recent data. Nevertheless, sign reversals were fewer in number than in the previous model.

In a third model, Reynolds and Timmons (1969) used a two-equation recursive system to identify the main determinants of farmland prices in the U.S. from 1933 to 1965. They used both the concept of delayed decision making as did Tweeten and Nelson, and the concept of market equilibrium as did Herdt and Cochrane. The two equations follow:

T = f(Du, D/E, La, E(F/NF), A, Cg, Cg(1933-1941)) (transfer equation)

P = f(T, GPL, CP, CG, CG(33-41), A, 1/r, NFI(1956-1965)) (price equation)

where

Du = dummy for intercept variable during 1942-1947,

D/E = ratio of debt to equity,

La = proxy measure of technology,

E(F/NF) = expected ratio of farm to nonfarm earnings,

A = changes in average size of farm,

Cg = expected capital gains,

P = farmland price,

T = predicted voluntary transfers of farmland,

GPL = government payment for land diversion,

CP = conservation payment,

r = rate of return on common stock, and

NFI = expected net farm income.

Based on the results of their model, they concluded that farmland value in the U.S. was affected by a number of variables. A positive effect was exerted by expected net farm income, government payments for land diversion, conservation payments, expected capital gains, farm enlargement, nonfarm population density, technological advance, and the ratio of debt to equity. On the other hand, a negative effect was exerted by voluntary transfers of farmland, capitalization rate, and expected ratio of farm to nonfarm earnings. This model also was updated by Pope et al. (1979) using data from 1946-1972. The results showed a number of changes in the signs and magnitudes of the coefficients.

For the single-equation models, at least four studies attempted to identify the factors that impact on farmland value at the national level. Reinsel (1973), for example, used M2 money supply and population to predict the 1971 and 1972 national average value per acre. He did not incorporate local structural factors that affect land prices at the subnational level.

In 1979, Duncan estimated the structural parameters for U.S. farmland values for 1929-1975 and for 1937-1975. He found that increases in land value more than kept pace with changes in general price level. Furthermore, the analysis of real changes in farm real estate values indicated farm enlargement pressure, farm income, and capital gains expectations continued to be the most important determinants of land prices.

Pope et al. (1979) used single equations to estimate U.S. farmland value in a model that was a modification of an earlier model by Klinefelter (1973). The purpose of their study, however, was to compare the forecasting accuracy of a single-equation ordinary least squares model to that of the multiple-equation model. Their results showed that single equations provided as good or better short-term forecasts than multiple equations.

Martin and Heady (1982) used a single equation model to test Feldstein's hypothesis that changes in the expected rate of inflation should affect the real value of farmland. Based on their models, they found no strong evidence to support the hypothesis. Inflationary expectations did not appear to have direct impact on the value of U.S. farm real estate. However, they noted that the above hypothesis could be correct, but undetected by their model which assumed that expectations of inflation are formed adaptively.

A number of studies analyzed determinants of farmland value at the regional level. A few will be discussed here. Klinefelter (1973) applied a single-equation model to explain the value of farmland and improvements for Illinois between 1951-1970. He concluded that 97 percent of the variation in land prices could be explained by net returns, average farm size, number of farm transfers, and expected capital gains. This model was updated by Kraft and Belbase (1983) to test for structural stability in the model during the 1970s. Sandrey, Arthur, Oliveira, and Wilson (1982) used a data base similar to that used by Klinefelter. However, pooled county data were used instead of aggregate state data to estimate farmland values in Oregon from 1954 to 1978. They found that income, average farm size, and percentage of farmland under irrigation had a significant effect on farmland value for the entire state during the study period.

Chavas and Shumway (1982) analyzed farmland prices in Iowa by using pooled time-series and cross-section data. In contrast to the previous models, their model included price and yield of agricultural products such as corn, soybean, and hogs (price only) and an explicit measure of soil and climatic quality (called a "corn suitability rating") in the model along with the consumer price index. They concluded that changes in commodities' prices as well as differences in the "corn suitability rating" explained farmland price in the study region. Clifton and Spurlock (1983) aggregated county data to form homogeneous markets throughout the Southeastern U.S. The markets were segmented by grouping counties with common characteristics. The single equation model of farmland values for each submarket was estimated for the period 1971-1979. Their results supported the hypothesis that a number of independently functioning land markets existed within the Southeastern region. Vollink (1978) conducted a study in North Carolina using agricultural conditions to divide the state into four homogeneous regions. The model for each region was estimated. Carriker, Curtis, and Johnson (1984) used cross-sectional data to estimate the value of farmland for each crop reporting district in Nebraska between 1978-1982. The ordinary least squares technique was employed to estimate coefficients. The majority of the models indicated that a structural change had occurred over the 1978-1982 period.

Burton and Nelson (1982), using specific tract information acquired from legal records (1976 to 1978), estimated three individual county models of farmland prices in eastern Oklahoma. They concluded that rural real estate values were particularly influenced by date of sale, size of tract, value of improvements per acre, distance to nearest county seat and definitions of agricultural and nonagricultural real estate. Warmann (1984) evaluated factors which influenced the value of farmland in western Oklahoma by using stepwise regression. He utilized two types of data: (1) base data -- size of tract, productivity, time, distance to nearest town and city, population of nearest town and (2) supplemental data -- land characteristics such as value of improvements, proportion of tract in cropland and pasture, county assessed value per square mile, and miles of gravel road per 100 square miles. He concluded that soil productivity information is important in explaining land price variability. Land cover (type of vegetation) factors were not shown to be useful in explaining the variation in per acre farmland prices when combined with soil productivity information.

It can be noted that the majority of previous analyses of farmland value utilized single-equation models rather than multi-equation models. The reason is that single-equation models give both estimation simplicity and forecasting reliability. As indicated by Pope et al. (1979), multi-equation models, although using more complicated techniques to estimate coefficients, gave forecasting results less satisfactory than the single-equation models. Taking this into account, a single-equation econometric model is chosen for this study. In the next section, the conceptual framework will be developed. Variables which may influence farmland value will be discussed later in this chapter.

Conceptual Framework

This section will explore the conceptual framework for the land valuation model. The possible impact for each of several variables on farmland value will be cited as a guideline for testing each hypothesis.

Classical Approach to Determine Farmland Value

Theoretically, the market value of a farmland equals the present worth of all future earnings. Future land earnings may be expected to increase at rate i + i' where i is the inflation rate and i' is the real growth rate. The value of i' may be positive, zero, or negative depending on whether land earnings increase in excess of national inflation rate, equal to the national inflation rate, or less than national inflation rate. The formula for land value can be expressed as:

$$V_0 = \int_{t=0}^{t=\infty} \frac{R_0 e^{(i + i')t}}{e^{kt}} dt \qquad (1)$$

$$= \int_{t=0}^{t=\infty} R_0 e^{-(r - i')t} dt$$

$$V_0 = R_0/(r - i') \qquad (2)$$

where

R_0 = earnings in the current period,

k = $r + i$ or nominal discount factor,

r = anticipated or desired real discount factor,

i' = anticipated real growth of R,

i = anticipated inflation rate.

This formula shows that current land value depends on current land earnings, anticipated real discount factor, and anticipated real growth of land earnings.

Where the return on land is expected to increase at the inflation rate or ($i' = 0$), the present value formula in (1) can be expressed as:

$$V_0 = \int_{t=0}^{t=\infty} \frac{R_0 e^{it}}{e^{kt}} dt$$

$$V_0 = R_0/r. \qquad (3)$$

Land value in this scenario depends on only current earnings and the anticipated real discount factor. If it is anticipated that land earnings will not keep up with inflation so that $R_0 = R_1 = \ldots R_n$, then the land value relationship in (1) can be expressed as:

$$V_0 = R_0/(r + i). \qquad (4)$$

This last case is where land earnings behave like a bond by paying a constant nominal return (expected rate of increase in nominal land earnings = 0).

To illustrate various situations regarding the theory of land pricing in a well-functioning land market, assume that r is .05 or 5%, the inflation rate i = .06 or 6%, and current land earnings is

TABLE II

THEORETICAL IMPACT OF VARIOUS VALUES OF i' ON LAND PRICE

Expected rate of increases in:		Land Value
Nominal Earnings (i + i')	Real Earnings (i')	($/acre)
(Percent)		
8	2	3,333
6	0	2,000
0	-6	909

\$100/acre. The results for each equation are summarized in Table II. This example shows that even if the expected real discount factor r is the same for all participants in the market, the land value can vary widely as a result of differences in expected land earnings trends. At the aggregate level, the variable i' cannot be observed but based on a previous theoretical framework it can be derived from anticipated nominal rate of earnings adjusted by inflation rate. If both anticipated nominal rate of earnings and inflation rate in land market are formed by their past values, the impact of i' value on farmland price can be calculated. Note that expected inflation impacts land value through i' and r for all situations, hence in theory expected inflation per se should not influence land value.

Another essential parameter for this concept is the anticipated or desired real discount factor r. However, at the aggregate level the value r cannot be observed directly. The value differs among participants in the market. It is determined in the long run by the discount rate on future versus present consumption by the marginal efficiency of capital and by the marginal utility of income factors which change slowly over time. The market rate is the result of a bidding process between farmland buyers and sellers. The discount rate may be influenced by the opportunity cost of investment and the cost of obtaining funds for investment. Thus r is assumed to be influenced by the real rate of return on common stock (CGD), real average interest on farm loans (RIRG), real rate of return on long-term government bonds (RG2), proportion of loans made by Federal Land Banks (F) to total debts, and proportion of loans made by the Farmers Home Administration (FHA). The variables F and FHA impact the discount rate through low interest rate loans and other concessional credit terms.

A theoretical framework derived previously suggests that the value of farmland depends on parameters R, r, and i' in all cases. The farmland value, therefore, can be written as a reduced form function of variables which influence these parameters:

$$V = f(R, i', CGD, RIRG, RG2, F, FHA) \qquad (5)$$

where variables in the model are previously defined. Other factors such as expected capital gains, expected inflation, urbanization, and income tax system may influence farmland price according to past studies (Reynold and Timmons, 1969; Duncan, 1979; Klinefelter, 1973). To introduce these factors in a farmland model, it is necessary to modify the capitalization formula in equation (1). As shown by equation (2), under strict assumptions farmland price is related to rent by a constant. It follows that if farmland rent is increasing at a rate i + i', then land price nominal capital gain rate i and real capital gain rate i' are driven by land earnings. If investors expect capital gains in excess of rate i + i' normal for a well functioning market, then such speculative capital gain may drive land price irrespective of land earnings. Assume that farmland price is determined by the summation of present value of land earnings and speculative capital gains. In other words, participants in farmland market consider both earnings and speculative windfall gains from price increases as factors to make their investment decision. The farmland price in equation (1) can be rewritten as:

$$V_0 = \int_{t=0}^{t=\infty} \frac{R_0 e^{(i + i')t}}{e^{kt}} dt + \int_{t=0}^{t=\infty} \frac{G_0 e^{(i + j)t}}{e^{kt}} dt \quad (6)$$

where j is the expected rate of increases in speculative capital gains, G_0 is current period speculative capital gains and other variables are as defined earlier.

Speculative capital gains are not easily measured. To differentiate between increases in land prices caused by land earnings and by speculative capital gains, the expected relationship between land earnings and price needs to be identified. If expected land earnings at period t (Rt) is $R_0e^{(i + i')t}$, and given land earnings and price are proportional as apparent in equation (2), then the price of land at period t (Pt*) increases at a rate i + i' as shown below,

$$Pt^* = P_0e^{(i + i')t}$$

where Pt* = expected price due to increases in land earning at period t. If land value increases as a rate in excess of i + i', because of a speculative element in land price determination, then speculative capital gains (SG) can be approximated by using Pt - Pt* where Pt is an observed price at period t. Therefore, equation (6) can be solved and written as:

$$V_0 = \{R_0/(r - i')\} + \{G_0/(r - j)\} \quad (7)$$

where j is considered to be the expectation of the real rate of increase in speculative capital gains in farmland market. This parameter needs to be measured after adjusting for expected increases in land demand due to population pressure (urbanization) and other factors, some of which interact with the parameters in (7).

One interaction factor is the income tax rate. Higher tax rates on ordinary income will enhance the value of farmland if it is perceived to be a source of capital gain taxed at lower rates than ordinary income. The effect of income tax rate on farmland price through capital gains was shown in Tweeten (1981). Assume real rate of return on farmland and bonds (r) are the same. Let the marginal tax rate on current earnings be T and capital gains be taxed at .4T. Let land earnings increase at the inflation rate. The tax on income from land T_L can be differentiated into two parts; current land earnings and capital gains. The total tax is,

$$T_{Lt} = TR_t\{1 + 0.4(i/r)\}.$$

Therefore, the tax rate (r_{Lt}) is T_{Lt}/P_{Lt}, where $r_{Lt} = T(r + .4i)$ and $R_t/P_{Lt} = r$. The tax rate on a bond (r_{Bt}), however, is T_{Bt}/P_{Bt} which is equal to $T(r + i)$. This example shows that the tax rate on a bond is higher than on farmland by $r_{Bt} - r_{Lt} = n = 0.6Ti$, where 0.6 is 1.0 minus the marginal tax rate on current earnings (0.4). If capital gains are taxed at the same rate as earnings, the value of n will disappear. The excess tax rate on a bond is high when the marginal tax rate on current earnings and the inflation rate are high. A high excess tax rate on bonds makes land more attractive to investors, thus more land is demanded. Because T and i influence the excess tax rate on a bond, their interaction with the inflation rate should affect the value of farmland. Given that parameters SG, j, and r are part of equation (7), the reduced form of the farmland price relationship can be shown as:

$$V = g(R, i', CGD, RIRG, RG2, F, FHA, POP, XCIGD, CIGD, SG, T) \quad (8)$$

where

X = tax rate on highest income,

SG = speculative capital gains,

CIGD = expected inflation rate,

POP = population density,

T = time trend,

XCIGD = X * CIGD.

The time trend T is introduced to capture the impact of gradually changing factors such as changing preferences for income now versus later and for the intrinsic value investors place on farmland. In function (5) and (8) cash rent is used to represent land earnings. Cash rent can be expected to include benefits of farm commodity programs, economies of size and other variables affecting land earnings for agricultural uses. However, some past studies (Klinefelter, 1973; Sandrey et al., 1982; Pope et al., 1979; etc.) suggested that farm income is also an important factor to explain farm land price variation. Therefore, the study will use farm income as an alternative to farm earnings in selected equations explaining land price. Government payments are included in farm income. When net cash rent is replaced by net farm income, the relationship can be rewritten as,

$$V = f(RI, i', CGD, RIRG, RG2, F, FHA, POP, XCIGD, CIGD, SG, T) \qquad (9)$$

where RI = net farm income.

Modification of Land Price Model

In the previous sections, the land price model was developed by using price as a dependent variable. Alternatively, the cash rent to land price ratio will be used as the dependent variable.

The concept of using the rent-land price ratio to investigate land market is not new. For example, in 1924 Chamber used cross-sectional and inter-temporal comparison ratios of cash rent to farmland values to investigate land market behavior. Buechel (1924) also used the rent-value ratio in his article entitled "The Relation Between Rents and Agricultural Land Values in Theory and in Practice". The USDA also published this ratio for selected states in the Farm Real Estate Situation until the publication ceased in 1949 (Walker, 1979). However, this ratio has reappeared in recent publications. Walker (1979), using data for 13 north-central states, found that the average ratio of net rent to land value rose slightly from the 1921-1949 time period to the 1970s but the relationship had remained remarkably stable throughout 1921-1979. He found that the rate of return on farmland investment tended to be slightly higher in less populated states, suggesting that urban population contributed to higher land prices.

In 1982, Gertel, using cash rent to measure rate of return on farmland, concluded that cash rent on farmland had outperformed common stocks over the long term. Doll and Widdows (1982) calculated and compared the value of cash rents to land values for selected farming regions. They concluded that the combined returns from agricultural gross cash rents and real capital gains suggest that returns from real estate compared favorably to returns from other investments from 1960 to 1979.

The ratio of cash rent to land price will also be used in this study by modifying the farmland price model in the previous section. From equation (1), it was shown that V = R/(r - i'); this relationship can be rewritten as:

$$R/V = r - i'. \tag{10}$$

Given that the value of r and i' are influenced by the variables previously defined, the variable R/V can also be a function of those variables:

$$R/V = f(i', CGD, RIRG, RG2, F, FHA, POP, XCIGD, CIGD, SG, T). \tag{11}$$

Using the ratio of cash rent to land price as a dependent variable has an advantage over using price alone because it avoids the direction of causality problem that might occur between price and cash rent. Having cash rent on the left hand side of equation also reduces multicollinearity problems between rent and other independent variables such as expected future earnings. A disadvantage of this procedure is that it cannot directly be used to predict or explain farmland price variation.

Elaboration on Variables Influencing Farmland Values

As indicated earlier, numerous variables affect farmland values. These variables range from farm income to the growth rate of money supply. For quantitative analysis, it is useful to reduce the number of variables to be considered to a few of the more important. Ideally, variables involved must be consistent with economic theory and availability of data. Statistical relationships among the variables considered also constrain the data. For example, if explanatory variables are too closely related, it may be necessary in the statistical analysis to let one serve as a proxy variable explaining its own effect as well as the effect of the others. Utilizing only the important variables will simplify the analysis and interpretation of the results.

Each of several prominent variables which may influence land value receives some elaboration in the following section. The variables include rent (or farm income), capital gain, inflation, alternative investment opportunities, interest on farm mortgage loans, government payments, concessional credit by financial institutions, population pressure, and income tax structure.

Rent

Farm income was frequently used to measure returns to land in the studies reviewed earlier. Farm income, however, may not be a reliable estimate of the return to land. It measures returns to operator and family labor, management and equity capital. Over time it does not necessarily reflect changes in land characteristics such as productivity, return to scale, or rate of substitution of land for other inputs. Rent would appear to be a better measure of the return to land.

The term "rent" has a specialized meaning for economists even though it is a common word. Generally, rent means a payment made to property owners for the use of their land and buildings. However, rent in economic terms can be divided into three concepts: contract rent, land rent (Ricardian rent), and economic rent (Barlowe, 1978).

The concept of contract rent is synonymous with the general meaning of rent. This term refers to the actual payments tenants make for their use of the property of others. The amount of these payments is normally agreed to by the landlord and tenant in advance of the period of property use and thus stems from mutual contractual arrangements. Therefore, rent in this concept can be considered as the expected income to be derived from farmland.

In theory, land rent represents the actual earnings of land resources and may be defined simply as the economic return that accrues or should accrue to land for its use. This concept applies to the combined earnings of land sites and improvements. Ricardian rent is a specialized economic concept. As stated by Malthus (Ely and Wehrwein, 1941, p. 117):

> The rent of land may be defined to be that portion of the value of the whole produce which remains to the owner of the land, after all the outgoings belonging to its cultivation, of whatever kind, have been paid, including the profits of the capital employed, estimated according to the usual and ordinary rate of the profits of agricultural capital at the time being.

Rent defined above as the excess value of the whole produce above what is necessary to pay the wages of labor and the profits of capital employed in cultivation differences from the concept of economic rent. Economic rent can be viewed as a short-run economic surplus that an operator can earn because of his/her clever foresight or unexpected demand and supply conditions (Leftwich and Eckert, 1982). Over longer time periods, the supply and demand for the goods and resources in question come into balance, and the economic rent disappears in a competitive market.

A short run cost-price diagram at the firm level helps to make clear the concept of economic rent. Figure 1 shows short-run average cost, average variable cost, and marginal cost curves. Suppose that the market price of the product is P; the firm output will be Y. Total cost of the variable resources is OVAY. This is the outlay necessary if the firm is to hold its variable resources. The fixed resources get whatever is left from the firm's total receipts; that is, they receive economic rent. Total rent for the fixed resources is VPBA. Economic rent may be equal to, greater than, or less than enough to cover the firm's fixed costs. When economic rent equals total firm fixed costs, the firm's pure profits are zero.

The concept of economic rent is a different concept from the theory of rent explained by Ricado (1817). In his theory of rent, Ricado was concerned almost entirely with the problem of agricultural rents (Barlowe, 1978). He argued that only the most fertile lands would be brought into cultivation and that no payment of rent would be associated with their use. Rents arise on these lands only when increases in population numbers and in the demand for land make it necessary for society to bring less fertile lands into use. Before the less fertile land will be utilized, product prices much increase enough to cover the higher unit production costs encountered on these lands. Once prices rise to this level, the extensive margin of cultivation shifts to less fertile lands and these lands become available for economic use. At the same time, additional units of product from more fertile lands will be induced by the higher product price. The value of additional units accrues on prior units as an economic surplus. This surplus, unnecessary from the standpoint of

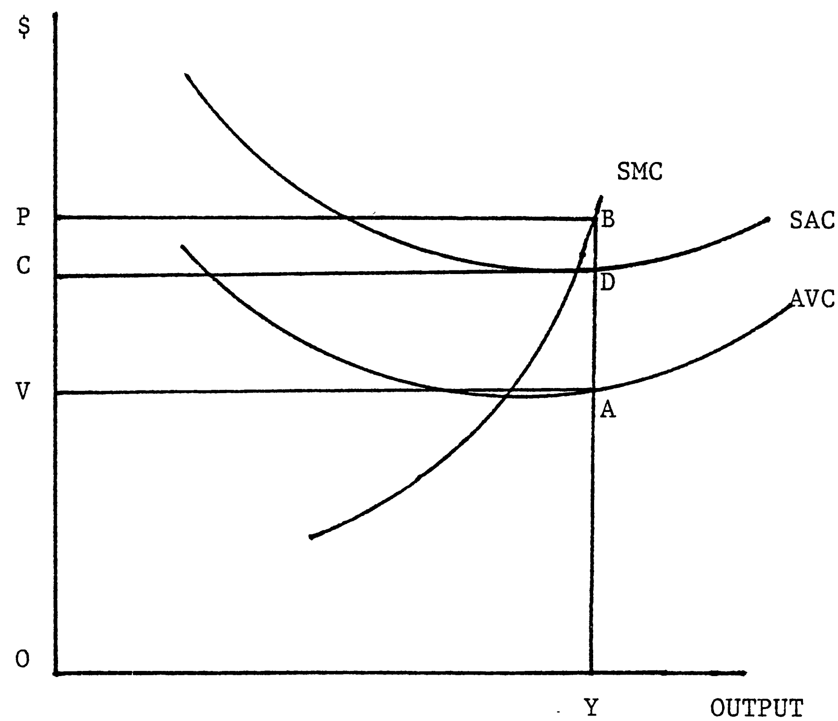


Figure 1. Short-Run Cost Price Diagram

continued production, goes as rent to the owners of more fertile lands. Rents in this concept continue to exist even in a competitive market.

From the previous definitions of rent, it is important to note that land rent and contract rent differ from each other in one significant respect. Contract rent involves an actual payment to the property owner. Contract rent has an element of expectations which may not measure true land earnings in a given year. This payment may either exceed or fall below the amount actually earned by the property.

This study considered rent as the income of land owners. Rent in this context corresponds to contract rent. In theory, land resources have a current market value equal to the present value of their expected future rents or returns. Determinations of current values call for estimates of the expected future flow of land rent and for calculations of the present value of those rental returns which will not be realized until specified times in the future.

Net Farm Income

Although rent may be a preferred measure of returns to land, the value of farmland has frequently been estimated from net farm income in past studies (Pope et al., 1979). At the regional level, net farm income plays an important role in determining farmland value (Klinefelter, 1973; Sandrey et al., 1982). Nationally, farmland value maintained a fairly stable relationship to net farm income from the mid-1920s to the mid-1950s. Since then and until the 1980s, however, farmland value increased at an increasingly rapid rate that outstripped increases in net farm income as shown in Figure 2. One reason is that in an inflationary economy such as of the 1970s much of the return to land comes as capital gain rather than current earnings.

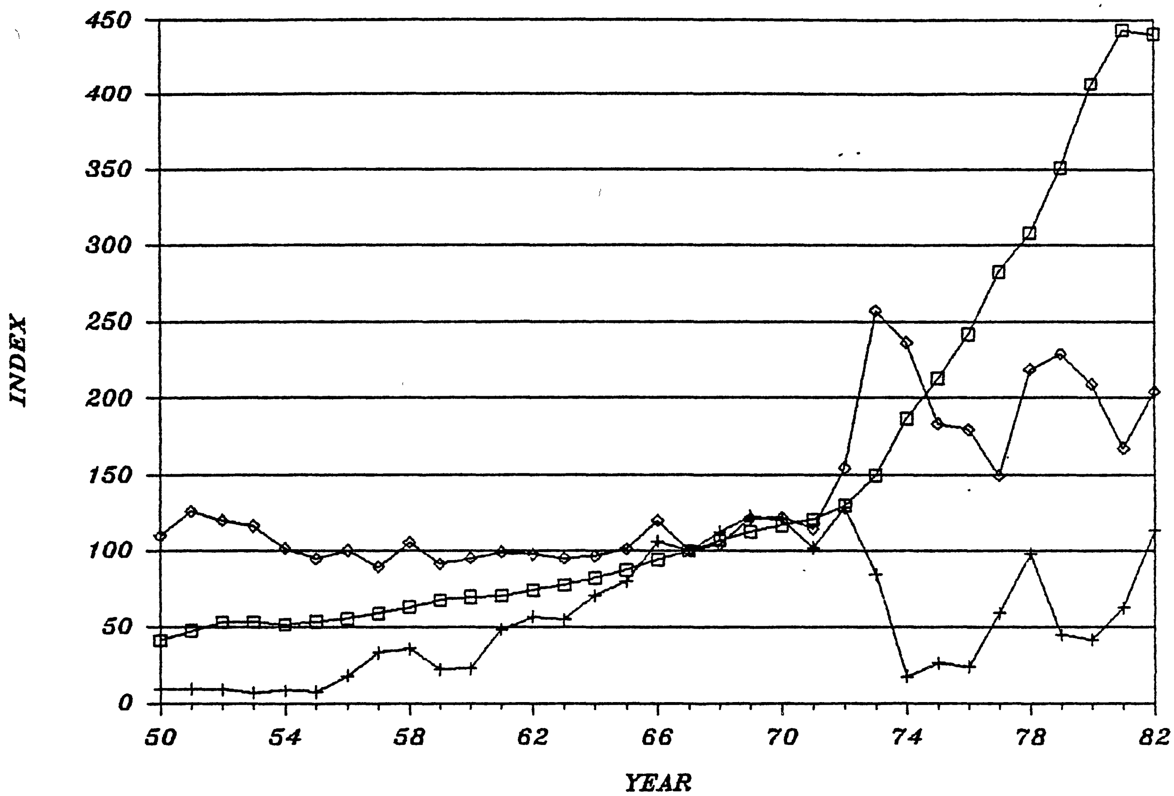
Net farm income may be a useful proxy for land earnings in determining farmland value. Net farm income data alone do not account for historical land price variations over an extended period (Tweeten, 1979) but alternative measures of returns to land such as cash rents also are frequently flawed by error in the data. This study will use net farm income as well as rent to explain the value of farmland. In part, net income is included to test empirically its ability compared to rent to account for changes in land prices.

Capital Gains

It has been hypothesized that rising farmland values have been an important source of income to landowners. The rising value of farmland is a capital gain rather than a direct income to the land owner. This capital gain is not realized until the farmland is sold. In the 1970s, capital gains in farmland were substantial and greater than net farm income (Plaxico and Kletke, 1979). The investors or land buyers view capital gain as a part of their income from owned land. Speculators might bid for land to realize future capital gains independent of earning capacity of land!

Even though capital gains can be considered as a deferred income of land buyers, this factor might influence the value of farmland, as stated by Tweeten:

> Capital gains can be a self-generating mechanism underlying land price appreciation. A negative residual income to real estate from farm production need not necessarily concern the speculative buyer - not if the sale price is sufficient to



◇ Net Farm Income Included Government Payments

□ Farmland Price

+ Government Payments

Figure 2. Farmland Price, Net Farm Income, and Government Payments Index (1967=100)

Source: U.S. Department of Agriculture, 1984a.

> cover the purchase price plus operating losses and still leave a satisfactory return for risk and capital (1979, p. 288).

With the exception of only three years since 1950, the holders of farm real estate in the aggregate have enjoyed capital appreciation of that asset. Furthermore, the annual rate of capital appreciation has been as high as 25.2 percent (Duncan, 1979). To test the hypothesis that capital gains influence farmland price, other things equal, the capital gains variable will be included in the model. Because capital gains may be the result of expected real or nominal increases in future land earnings from inflation and other sources, a framework was suggested in the previous section to disentangle the separate impacts. The capital gain in excess of that predicted by land earnings represents a speculative factor. A positive relationship is expected between the speculative element and farmland price.

Inflation

Inflation may influence the value of farmland indirectly by influencing land earnings and directly because investors view farmland as a hedge against inflation due to the interaction between inflation and tax rates (Feldstein, 1980). However, Tweeten stated that:

> The important point, however, is that the attractiveness of farmland investment is better judged by trends in land earnings than by national inflation rates (1981, p. 21).

Martin and Heady (1982) tested Feldstein's hypothesis and concluded that it did not appear that inflationary expectations have had a major direct impact on the value of U.S. farm real estate. Nevertheless, they also reported that study at the regional or state level may be needed to support or refute their conclusion. Since the impact of inflation on farmland value is still inconclusive, this research will include the expected inflation factor in the study model. The positive relationship is expected between anticipated future inflation and farmland price.

Alternative Investment Opportunities

Land is one component of an investment portfolio for investors. Rational investors will make investments to maximize their total net return over time. When returns are higher in agricultural investments than elsewhere, it is reasonable to expect asset prices in the farm sector to be bid up relative to prices of nonfarm assets. On the other hand, higher rates of return outside of agriculture would cause investors to shift out of agricultural investment. Stocks and bonds are examples of alternative investments. If either or both of these rates are equal or higher than the rate of return on farmland investment, investors may invest in these assets rather than in farmland. It is not possible to state whether rates of return need to be higher, lower, or equal for land versus other investments to provide comparable alternativeness to investors. Common stocks and government bonds are more liquid than farmland, but farmland has intrinsic value and special amenities that reward the investor. The real rate of return on common stock and real rate of return on long-term government bonds are included to show rates of return on alternative investments. The hypothesis of negative relationship between returns on other investments and farmland value is assumed.

Interest on Farm Mortgage Loans

The interest rate on farm mortgage loans is expected to influence the value of farmland. Generally, if the cost of obtaining a farm loan is low, it is easier for farmers and others to finance farmland purchases which pushes up the demand for farmland. A higher real interest rate on mortgages causes future rents to be discounted more heavily, reducing land price. The farmland price is assumed to be negatively related to farm mortgage interest rates.

Government Payments on Farm Programs

Government programs raising farm income in turn boost farmland price over time as stated by Tweeten:

> Control of the land resource has been used as a public instrument to raise farm prices and incomes. Output restrictions, coupled with an inelastic (except in the long run) demand for farm commodities, effectively raised farm income. Economic theory and observed behavior suggest that the monetary benefit of federal programs controlling land would be capitalized into land value over time (1979, p. 287).

Since 1960, government payments to farmers were more than one billion dollars annually except for the years 1974-1976, as indicated in Table III. The income maintenance aspects of government farm programs reduce the risk in farming, thus increasing the value of farm real estate. The benefits from government payment can be divided in two parts: 1) annual income from price supports or provisions to grow crops while the initial owner retains title and 2) the discounted value of all expected future earnings that will accrue from the support program through land ownership (Tweeten, 1979). However, the proportion of the payments actually capitalized into land values may

TABLE III

TOTAL GOVERNMENT PAYMENTS TO FARMERS
IN THE UNITED STATES

Year	$million
1960	702
1961	1,493
1962	1,747
1963	1,696
1964	2,181
1965	2,463
1966	3,277
1976	3,079
1968	3,462
1969	3,794
1970	3,717
1971	3,145
1972	3,961
1973	2,607
1974	530
1975	807
1976	734
1977	1,819
1978	3,030
1979	1,375
1980	1,286
1981	1,932
1982	3,492

Source: U.S. Department of Agriculture, 1984.

be moderate because of uncertainty over the duration of such payments (Reinsel and Krenz, 1972). In spite of the uncertainty of government programs, such programs are usually recognized as having some impact on farmland value. This research, thus, will include government payments in the study model. Because payments, diverted acres and other income enhancement provisions of programs are closely correlated, payments will be used as a proxy for overall commodity program impacts. The positive relationship to farmland price is expected for this variable.

Concession Credit by Financial Institutions

Federal Land Banks (cooperative institutions not charged federal corporate income taxes) and the Farmers Home Administration have played a major role in the farming business by offering interest rates for farm loans below those available from commercial lenders. Lower credit cost of owning farmland compared to other assets increases the demand for farmland. Table IV shows the amount of agricultural loans offered by these two agencies since 1950. Major increases are apparent in lending by both agencies. Although concessional lending has not been widely considered in past studies, the recent literature has mentioned the possible impact of this factor on farmland value (Tweeten, 1981). This study will test whether or not this factor influences the value of farmland. A positive relationship between land price and concessional lending activity is assumed.

Population Pressure

The growth of population expands demand for food, and hence for land. Also urban population pressure directly increases land demand

TABLE IV

AMOUNT OF LOAN MADE BY FARMERS HOME ADMINISTRATION AND FEDERAL LAND BANK

Year	Farmers Home Administration	Federal Land Bank
	------------------(\$1,000)----------------	
1960	96,660	499,581
1961	185,200	629,209
1962	401,120	637,226
1963	325,320	738,248
1964	349,110	990,645
1965	390,070	1,216,643
1966	577,260	1,329,798
1967	736,700	1,256,444
1968	736,220	1,096,172
1969	848,610	1,161,206
1970	1,312,720	1,006,551
1971	1,757,420	1,547,360
1972	2,211,650	2,222,026
1973	1,893,710	3,261,617
1974	2,524,500	4,163,944
1975	3,036,360	4,332,322
1976	3,052,790	4,614,514
1977	3,903,780	5,715,166
1978	4,488,060	6,334,249
1979	4,334,370	9,066,642
1980	4,461,880	10,253,223
1981	4,072,230	12,163,942
1982	4,216,550	8,459,517

Sources: U.S. Department of Agriculture, 1952-1983.

for residential, commercial, and industrial developments. The study by Crowley (1972) showed that land value in urban-influenced counties appreciated at a faster rate than in the non-urban grain growing areas.

A proxy for population pressure is population density (Sandrey et al., 1982). This variable has been found to be superior to population number alone to represent population pressure. This variable is hypothesized to have a positive relationship with farmland value.

Income Tax Structure

It has been hypothesized that people buy farm real estate as a way to reduce their income tax. In other words, buying farmland can be considered as a tax shelter for high income people. For many part-time farmers, tax advantages are decisive in exercising their preference to reside on and operate a small farm. People in the highest income brackets gain the most from purchase of land as a tax shelter. Based on these assumptions, the tax rate for the highest income bracket will be used as a proxy to measure the influence of the tax system on land values. Furthermore, tax rate is assumed to interact with the inflation rate as indicated earlier. A positive relationship is expected between this variable and farmland price.

Test of Structural Stability

Ordinary least squares will be used to estimate the coefficients of independent variables for models specified in the previous sections. These models will allow for structural stability tests between the regions and between time periods. The test will be applied to both price and cash rent to land price models. The null hypothesis tested is: there is no difference in the structural coefficients across the regions.

The mathematical derivation for this test can be briefly illustrated (see Chow, 1960 and Fisher, 1970). Let the two samples (regions) of n1 and n2 observations be represented by

$$Y1 = X1b1 + e1 \text{ and } Y2 = X2b2 + e2$$

where Y1 and Y2 are n1 x 1 and n2 x 1, X1 and X2 are n1 x k and n2 x k, respectively. If the null hypothesis is H0: b1 = b2. In the framework of testing linear restrictions Rb = r, the model can be written as:

$$\begin{bmatrix} Y1 \\ Y2 \end{bmatrix} = \begin{bmatrix} X1 & 0 \\ 0 & X2 \end{bmatrix} \begin{bmatrix} b1 \\ b2 \end{bmatrix} + \begin{bmatrix} e1 \\ e2 \end{bmatrix}$$

and the k restrictions as,

$$Rb = [I \ - I] \begin{bmatrix} b1 \\ b2 \end{bmatrix} = 0$$

the sum of squares e*'e* is obtained by regressing the n1 + n2 observations of Y on X1 and X2 assuming that b1 = b2. It has n1 + n2 - k degrees of freedom. The sum of squares e'e is obtained by the regression model without assuming b1 = b2. It has n1 + n2 - 2k degree of freedom. Thus, the null hypothesis b1 = b2 is tested by using:

$$F(k, n1 + n2 - 2k) = ((e^{*\prime}e^{*} - e'e)/k)/(e'e/(n1 + n2 - 2k)) \quad (16)$$

If the value of calculated F from equation (16) is greater than the F value obtained from the F-table at appropriate degrees of freedom and level of significance, then the null hypothesis will be rejected and it will be concluded that there is a difference in structural coefficients among groups of data sets (regions or time periods).

Testing Model Stability Under Differences In Expected Inflation

This section is the extension of the previous section. Again a dummy variable is applied to the models to test for the impact of anticipated inflation rates on land price. Under this scenario, the data will be separated into two subperiods: high and low expected inflation. The dummy variable equals one for high expected inflation and zero otherwise. Both slope and intercept in the model can be changed by expected inflation. The model under this scenario can be shown as following:

$$Y = aX1 + bD + CiZi + GiDZi \qquad (i = 2, 3, \ldots k)$$

where

Y = dependent variable

X1 = 1

D = dummy variable (1 = high inflation rate, 0 otherwise)

Zi = explanatory or independent variables

a, b, Ci, and Gi = estimated parameters.

The models for high and low expected inflation rate can be written as:

$$Y = (a + b)X1 + (Ci + Gi)Zi \text{ and,}$$

$$Y = aX1 + CiZi, \text{ respectively.}$$

The null hypothesis is set as H0: b = Gi = 0. The Chow-test will be performed to test this hypothesis. The criteria for accepting or rejecting the hypothesis is the same as indicated in equation (16) in the previous section. If the null hypothesis is rejected, it means a degree of expected inflation influences farmland price behavior.

The conceptual framework for this study has been discussed in this chapter. In addition, the past studies on farmland price were reviewed and a series of hypotheses and tests also were stated. In the following chapter, the data used in this study will be presented.

CHAPTER III

DATA AND VARIABLE CONSTRUCTION

The purpose of this chapter is to present data needs and sources for this study. A most difficult task in econometric modeling is to identify which variables to include in the model. Generally, the most useful guide in such a search is economic theory (Kenedy, 1981). Chapter II in this study presented the conceptual framework for including variables in the econometric model. Some of the values for these variables can be obtained directly from secondary sources. Others need to be constructed. The procedure for constructing such variables is detailed in the following section.

Variable Construction

Anticipated Real Growth of Earnings (i')

The value of this variable is derived from the changes in land cash rent. In reality, there are many types of rents. Even under a given type of rent, such as share rent, the landlords and tenants share the farm production will vary among situations (Scott, Jr., 1983). This study nevertheless, uses only cash rent because it is the only data available for most states.

The percent changes in cash rent is computed by using the following formula;

$$\Delta R = (R_n - R_{n-1}) * 100/R_{n-1}$$

where R_n is real net cash rent at period n. Real net cash rent is net cash rent deflated by GNP deflator.

Real Rate of Return on Common Stock (CGD)

This variable is calculated by utilizing Standard and Poor's composite price index and dividend price ratio. The composite price index is used as a proxy to calculate the percent of capital gains or losses by investors. This percent gain or loss is added to a percent of common stock yield. The resulting variable is adjusted by the inflation rate to obtain the real rate of return on common stock.

Inflation Rate (CIGD)

The changes in the index of the GNP price deflator is chosen to represent the inflation rate as shown in a following formula:

$$CIGD = (GNPD_n - GNPD_{n-1}) * 100/GNPD_{n-1}.$$

Share of Loans Made by Federal Land Bank

Data on annual outstanding loans made by this agency are available for each state. However, annual total outstanding loans made are not available by state. Thus the total debt by state is used as a proxy for its value. The final variable is the ratio of loans made by Federal Land Banks to total debt.

Share of Loan Made by Farmers Home Administration (FHA)

This variable is not reported at the state level but is available at the national level. The variable is obtained by dividing total loans made by Farmers Home Administration by total agricultural loans.

Other Variables

The remaining variables in the model do not need detailed elaboration because they were obtained directly from secondary sources or needed only minor adjustment.

Data Sources

The data used in this study are obtained from secondary sources such as USDA publications, Economic Report of the President, etc. The secondary data and their sources are presented in the following section (see appendix).

1. Farm cash rents and farmland value are provided by USDA from unpublished worksheets.

2. Taxes levied on farm real estate by state are obtained from Farm Real Estate Taxes, various issues (USDA, 1967, 1973, 1979, 1981).

3. Population by state is collected from the Statistical Abstract of the U.S., (U.S. Department of Commerce, 1956, 1962, 1968, 1972, 1983).

4. Implicit price deflator for gross national product is from the Economic Report of the President 1983 (Council of Economic Adviser, 1983).

5. Standard & Poor's Composite Index and dividend price ratio are obtained from the same source as (4).

6. Average interest rates on farm loan are obtained from Agricultural Statistics, various issues (USDA, 1952-1983).

7. Rate of return on 10-year U.S. Treasury securities is collected from Banking and Monetary Statistics 1970 (Board of

Governorsof the Federal Reserve System, 1970), and Economic Report of the President 1983 (Council of Economic Adviser, 1983).

8. Tax rate on highest income is collected from Statistics of Income, various issues (U.S Department of Treasury, 1950-1953) and Statistics of Income: Individual Income Tax Returns, various issues (U.S. Department of Treasury, 1954-1982).

9. Amount of loans made by Federal Land Banks by state, amount of loans made by Farmers Home Administration in the U.S., amount of total agricultural loans in the U.S., and area of land in farms by states are reported in Agricultural Statistics, various issues (USDA, 1952-1983).

10. Government spending on farm programs and net farm income by state are collected from Economic Indicators of the Farm Sector, various issues (USDA, 1984).

In summary, this chapter showed sources of variables used in this study. In some cases, the value of variables could not be directly obtained from the secondary sources. The methodology to construct those variables was presented herein. The next chapter will utilize variables in this chapter to estimate the parameters in the econometric model. The econometric relationship also will be presented in the next chapter.

CHAPTER IV

ECONOMETRIC MODEL FOR FARMLAND PRICE AND RATIO OF RENT TO FARMLAND PRICE

The purpose of this chapter is to present a background for the econometric model used in this study. Various econometric models will be discussed as well as the statistical and economic criteria used to determine the importance of estimated parameters in the model.

Functional Relationship and Expectations

In the previous chapter, the functional relationship of farmland price and rent-farmland price ratio to explanatory variables was illustrated. One explanatory variable is the expectation of future increases in real farmland earnings. This study assumes that expectations are formed from past values of increases in real earnings. The near-term value of increases in real earnings carries more weight than more distant ones. In other words, the impact of real earnings on farmland price continuously declines over a period of time. This relationship is illustrated graphically in Figure 3. The functional relationships can be written as:

$$V_t = f(i_t, i_{t-1}, \ldots, i_{t-n}, \text{ other variables})$$

where

V_t = farmland value at period t and

i_t = real increases in farmland earnings at period t.

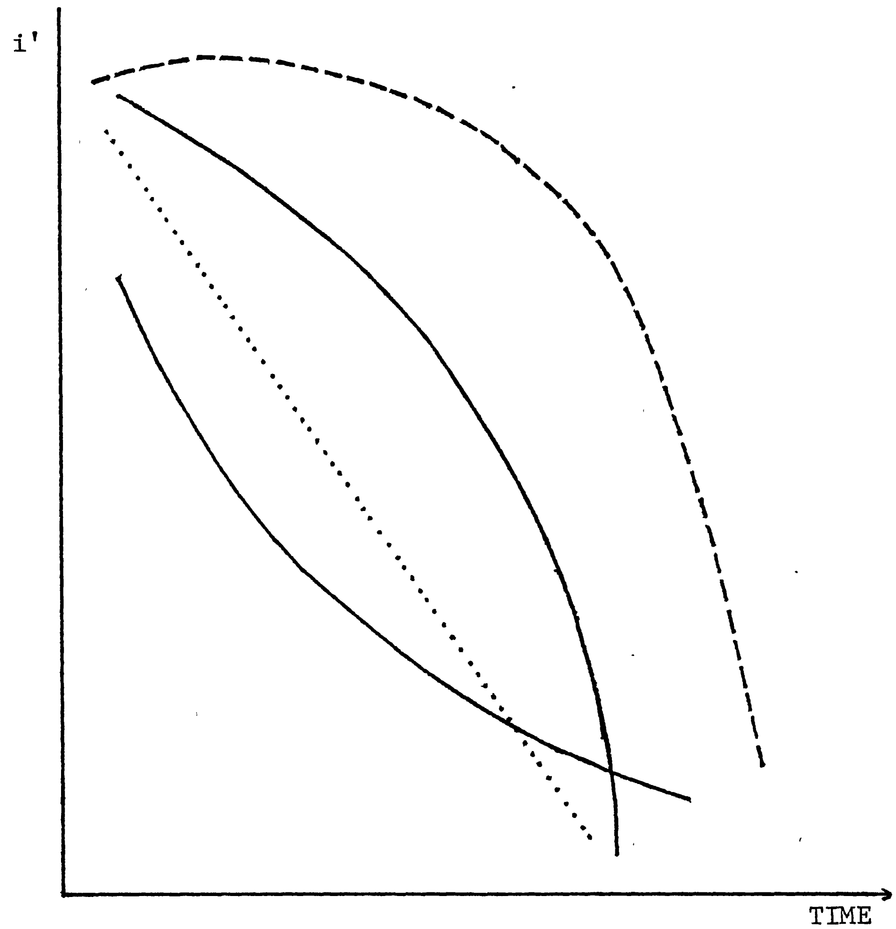


Figure 3. The Possible Shapes of the Impact of Increase in Real Earnings on Land Price Over Time

Based on this reduced functional form, the distributed lag model is appropriate to represent farmland price and the ratio of rent to farmland price.

Elaboration of the Distributed Lag Model

A distributed lag model can be expressed as

$$V_t = \Sigma_{k=0}^{t} \beta_k X_{t-k} + u_t$$

so that V_t is some weighted sum of past values of X_t and the weights β_k are some function of K, the lag period. The range of summation, t, may be finite or infinite. This model has proven to be useful in many econometric problems where several lagged values of a predetermined variable act on the current dependent variable. Many alternative specifications for β_k have been proposed for both finite and infinite lags. One of the examples of an infinite lag model is the geometric lag;

$$\beta_k = (1 - \delta)\delta^k, \quad 0 < \delta < 1$$

which was introduced by Koyck (1954). Coefficients estimated by ordinary least squares are not statistically consistent and efficient unless the residual follows a particular first order autoregressive scheme. A direct ordinary least squares estimate of the model often yields an excessively high value of δ, thus giving an impression of a slowly decaying or long lag (Maddala, 1977). Solow (1960) proposed lag weights which follow a Pascal probability distribution as follows,

$$\beta_k = (1 - \delta)^r \binom{r+k-1}{i} \delta^k$$

thus,

$$V_t = \{\beta(1 - \delta)^r/(1 - \delta L)^r\}X_t + u_t.$$

The estimation procedure for this model must account for nonlinearities to derive maximum likelihood estimates for δ and β. In addition, the problem will involve choosing the degree of r.

Jorgenson (1966) suggested approximating the lag distribution by the ratio of two polynomials A(L)/B(L) in the lag operator L. This model is the class of rational infinite distributed lag functions. The models by Koyck and Solow are considered to be special cases of the rational distributed lag model. In this model, as in Koyck's, the ordinary least squares estimation is valid only if the residuals in the distributed lag model follow a special autoregressive process. Tsurumi (1971) proposed using the Gamma probability distribution for the distributed lag weight, that is

$$\beta_k = \beta k^{S-1} e^{-k}$$

where S = some constant value. This model also needs a search procedure to estimate parameters.

In most situations the impact of explanatory variables on the dependent variable is spread over a finite time period. This calls for the finite distributed lag model. An example is the arithmetic lag model proposed by Fisher (1937). This model assumes that the lag coefficients β_i decline arithmetically as shown below;

$$\begin{aligned} \beta_i &= (K + 1 - i)\beta, \ 0 \leq i \leq K \\ &= 0, \ i > K. \end{aligned}$$

DeLeeuw (1962, 1965) proposed weights following a finite inverted V shape, that is

$$\begin{aligned} \beta_i &= i\beta, \ 0 \leq i \leq k/2 \\ &= (k - i)\beta, \ k/2 \leq i \leq k. \end{aligned}$$

Almon (1965) suggested that a finite number of lag weights follow a low order polynomial. The value of β_i can be illustrated as:

$$\beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2 + \ldots + \alpha_k i^k.$$

where k = degree of polynomial. In his work, Almon proposed the endpoint constraint such that $\beta_{-1} = \beta_{k+1} = 0$. This restriction later was relaxed by Bischoff (1966) and by Modigliani and Sutch (1966). Hall and Sutch (1968) proposed extending the Almon model with lag weights that first follow the finite polynomial scheme and then after a smooth transition follow the infinite geometric shape.

The Choice of Distributed Lag Models

As previously indicated, many types of distributed lag models are available. To choose a suitable one, information and assumptions from a theoretical framework are needed. In this study, price and the net rent-farmland price ratio are assumed to be a function of expected increases in real earnings and other relevant variables. Expectations of increases in real earnings are assumed to be formed from a finite number of its past values. This scenario limits the model to a finite distributed lag.

Within the class of finite distributed lag models, the polynomial distributed lag gives more flexibility to the lag coefficients than do other models. The lag coefficients depict a decaying effect of real earnings increments. The polynomial lag model does not utilize the lagged dependent variable as an independent variable, hence the estimated coefficients may be consistent under OLS. Therefore, the polynomial distributed lag model is chosen for this study.

The polynomial distributed lag model necessitates choosing the degree of polynomial and the lag length. A larger degree provides more flexibility, but reduces degrees of freedom. A polynomial of degree 2 or 3 usually provides a sufficiently accurate approximation to the lag structure (Pindyck and Rubinfeld, 1981).

The lag length also poses problems. A priori knowledge about the lag length would be useful but usually is inadequate. The lag length can be parametrically changed to obtain the most suitable model structure based on minimizing error or other criteria.

Model Estimation

This study assumes a declining lag weight for increases in real earnings that can be approximated by a second degree polynomial. In addition, end point restriction are imposed. The estimated model can be illustrated as follows:

$$V_t = \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_k X_{t-k} + d_{it} A_{it} + u_t \quad (1)$$

and

$$\beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2 \quad (2)$$

where

A_{it} = other relevant variables in the model,

X_t = increases in real earnings at period t.

If the tail restriction is imposed, $\beta_{k+1} = 0$, then

$$\alpha_0 + \alpha_1(k + 1) + \alpha_2(k + 1)^2 = 0 \quad (3)$$

and thus,

$$\alpha_0 = -\alpha_1(k + 1) - \alpha_2(k + 1)^2. \quad (4)$$

From equation (1) and (2),

$$V_t = \alpha_0 Z_{0t} + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + d_{it} A_{it} + u_t \quad (5)$$

where

$$Z_{0t} = \Sigma_{i=0}^{k} X_{t-i}, \; Z_{1t} = \Sigma_{i=0}^{k} i X_{t-i}, \text{ and } Z_{2t} = \Sigma_{i=0}^{k} i^2 X_{t-i}. \quad (6)$$

Substituting equation (4) into (5) yields (9)

$$Vt = \{-\alpha_1(k+1)-\alpha_2(k+1)^2\}Z_{0t}+\alpha_1 Z_{1t}+\alpha_2 Z_{2t}+d_{it}A_{it}+u_t \quad (7)$$

$$= -\alpha_1(k+1)Z_{0t}-\alpha_2(k+1)^2 Z_{0t}+\alpha_1 Z_{1t}+\alpha_2 Z_{2t}+d_{1t}A_{it}+u_t \quad (8)$$

$$= \{Z_{1t}-(k+1)Z_{0t}\}\alpha_1+\{Z_{2t}-(k+1)^2 Z_{0t}\}\alpha_2+d_{it}A_{it}+u_t. \quad (9)$$

The value of α_1, α_2, and d_1 can be estimated by OLS; α_0 is obtained by substituting α_1 and α_2 in (4). Finally, the value β_i are found by substituting α_0, α_1, and α_2 into (2).

This study will start with the full model for both price and rent-farmland price ratio. The pooled cross-section (state data) and time-series data are used to estimate model coefficients. Pindyck and Rubinfeld (1981) indicated that pooling data is an acceptable procedure when time series related explanatory variables such as expectations, prices, and interest rates appear in the model. However, this method assumes that cross-section parameters do not shift over time.

Based on the conceptual framework in Chapter II, 6 models are to be estimated:

$RA_t = f_4(i'_t,...,i'_{t-n}$, RIRG, FHA, F, POP, CIGD, XCIGD, SG, T)

$RA_t = f_5(i'_t,...,i'_{t-n}$, CGD, FHA, F, POP, CIGD, XCIGD, SG, T)

$RA_t = f_6(i'_t,...,i'_{t-n}$, RG2, FHA, F, POP, CIGD, XCIGD, SG, T)

$V_t = f_1(i'_t,...,i'_{t-n}$, RIRG, FHA, F, POP, CIGD, XCIGD, R, SG, T)

$V_t = f_2(i'_t,...,i'_{t-n}$, CGD, FHA, F, POP, CIGD, XCIGD, R, SG, T)

$V_t = f_3(i'_t,...,i'_{t-n}$, RG2, FHA, F, POP, CIGD, XCIGD, R, SG, T)

where all variables were defined earlier in Chapter II. The second degree polynomial lag model was estimated with 5, 10, and 15 year lags. The estimated coefficients for each model are shown in Tables V and VI. Note that there are 3 equations for both the price and rent-land price models because there are 3 alternative variables used

TABLE V

THE ESTIMATED COEFFICIENTS FOR THE RATIO OF RENT TO FARMLAND PRICE BY USING SECOND DEGREE POLYNOMINAL LAG

	i_0	i_1	i_2	i_3	i_4	i_5	i_6	i_7	i_8	i_9	i_{10}	i_{11}	i_{12}
RA_t	-0.0000082	-0.000043	-0.000059	-0.000057	-0.000037								
t-Value	-0.006	-0.033	-0.044	-0.040	-0.024								
RA_t	-0.0000078	-0.000023	-0.00003	-0.000029	-0.000018								
t-Value	-0.006	-0.018	-0.023	-0.020	-0.120								
RA_t	-0.0000075	-0.000013	-0.000014	-0.000013	-0.00008								
t-Value	-0.005	-0.009	-0.011	-0.009	-0.005								
RA_t	-0.000011	0.000060	0.00012	0.00015	0.00018	0.00019	0.00018	0.00016	0.00012	0.000069			
t-Value	-0.006	0.034	0.064	0.085	0.097	0.099	0.092	0.077	0.055	0.029			
RA_t	-0.000011	0.000066	0.00013	0.00017	0.00019	0.00021	0.00020	0.00017	0.00013	0.000076			
t-Value	-0.006	0.040	0.071	0.094	0.110	0.110	0.100	0.080	0.060	0.030			
RA_t	-0.000017	0.000070	0.00014	0.00019	0.00022	0.00023	0.00022	0.00019	0.00015	0.000084			
t-Value	-0.009	0.040	0.080	0.100	0.120	0.120	0.110	0.090	0.060	0.030			
RA_t	-0.000012	0.000052	0.00010	0.00015	0.00019	0.00022	0.00023	0.00024	0.00024	0.00023	0.00022	0.00019	0.00016
t-Value	-0.005	0.020	0.050	0.070	0.080	0.090	0.100	0.100	0.100	0.090	0.090	0.070	0.050
RA_t	-0.000013	0.000056	0.00012	0.00016	0.00021	0.00024	0.00025	0.00026	0.00027	0.00025	0.00024	0.00021	0.00017
t-Value	-0.006	0.020	0.050	0.070	0.090	0.100	0.110	0.110	0.110	0.100	0.090	0.080	0.060
RA_t	-0.00001	0.000060	0.00013	0.00019	0.00024	0.00027	0.00029	0.00031	0.00031	0.00030	0.00028	0.00024	0.00020
t-Value	-0.006	0.030	0.060	0.080	0.100	0.120	0.130	0.130	0.130	0.120	0.110	0.090	0.070

TABLE V (Continued)

	i_{13}	i_{14}	RIRG	CGD	RG2	FHA	F	POP	CIGD	XCIGD	SG	T	R^2	No. of Lag	
RA_t			0.378			1.822	-1.666	-4.521	0.231	0.00200	-0.00002	-0.184	0.4011	5	(10)
t-Value			2.650			0.960	-1.700	-9.130	1.360	1.320	-0.180	-7.030			
RA_t				0.0019		1.120	-1.980	-4.480	0.015	-0.00009	-0.00002	-0.130	0.3949	5	(11)
t-Value				0.900		0.595	-2.040	-8.870	0.110	-0.054	-0.216	-8.479			
RA_t					-0.032	0.314	-2.090	-4.489	-0.060	0.00048	-0.00003	-0.114	0.3948	5	(12)
t-Value					-0.632	0.155	-2.110	-8.890	-0.431	0.302	-0.311	-4.520			
RA_t			0.243			1.866	-1.148	-4.460	0.235	0.00009	0.00003	-0.190	0.4139	10	(13)
t-Value			1.649			1.023	-1.233	-9.335	1.519	0.056	0.277	-5.987			
RA_t				0.004		2.175	-1.164	-4.480	0.168	-0.00220	0.00004	-0.153	0.414	10	(14)
t-Value				1.608		1.165	-1.250	-9.390	1.256	-1.332	0.397	-9.120			
RA_t					-0.050	0.628	-1.431	-4.480	0.027	-0.00100	0.00002	-0.125	0.413	10	(15)
t-Value					-1.036	0.324	-1.516	-9.410	0.205	-0.677	0.170	-4.802			
RA_t	0.00012	0.00006	0.246			3.026	-1.050	-4.748	0.211	0.00052	0.00003	-0.214	0.4352	15	(16)
t-Value	0.040	0.020	1.406			1.423	-1.143	-10.568	1.330	0.276	0.248	-5.194			
RA_t	0.00012	0.00006		0.003		2.377	-1.014	-4.742	0.154	-0.00190	0.00004	-0.170	0.4345	15	(17)
t-Value	0.040	0.020		1.301		1.144	-1.100	-10.523	1.115	-1.159	0.334	-9.433			
RA_t	0.00014	0.00007			-0.050	1.542	-1.286	-4.745	0.017	-0.00083	0.00001	-0.137	0.4341	15	(18)
t-Value	0.050	0.020			-1.026	0.689	-1.374	-10.538	0.134	-0.538	0.130	-4.836			

TABLE VI

THE ESTIMATED COEFFICIENTS FOR THE FARMLAND PRICE BY USING SECOND DEGREE POLYNOMIAL LAG

	i_0	i_1	i_2	i_3	i_4	i_5	i_6	i_7	i_8	i_9	i_{10}	i_{11}	i_{12}	i_{13}	i_{14}
V_t	0.0011	-0.030	-0.045	-0.046	-0.030										
t-Value	0.007	-0.199	-0.293	-0.276	-0.166										
V_t	0.0012	-0.027	-0.041	-0.041	-0.028										
t-Value	0.007	-0.180	-0.260	-0.250	-0.150										
V_t	0.0010	-0.030	-0.046	-0.046	-0.031										
t-Value	0.006	-0.200	-0.300	-0.280	-0.170										
V_t	0.0026	-0.016	-0.031	-0.041	-0.048	-0.050	-0.048	-0.042	-0.032	-0.018					
t-Value	0.010	-0.067	-0.127	-0.169	-0.191	-0.194	-0.181	-0.151	-0.109	-0.058					
V_t	0.0025	-0.015	-0.029	-0.039	-0.046	-0.048	-0.046	-0.040	-0.031	-0.017					
t-Value	0.010	-0.064	-0.122	-0.161	-0.183	-0.186	-0.173	-0.145	-0.105	-0.055					
V_t	0.0026	-0.018	-0.035	-0.047	-0.054	-0.057	-0.055	-0.048	-0.037	-0.021					
t-Value	0.010	-0.078	-0.146	-0.193	-0.218	-0.223	-0.206	-0.173	-0.125	-0.066					
V_t	0.0029	-0.016	-0.033	-0.047	-0.059	-0.067	-0.073	-0.076	-0.076	-0.074	-0.068	-0.060	-0.049	-0.035	-0.019
t-Value	0.008	-0.049	-0.098	-0.139	-0.171	-0.194	-0.207	-0.212	-0.208	-0.196	-0.176	-0.150	-0.118	-0.082	-0.042
V_t	0.0028	-0.016	-0.032	-0.046	-0.057	-0.066	-0.071	-0.074	-0.074	-0.072	-0.067	-0.059	-0.048	-0.034	-0.018
t-Value	0.008	-0.048	-0.096	-0.136	-0.167	-0.189	-0.202	-0.207	-0.203	-0.191	-0.172	-0.146	-0.115	-0.080	-0.041
V_t	0.003	-0.019	-0.038	-0.054	-0.067	-0.077	-0.083	-0.087	-0.087	-0.084	-0.078	-0.068	-0.056	-0.040	-0.021
t-Value	0.009	-0.057	-0.113	-0.159	-0.196	-0.221	-0.236	-0.242	-0.237	-0.223	-0.201	-0.171	-0.135	-0.093	-0.048

TABLE VI (Continued)

	RIRG	CGD	RG2	FHA	F	POP	CIGD	XCIGD	R	SG	T	R^2	No. of Lag	
V_t	41.399			-439.990	178.947	1058.930	20.090	0.386	13.672	0.019	17.631	0.8050	5	(19)
t-Value	2.406			-2.010	1.577	17.631	1.088	1.877	21.181	7.562	5.755			
V_t		0.095		-545.600	143.940	1064.270	-4.119	0.146	14.087	0.106	23.346	0.8036	5	(20)
t-Value		0.379		-2.486	1.289	17.810	-0.259	0.755	22.440	7.351	12.289			
V_t			22.425	-187.050	228.630	1053.220	18.675	0.059	13.938	0.111	14.627	0.8067	5	(21)
t-Value			3.818	-0.798	1.998	17.863	1.151	0.317	22.320	7.722	4.931			
V_t	18.322			-465.490	131.920	1099.270	-5.126	0.394	13.998	0.113	25.818	0.8038	10	(22)
t-Value	0.883			-1.885	1.047	17.020	-0.242	1.659	19.702	6.925	5.989			
V_t		0.162		-475.450	126.300	1095.900	-13.259	0.255	14.157	0.113	28.710	0.8036	10	(23)
t-Value		0.476		-1.879	1.001	17.147	-0.730	1.150	20.447	6.897	11.820			
V_t			22.126	-171.930	197.270	1100.530	7.010	0.198	14.020	0.116	19.907	0.8065	10	(24)
t-Value			3.370	-0.660	1.558	17.113	0.390	0.952	20.350	7.188	5.580			
V_t	19.230			-311.970	181.116	1195.420	-1.348	0.362	14.481	0.119	31.300	0.8020	15	(25)
t-Value	0.707			-0.953	1.280	17.208	-0.055	1.240	18.631	6.500	4.920			
V_t		0.239		-363.930	182.530	1195.670	-6.760	0.178	14.565	0.119	34.714	0.8020	15	(26)
t-Value		0.562		-1.138	1.286	17.253	-0.316	0.679	18.950	6.550	11.621			
V_t			19.450	-29.200	246.290	1196.370	7.946	0.166	14.488	0.122	26.243	0.8030	15	(27)
t-Value			2.603	-0.080	1.726	17.166	0.391	0.700	18.897	6.780	5.875			

to measure opportunity cost: real average interest rate on farm mortgage loans, real rate of return on common stock, and real rate of return on long-term government bonds.

Equation (10) to (18) show the regressions of net cash rent-farmland price ratio on explanatory variables. The R^2 ranges from 0.3948 (equation 12) to 0.4352 (equation 16). Coefficients of real earnings increments (i') in several cases do not have the expected sign and t-values are low. In addition, the shape of the lag coefficients does not always follow the hypothesized pattern. The shapes of distributed lag are shown in Figures 4, 5, and 6 for 5, 10, and 15 year lags respectively. Each figure shows the pattern of lag coefficient when using variables RIRG, CGD, and RG2. Note that all 5 year lag coefficients have the expected negative signs. Coefficients are positive for 10 and 15 year lag models.

The farmland price model, equation (19) to (27) from Table VI, has the same explanatory variables as the previous model (ratio model) plus the net cash rent variable. The R^2 for this model ranges from 0.8020 to 0.8067. Similar to the ratio model, the coefficients of the real rate of increase in farmland earnings (i') do not have the expected sign and has low t-values in all the models. The plot of lag coefficients also does not show a reasonable pattern as shown in Figures 7, 8, and 9.

Equations (10) to (27) indicate that i' does not perform very well in both the price and ratio models. Several regression coefficients link the predetermined i' to the dependent variable. An F-test of the joint hypothesis HO: $\beta_1 = \beta_2 = \ldots = \beta_k = 0$ is the appropriate test of whether i' makes a significant contribution to

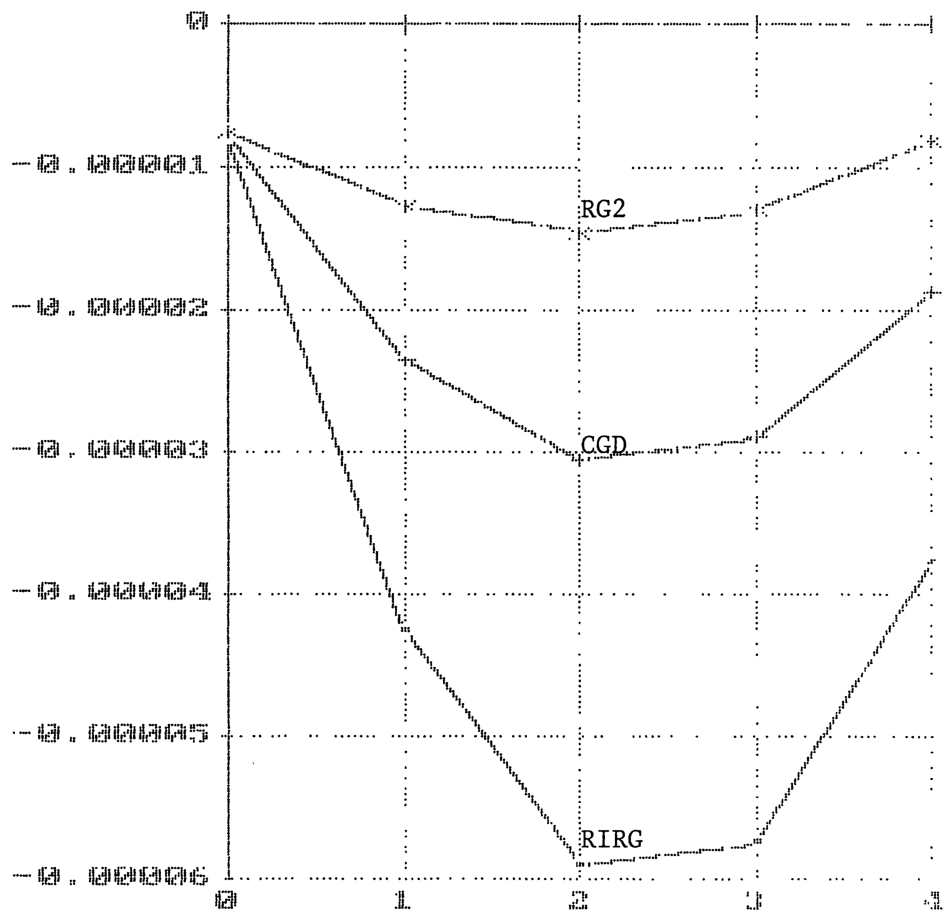


Figure 4. Shapes of the Lag Coefficients in the Ratio Model Using 5 Year Second Degree Polynomial Lags for the Variables RG2, CGD, and RIRG

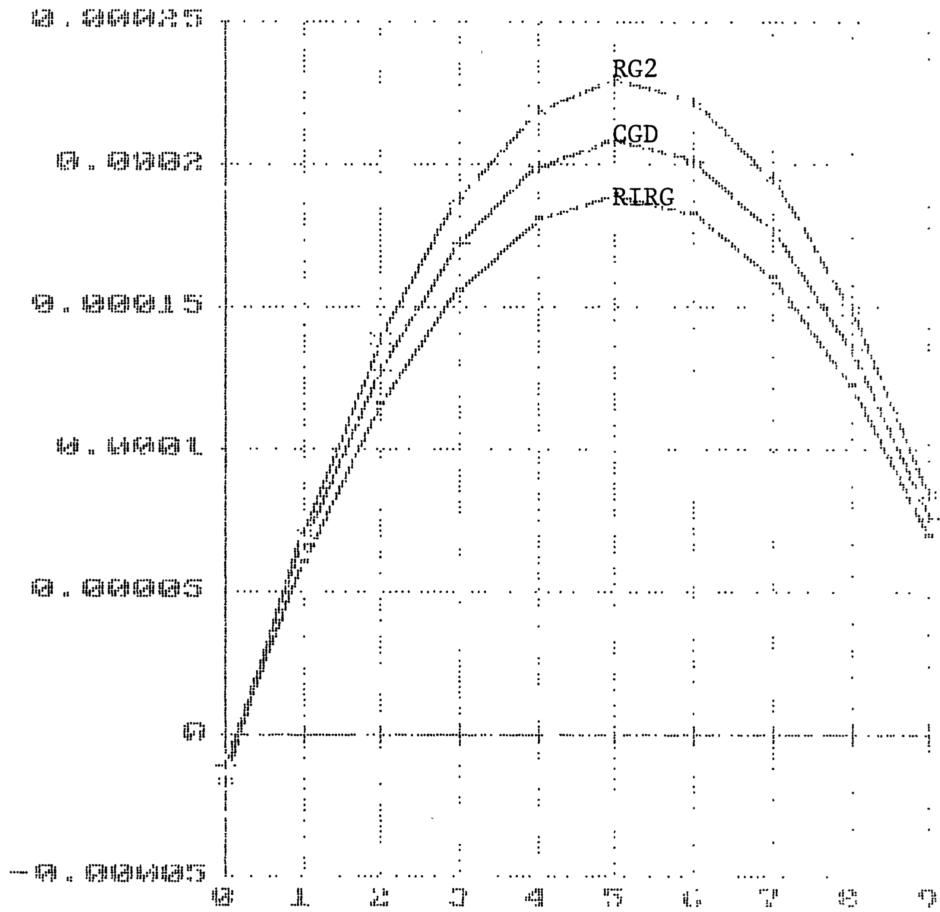


Figure 5. Shapes of the Lag Coefficients in the Ratio Model Using 10 Year Second Degree Polynomial Lags for Variables RG2, CGD, and RIRG

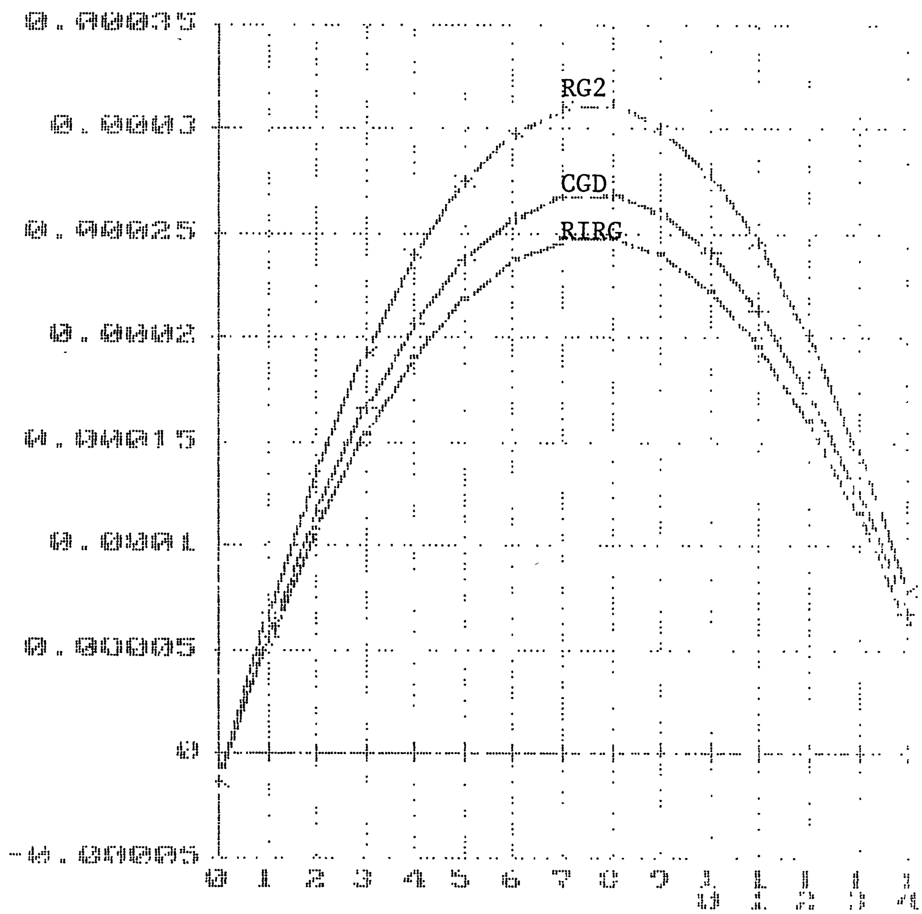


Figure 6. Shapes of the Lag Coefficients in the Ratio Model Using 15 Year Second Degree Polynomial Lags for Variables RG2, CGD, and RIRG

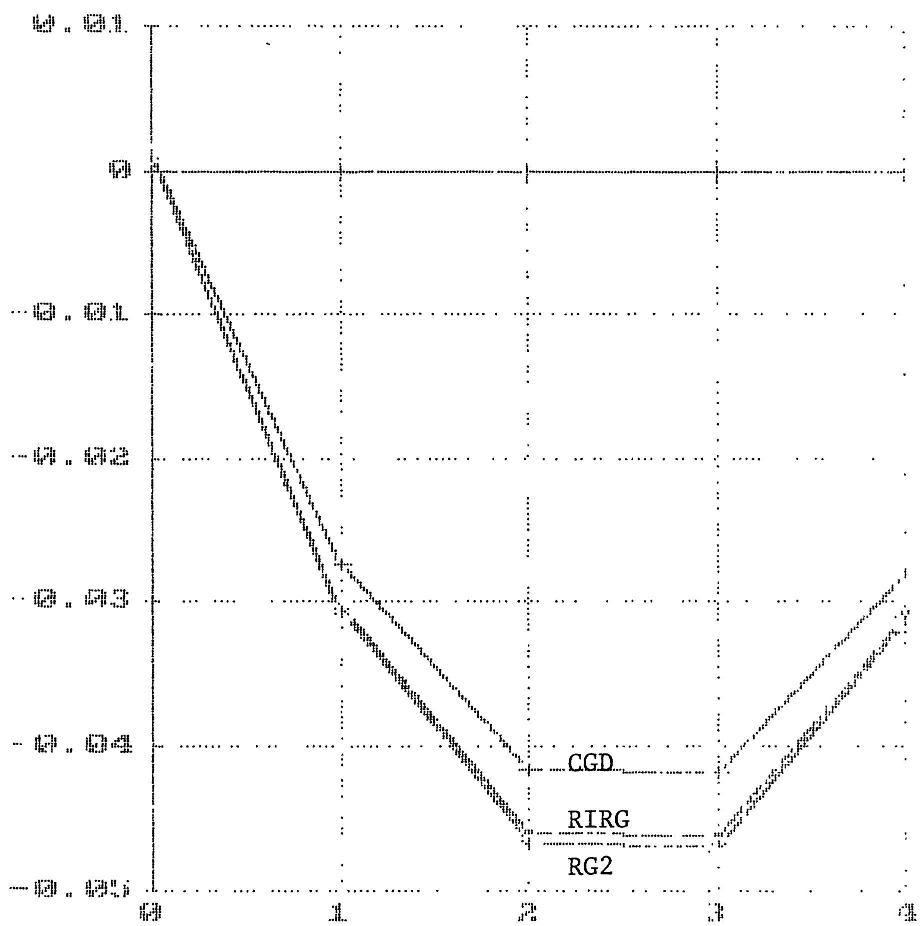


Figure 7. Shapes of the Lag Coefficients in the Price Model Using 5 Year Second Degree Polynomial Lags for Variables RG2, CGD, and RIRG

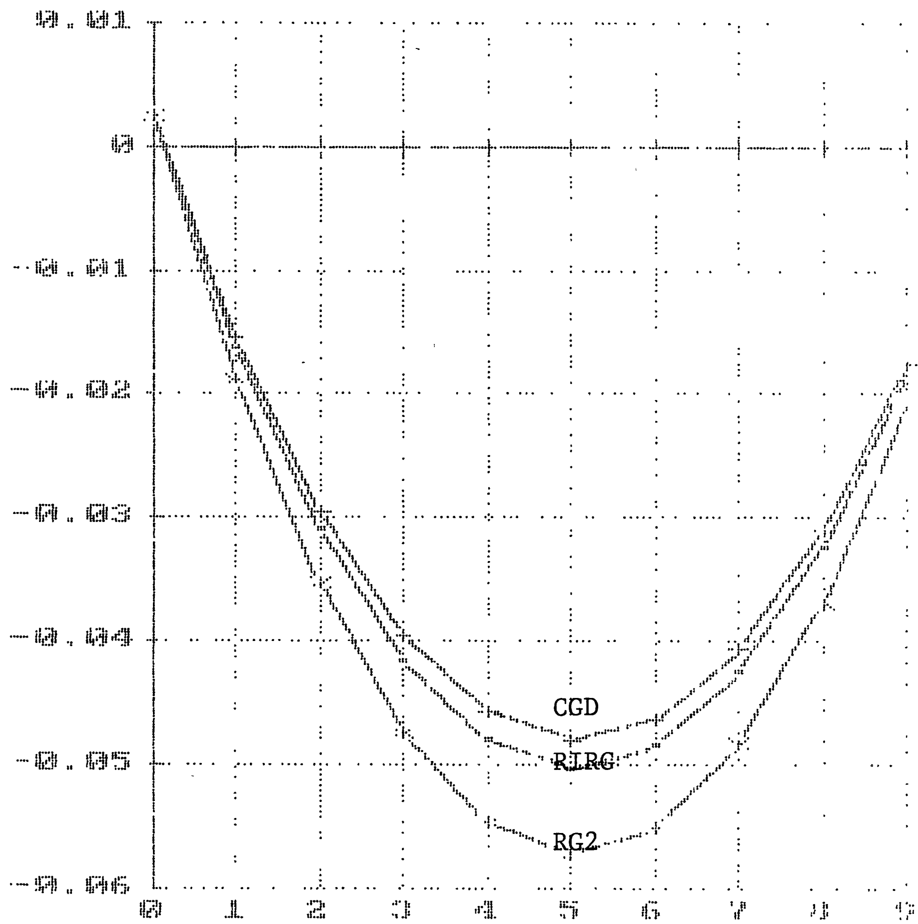


Figure 8. Shapes of the Lag Coefficients in the Price Model Using 10 Year Second Degree Polynomial Lags for Variables RG2, CGD, and RIRG

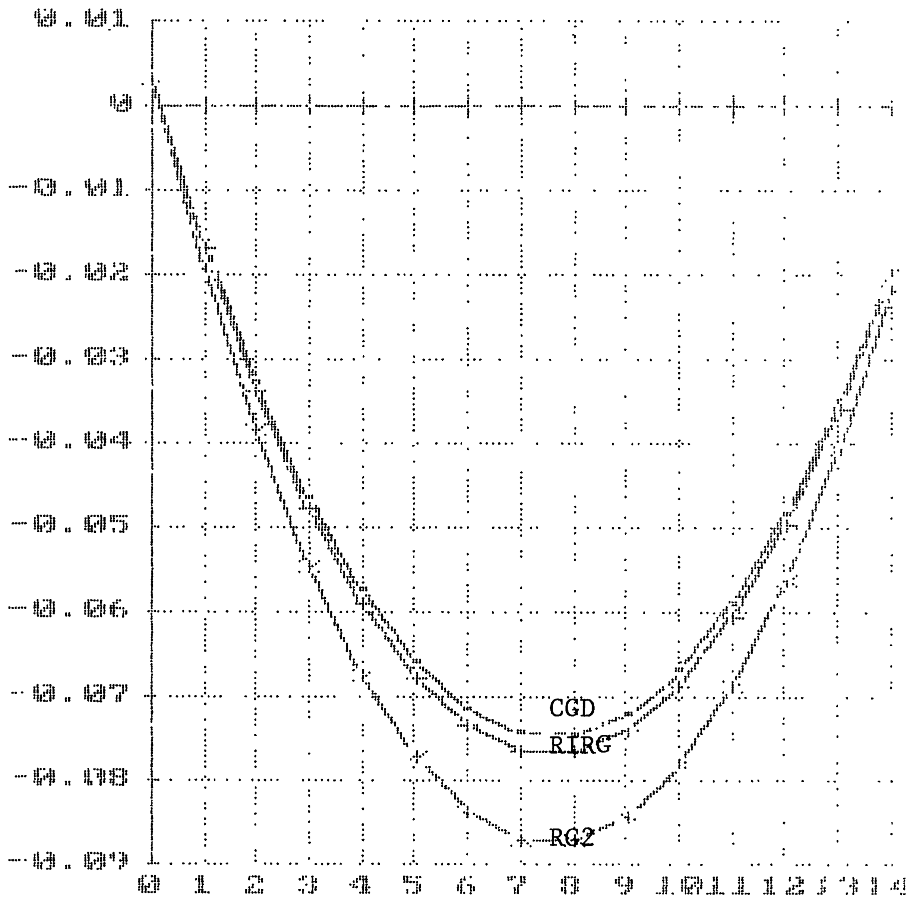


Figure 9. Shapes of the Lag Coefficients in the Price Model Using 15 Year Second Degree Polynomial Lags for Variables RG2, CGD, and RIRG

the regression. The test statistic is,

$$F_{(K,\ T-N)} = \{(ESSR - ESSU)/ESSU\}(T-N)/K$$

where ESSR is the error sum of square for the restricted regression which forces $\beta_1 = \beta_2 = \ldots = \beta_k = 0$. ESSU is unconstrained error sum of squares. T is the number of observations, N is the number of predetermined variables in the unconstrained regression and K is the number of constraints imposed by the hypothesis. Tables VII and VIII show that the hypothesis of lag coefficients equal to zero cannot be rejected because the calculated F-values are less than the tabular F-values.

Based on the F-test, t-tests, and the sign and shape of lag coefficients i', it is concluded that i' does not play a significant role on this model. This result is the same as that arrived at by Martin and Heady (1982). They were unable to establish a positive relationship between expected growth rate in real returns and real estate values. Their study, however, assumed that expected growth rates were formed adaptively. The variable i' is dropped from the model. A majority of farmland participants might consider increases in real earnings too nebulous or unpredictable a factor in making a decision to buy farmland and merely assume i' = 0. Real earnings increments appear to be heavily discounted by farmland market participants in making investment decisions.

The estimated coefficients for models without i' are shown in Table IX. Equations (28) to (30) show models for the ratio of rent to farmland price. The R^2 for these 3 equations ranges from 0.3251 to 0.3352. The estimated coefficients for the price model are shown in equations (31) to (33). The value of R^2 for these equations ranges from 0.8083 to 0.8032.

TABLE VII

CALCULATED F-VALUE FOR IMPOSED RESTRICTION ON LAG COEFFICIENTS IN THE RATIO MODEL

Equation	F-Value	F-Value at 5%
10	0.0579	2.21
11	0.0308	2.21
12	0.0296	2.21
13	0.0562	1.83
14	0.0603	1.83
15	0.0731	1.83
16	0.0367	1.67
17	0.0489	1.67
18	0.0599	1.67

TABLE VIII

CALCULATED F-VALUE FOR IMPOSED RESTRICTION ON LAG COEFFICIENTS IN THE PRICE MODEL

Equation	F-Value	F-Value at 5%
19	0.8347	2.21
20	0.6893	2.21
21	0.8394	2.21
22	0.2108	1.83
23	0.1919	1.83
24	0.2468	1.83
25	0.1439	1.67
26	0.1356	1.67
27	0.1751	1.67

TABLE IX

THE ESTIMATED COEFFICIENTS FOR THE RATIO OF RENT TO FARMLAND PRICE AND FARMLAND PRICE MODELS

Equation	Intercept	RIRG	CGD	RG2	FHA	F	POP	CIGD	XCIGD	SG	T	R	R^2
RA (28)	14.689	0.417			1.9331	-0.980	-4.544	0.192	0.0029	0.00010	-0.165		0.3352
t-value	15.940	2.827			0.937	-1.909	-8.881	1.181	1.559	1.049	-6.743		
RA (29)	13.518		0.001		0.9052	-1.335	-4.443	-0.027	0.0003	0.00015	-0.109		0.3251
t-value	16.402		0.606		0.444	-1.245	-8.355	-0.190	0.178	1.119	-7.858		
RA (30)	12.568			-0.053	-0.140	-1.499	-4.443	-0.104	0.0007	-0.00016	-0.090		0.3252
t-value	10.318			-0.977	-0.063	-1.377	-8.342	-0.707	0.437	-1.266	-3.905		
V (31)	-1120.208	45.316			-381.299	203.887	1056.700	35.448	0.2360	-0.11710	12.305	13.577	0.8083
t-value	-11.984	2.924			-1.884	1.925	18.450	1.151	2.259	-0.731	4.957	22.687	
V (32)	-1222.270		0.148		-500.739	164.581	1029.331	11.294	-0.0508	0.11470	17.9837	14.081	0.8032
t-value	-14.298		0.684		-2.469	1.546	18.641	0.793	-0.293	8.433	12.192	24.233	
V (33)	-815.440			25.512	-88.450	258.158	1054.113	34.007	-0.1166	-0.11970	9.6126	13.860	0.8078
t-value	-6.685			4.760	-0.411	2.429	18.588	2.345	-0.699	-8.969	4.172	24.028	

Based on Table IX, the equation that contains the real rate of interest on farm mortgage loans (RIRG) performs better than the equations containing the real rate of return on common stock (CGD) or real rate of return on long-term government bonds (RG2). Thus, the real average interest rate on farm loans is chosen to represent the opportunity cost for farmland investment in subsequent analysis. This reduces the estimated models (price and ratio) to only two equations, (28) and (31). The coefficients of variables FHA and SG are not statistically different from zero in (28), and have unexpected signs. Hence, these variables are eliminated from the model. The correlation coefficient between variables CIGD and XCIGD indicates a high degree of multicollinearity. The mean squares error criterion is used for selecting variables to be included in the models (Maddala, 1977 and Kennedy, 1984). Thus, only the variable XCIGD is used subsequently to represent the effect of both inflation and tax rate. The estimated model is reduced to

$$RA = f(RIRG, F, POP, XCIGD, T)$$

and

$$V = f(RIRG, F, POP, XCIGD, R, T).$$

The least squares estimates of these two functions are shown in Table X. The estimated equations (34) and (35) used pooled state and time-series data to obtain a unique set of explanatory variables for each state.

Equation (34) and (35) are estimated by using OLS and adjusted for autocorrelation by applying the Cochrane-Orcutt method. The coefficient of determination, R^2, for the ratio model is 0.3279 and F-test indicates that the composite hypothesis $\beta_1 = \beta_2 = \ldots =$

TABLE X

ESTIMATED COEFFICIENTS FOR THE RATIO OF RENT TO LAND PRICE AND PRICE MODELS

Equation	Intercept	RIRG	F	POP	XCIGD	R	T	R^2	F-Value
RA (34)	13.627	0.307	-1.329	-4.396	0.0039		-0.133	0.3279	105.18
t-value	32.689	2.477	-1.283	-8.308	2.391		-11.216		
V (35)	-1237.617	27.235	185.543	1054.800	0.4315	14.216	15.383	0.7899	674.85
t-value	-23.799	2.077	1.758	17.458	2.499	23.280	11.700		

$\beta_5 = 0$ is rejected. The t-values for all coefficients are significant at the 10 percent level except for the variable F. In the price model, t-values for all of the coefficients are significant at the 10 percent level. The coefficient of real rate of interest, however, does not show expected sign. In addition, the composite hypothesis that all coefficients are equal to zero is also rejected. The R^2 for the price model is 0.79.

Estimates for each state for the ratio and price models are shown in Tables XI and XII, respectively. In the ratio model, the R^2 ranges from 0.36 for Indiana to 0.97 for South Carolina. The coefficient signs in some states are different from those for the pooled data. Because equations for 35 states were estimated, explanations for each state would be too lengthy. Thus, the explanation of the coefficients will be for all states.

The variable RIRG has coefficients significant at the 10 percent level in 12 states but only 3 of these coefficients show the expected sign. The coefficients of variable F are significant at 10 percent level in 6 states. Four out of these 6 coefficients have the expected sign. The variable POP has significant coefficients at the 10 percent level in 11 states and 7 of these coefficients have the expected sign. The interaction between tax rate and inflation (XCIGD) has significant coefficients in 13 states. The expected coefficient signs for this variable are not clear because the variable XCIGD has positive impact on both price and rent. The coefficients of the time variable are significant at the 10 percent level in 12 states.

The ratio model presents low t-values but high R^2 which suggests a problem of multicollinearity between explanatory variables.

TABLE XI

ESTIMATED COEFFICIENT FOR THE RATIO OF NET CASH RENT TO FARMLAND PRICE MODELS WITH VARIABLE XCIGD

States	Intercept	RIRG	F	POP	XCIGD	T	R^2	F-Value	Region
Maine	2.841	-4.427	15.161	1594.768	-0.062	-0.311	0.8124	21.64	NE
t-value	0.189	-3.253*	1.306	1.556	-3.526*	-1.646			
New Hampshire	2.388	1.664	-4.351	-531.068	0.025	0.499	0.5530	6.18	NE
t-value	0.304	1.543	-0.957	-2.043*	1.743*	1.416			
Vermont	19.103	0.240	-8.214	-549.448	0.004	0.143	0.7733	17.05	NE
t-value	7.209*	0.491	-1.267	-2.678*	0.707	1.462			
Massachusetts	31.374	-1.544	0.147	-46.245	-0.020	0.176	0.7936	19.22	NE
t-value	3.905*	-2.364*	0.027	-2.107*	-2.407*	1.138			
Rhode Island	16.776	0.611	4.901	-6.985	0.006	-0.175	0.8206	22.86	NE
t-value	2.550*	1.216	1.283	-0.578	0.993	-2.009*			
Connecticut	8.806	0.283	1.320	-9.924	0.002	-0.042	0.6261	8.37	NE
t-value	3.940*	0.385	0.319	-0.652	0.217	-0.235			
New York	-2.075	0.308	-9.254	39.027	0.002	-0.123	0.7611	15.92	NE
t-value	-0.479	0.745	-2.149*	2.456*	0.442	-2.099*			
New Jersey	9.315	-0.345	0.062	-15.131	-0.004	0.111	0.8930	41.73	NE
t-value	10.785*	-1.397	0.025	-4.524*	-1.447	2.020*			

TABLE XI (Continued)

States	Intercept	RIRG	F	POP	XCIGD	T	R^2	F-Value	Region
Pennsylvania	7.263	0.172	-1.384	12.448	0.001	-0.119	0.9573	112.18	NE
t-value	2.036*	1.120	-0.557	0.669	0.643	-3.954*			
Delaware	10.604	0.608	-4.984	61.893	0.007	-0.381	0.6057	7.68	NE
t-value	6.198*	1.460	-1.134	3.245*	1.416	-3.356*			
Maryland	11.096	0.034	4.200	-33.831	-0.001	0.067	0.8980	43.99	NE
t-value	8.615*	0.091	0.784	-2.643*	-0.163	0.637			
Michigan	9.333	-0.139	3.078	33.691	-0.003	-0.137	0.9476	90.36	LS
t-value	8.236*	-0.723	1.265	1.659	-1.086	-3.286*			
Wisconsin	10.443	0.090	-8.402	52.367	0.001	-0.129	0.8144	21.06	LS
t-value	3.838*	0.325	-1.588	0.484	0.340	-1.317			
Minnesota	0.936	-0.556	1.893	413.376	-0.007	-0.164	0.4726	4.30	LS
t-value	0.280	-2.415*	0.472	1.949*	-2.437*	-1.609			
Ohio	4.955	0.051	0.090	11.371	0.0002	-0.053	0.6941	11.34	CB
t-value	4.345*	0.322	0.042	1.165	0.109	-1.595			
Indiana	2.289	-0.135	2.399	88.890	-0.002	-0.121	0.3617	2.87	CB
t-value	0.644	-0.414	0.533	1.339	-0.530	-1.111			
Illinois	5.778	-0.538	-3.231	-8.883	-0.007	0.055	0.5991	7.47	CB
t-value	3.640*	-2.603*	-1.716*	-0.426	-2.395*	1.034			
Iowa	-4.036	-0.876	-7.907	222.633	-0.011	0.051	0.6785	10.13	CB
t-value	-0.662	-4.812*	-1.995*	1.428	-4.339*	1.617*			

TABLE XI (Continued)

States	Intercept	RIRG	F	POP	XCIGD	T	R^2	F-Value	Region
Missouri	2.174	0.168	3.417	166.866	0.002	-0.122	0.3946	3.25	CB
t-value	0.316	0.767	0.815	0.884	0.692	-1.256			
North Dakota	4.356	-1.176	-6.486	324.002	-0.015	0.102	0.7424	14.41	NP
t-value	0.603	-5.111*	-2.173*	0.363	-5.460*	4.711*			
South Dakota	8.545	-0.466	-1.856	59.902	-0.006	-0.005	0.7565	15.53	NP
t-value	2.845*	-4.067*	-1.111	0.164	-3.853*	-0.368			
Kansas	5.484	-0.162	-0.288	111.789	-0.002	-0.035	0.4154	3.41	NP
t-value	1.908*	-0.948	-0.097	0.691	-0.961	-1.124			
Virginia	17.950	-0.371	-2.942	-104.477	-0.007	0.045	0.7292	12.92	AP
t-value	7.608*	-0.757	-0.426	-0.553	-1.109	0.135			
West Virginia	58.707	1.967	16.267	-504.311	0.022	-0.376	0.8639	31.73	AP
t-value	4.661*	2.351*	0.830	-3.076*	1.984*	-5.236*			
North Carolina	29.527	0.335	7.170	-39.178	0.001	-0.299	0.7560	14.87	AP
t-value	5.696*	0.490	1.359	-0.152	0.132	-0.974			
Kentucky	22.499	0.176	8.076	-248.588	0.0001	0.054	0.7833	18.07	AP
t-value	3.787*	0.413	0.944	-1.455	0.019	0.586			
Tennessee	21.625	-0.064	17.813	-41.041	-0.005	-0.144	0.9285	64.95	AP
t-value	7.251*	-0.172	2.309*	-0.308	-1.130	-1.160			

TABLE XI (Continued)

States	Intercept	RIRG	F	POP	XCIGD	T	R^2	F-Value	Region
South Carolina	18.507	-0.516	-1.144	50.426	-0.008	-0.192	0.9725	176.93	SE
t-value	22.091*	-2.088*	-0.826	1.016	-2.763*	-4.358*			
Georgia	26.635	-0.136	-1.399	-50.438	-0.002	-0.206	0.8477	26.71	SE
t-value	12.546*	-0.243	-0.207	-0.263	-0.361	-0.962			
Florida	9.398	0.577	3.091	-60.334	0.007	-0.028	0.7328	13.16	SE
t-value	0.724	0.902	0.557	-0.853	0.898	-0.097			
Alabama	7.890	-0.781	-5.848	525.823	-0.010	-0.457	0.8944	42.32	SE
t-value	1.508	-1.847*	-0.851	2.861*	-1.968*	-4.267*			
Mississippi	29.512	0.811	-6.864	40.189	0.009	-0.395	0.9130	52.47	DS
t-value	5.303*	1.348	-0.725	0.201	1.190	-5.632*			
Arkansas	27.683	0.672	25.647	-283.203	0.009	-0.226	0.9270	63.66	DS
t-value	11.100*	2.004*	2.886*	-2.200*	1.968*	-6.112*			
Louisiana	17.183	1.130	1.116	-130.281	0.015	-0.116	0.8800	36.65	DS
t-value	12.149*	3.341*	0.242	-1.104	3.351*	-0.906			
Oklahoma	10.417	0.091	1.413	-108.175	0.001	-0.043	0.9228	59.77	SP
t-value	15.915*	0.427	0.533	-1.149	0.565	-1.294			

NE = North Eastern States; LS = Lake States; CB = Corn Belt States; NP = Northern Plains States; AP = Appalachian States; SE = Southeast States; DS = Delta States; SP = Southern Plains States

* = Significant at 10% level.

TABLE XII

ESTIMATED COEFFICIENTS FOR FARMLAND
PRICE MODEL WITH VARIABLE XCIGD

States	Intercept	RIRG	F	POP	XCIGD	R	T	R^2	F-Value	Region
Maine	-608.43	167.91	406.81	-17282.70	2.30	2.93	4.64	0.7062	9.21	NE
t-value	-0.69	2.56*	1.03	-0.31	2.68*	0.50	0.41			
New Hampshire	185.02	4.36	27.08	75938.06	-0.42	3.73	-87.11	0.8721	26.13	NE
t-value	0.37	0.06	0.09	4.57*	-0.48	0.50	-3.79			
Vermont	-1427.01	109.96	-164.11	32578.19	1.36	-0.10	-7.05	0.9251	49.43	NE
t-value	-7.96*	3.57*	-0.38	2.54*	3.28*	-0.02	-1.14			
Massachusetts	-1028.55	271.28	-86.25	-3844.92	4.05	28.32	33.59	0.9372	59.71	NE
t-value	-0.97	3.19*	-0.12*	-1.36	3.69*	3.52*	1.69			
Rhode Island	-4124.60	146.01	44.62	2702.97	2.55	26.07	18.32	0.7475	11.84	NE
t-value	-2.17*	1.00	0.03	0.76	1.39	3.04*	0.70			
Connecticut	-1671.72	126.34	1402.92	-1049.48	2.32	7.01	26.60	0.9497	75.57	NE
t-value	-5.52*	1.25	2.50*	-0.50	1.72*	1.23	1.09			
New York	321.99	-2.24	227.38	-3382.16	-0.07	4.02	16.21	0.9870	304.52	NE
t-value	2.91*	-0.21	1.96*	-6.96*	-0.51	1.24	67.0*			
New Jersey	-3370.01	181.69	2848.11	-7356.35	2.54	-16.67	145.48	0.9837	241.38	NE
t-value	-10.90*	2.02*	3.33*	-4.70*	2.10*	-1.86*	5.81*			

TABLE XII (Continued)

States	Intercept	RIRG	F	POP	XCIGD	R	T	R^2	F-Value	Region
Pennsylvania	1689.41	7.97	589.77	-11768.30	0.03	54.41	17.76	0.9899	392.51	NE
t-value	1.43	-0.20	1.09	-1.50	0.08	5.03*	1.23			
Delaware	-958.02	23.05	820.46	-8985.07	0.45	27.16	45.91	0.9869	301.98	NE
t-value	-2.00	0.62	2.09*	-3.40*	0.95	6.14*	2.44*			
Maryland	-3461.82	78.12	-934.40	-12188.10	1.32	8.31	117.63	0.9777	175.50	NE
t-value	-5.58*	1.22	-1.06	-2.63*	1.67	0.95	3.04*			
Michigan	-45.93	22.29	216.27	-21525.00	0.32	17.89	47.74	0.9561	83.48	LS
t-value	-0.19	0.66	0.56	-5.04*	0.75	3.30*	5.37*			
Wisconsin	-219.40	12.03	967.49	4715.81	0.07	26.85	-5.35	0.9626	98.66	LS
t-value	-0.89	0.47	2.15*	0.41	0.21	7.13*	-0.47			
Minnesota	358.77	40.84	-247.73	-18794.37	0.60	22.74	2.71	0.9572	85.73	LS
t-value	0.81	1.32	-0.53	-0.63	1.48	9.69*	0.17			
Ohio	62.23	-34.62	103.44	4279.39	-0.25	31.41	-17.33	0.9935	610.92	CB
t-value	0.24	-0.63	0.22	1.58	-0.34	10.32*	-1.97*			
Indiana	-11.81	33.94	-55.63	4915.31	0.50	22.10	-14.77	0.9571	85.52	CB
t-value	-0.01	0.47	-0.06	0.28	0.52	5.85*	-0.52			
Illinois	-127.35	37.93	639.34	12541.97	0.77	29.89	-42.383	0.9795	183.15	CB
t-value	-0.23	0.52	1.11	1.28	0.80	7.63*	-1.715			
Iowa	2046.56	152.70	1188.09	-55271.80	2.02	20.19	-3.32	0.9728	137.09	CB
t-value	1.40	2.40*	1.38	-1.38	2.32*	7.50	-0.35			

TABLE XII (Continued)

States	Intercept	RIRG	F	POP	XCIGD	R	T	R^2	F-Value	Region
Missouri	64.34	-16.15	-341.31	352.88	-0.23	20.20	-0.42	0.9978	1845.45	CB
t-value	0.27	-1.17	-2.39*	0.05	-1.24	18.23*	-0.11			
North Dakota	-101.59	37.05	-9.51	8649.17	0.46	16.94	-2.81	0.9964	739.17	NP
t-value	-0.59	4.13*	-0.12	0.40*	3.91*	11.31*	-4.64*			
South Dakota	-42.50	8.20	17.31	5462.65	0.09	21.69	-1.269	0.9946	767.79	NP
t-value	-0.52	1.20	0.37	0.47	0.93	11.42*	-3.00*			
Kansas	-104.70	35.53	-89.05	1629.28	0.50	20.93	-2.18	0.9911	447.64	NP
t-value	-0.91	2.25*	-0.57	0.19	2.39*	6.12*	-1.082			
Virginia	-963.58	122.00	633.93	-13522.60	1.63	18.84	26.01	0.9792	188.39	AP
t-value	-5.57*	4.71*	1.96*	-1.80*	5.17*	4.57*	1.87*			
West Virginia	-3607.42	78.23	-572.69	30689.55	1.15	0.17	14.57	0.9603	96.70	AP
t-value	-5.82*	1.70	-0.59	3.77*	1.87*	0.03	4.12*			
North Carolina	-1594.69	117.48	-310.14	13601.04	1.68	10.60	-5.46	0.9834	237.06	AP
t-value	-9.17*	5.71*	-1.43	1.44	6.86*	5.08*	-0.49			
Kentucky	-607.43	8.09	-562.00	12219.41	0.24	22.12	-8.35	0.9816	213.73	AP
t-value	-1.10	0.27	-0.93	1.01	0.59	6.83*	-1.41			
Tennessee	-973.86	58.33	-1412.64	14789.68	0.99	17.42	-11.75	0.9908	430.52	AP
t-value	-3.41*	3.53*	-3.89*	1.83*	4.85*	6.10*	-1.83*			

TABLE XII (Continued)

States	Intercept	RIRG	F	POP	XCIGD	R	T	R^2	F-Value	Region
South Carolina	-544.21	49.07	-50.63	8330.42	0.72	29.82	-9.21	0.9884	341.01	SE
t-value	-3.06*	2.72*	-0.49	1.90*	3.21*	5.99*	-2.92*			
Georgia	-1333.68	91.86	-532.42	40124.56	1.40	-1.61	-30.78	0.9889	357.17	SE
t-value	-6.50*	4.90*	-2.21*	5.44*	6.02*	-0.29	-4.71*			
Florida	1893.35	-10.96	-401.23	17908.48	0.06	29.08	-58.51	0.9742	150.75	SE
t-value	2.31*	-0.25	-0.99	4.03*	0.11	5.02*	-3.49*			
Alabama	649.21	32.60	-144.04	-20671.90	0.36	33.83	5.45	0.9757	160.75	SE
t-value	1.74*	1.33	-0.50	-2.35	1.12	7.66*	1.21			
Mississippi	-1052.60	98.34	398.92	7015.49	1.29	12.08	2.09	0.9384	58.39	DS
t-value	-3.12*	2.76*	0.97	0.69	2.73*	3.03*	0.53			
Arkansas	-311.66	39.20	-1114.66	2368.43	0.48	26.53	-1.75	0.9841	247.15	DS
t-value	-1.20	1.42	-2.12*	0.29	1.31	8.04*	-0.80			
Louisiana	-870.64	87.39	551.11	6384.59	1.15	13.91	-1.59	0.9652	106.31	DS
t-value	-4.26*	2.50*	1.78*	0.63*	2.49*	5.76*	-0.14			
Oklahoma	-597.01	1.34	-400.88	40301.98	0.05	5.71	-13.22	0.9891	363.13	SP
t-value	-3.77*	0.05	-1.59	4.16*	0.18	5.51*	-4.15*			

NE = North Eastern States; LS = Lake States; CB = Corn Belt States; NP = Northern Plains States; AP = Appalachian States; SE = Southeast States; DS = Delta States; SP = Southern Plains States

* = Significant at 10% level.

The correlation matrix among variables indicated a high correlation between real interest rate on farm mortgage loans (RIRG) and the interaction between tax rate and inflation (XCIGD). The multicollinearity problem did not occur in the pooled-data model because there are more observations than in the state data set. The multicollinearity can cause the unexpected signs and magnitudes of the coefficients (Maddala, 1977). To correct this problem, the variable XCIGD is dropped from the model.

In the price model (Table XII), all equations show a high R^2. The composite hypothesis that all coefficients are equal to zero is rejected. There are 14 states showing significant coefficients at 10 percent level for real interest rate on farm loans (RIRG) but none of the coefficients has the expected sign. The unexpected sign can be caused by multicollinearity between this variable and the variable XCIGD. The estimated coefficients for variable F are significant in 11 states and 7 of the coefficients show expected signs. The coefficients of population density are significant at the 10 percent level in 15 states. Eight of the coefficients have the expected sign. The variable XCIGD has significant coefficients and expected signs in 16 states. The estimated coefficients of variable R are also significant at that level in 32 states and only 1 coefficient does not have the expected sign. The coefficients of the time variable are significant in 17 states.

The price model exhibits results similar to the ratio model. The estimated coefficients for both ratio and price models are shown in Tables XIII and XIV.

In the ratio model, the calculated F-values for all equations indicate that the composite hypothesis for all estimated coefficients

TABLE XIII

ESTIMATED COEFFICIENT FOR THE RATIO OF NET CASH RENT FOR FARMLAND PRICE MODEL (RA)

States	Intercept	RIRG	F	POP	T	R^2	F-Value	Region
Maine	47.253	0.318	-6.138	-1573.770	0.172	0.7190	16.330	NE
t-value	4.754*	1.301	-0.516	-2.659*	1.097			
New Hampshire	12.311	-0.164	-4.065	-191.552	0.112	0.4987	6.467	NE
t-value	2.185*	-0.637	-0.862	-1.072	0.393			
Vermont	18.430	-0.091	-9.479	-462.177	0.124	0.7688	21.611	NE
t-value	7.525*	-0.658	-1.536	-2.847*	1.329			
Massachusetts	16.216	-0.003	-3.511	-5.454	-0.148	0.7458	19.071	NE
t-value	2.987*	-0.020	-0.627	-0.360	-1.796*			
Rhode Island	19.867	0.127	3.740	-12.097	-0.114	0.8135	28.352	NE
t-value	3.429*	1.032	1.029	-1.107	-1.852*			
Connecticut	9.013	0.125	1.228	-12.702	-0.007	0.6254	10.852	NE
t-value	4.541*	1.007	0.304	-1.567	-0.094			
New York	-0.485	0.129	-8.438	33.183	-0.099	0.7592	20.497	NE
t-value	-0.204	1.591	-2.203*	3.826*	-4.461*			
New Jersey	8.602	0.004	-0.156	-11.237	0.039	0.8841	49.561	NE
t-value	11.885*	0.087	-0.061	-5.546*	1.645			

TABLE XIII (Continued)

States	Intercept	RIRG	F	POP	T	R^2	F-Value	Region
Pennsylvania	8.981	0.076	-1.068	3.745	-0.103	0.9566	143.362	NE
t-value	3.848*	2.086*	-0.444	0.297	-6.190*			
Delaware	10.229	0.037	-4.548	44.255	-0.257	0.5740	8.760	NE
t-value	5.938*	0.348	-1.018	3.007*	-3.486*			
Maryland	11.156	0.093	4.347	-32.232	0.053	0.8978	57.129	NE
t-value	9.208*	1.177	0.839	-4.012*	0.964			
Michigan	8.419	0.066	1.534	50.473	-0.175	0.9451	111.892	LS
t-value	11.057*	1.862*	0.774	3.815*	-7.583*			
Wisconsin	10.296	0.055	-6.800	52.112	-0.121	0.8904	52.826	LS
t-value	4.712*	0.993	-1.673	0.536	-1.401			
Minnesota	-0.305	-0.007	-3.991	481.136	-0.233	0.3542	3.428	LS
t-value	-0.084	-0.147	-1.112	2.088*	-2.156*			
Ohio	5.044	0.034	0.153	10.529	-0.049	0.6939	14.736	CB
t-value	6.485*	1.137	0.076	1.806*	-3.495*			
Indiana	0.865	0.035	2.189	116.857	-0.172	0.3545	3.570	CB
t-value	0.377	0.574	0.495	2.943*	-3.255*			
Illinois	2.453	0.004	-3.499	31.728	-0.055	0.3132	2.850	CB
t-value	1.700*	0.127	-1.673	1.975*	-1.972*			
Iowa	-3.494	-0.102	-17.316	210.838	-0.009	0.4360	4.831	CB
t-value	-0.438	-2.291*	-3.916*	1.034	-0.266			

TABLE XIII (Continued)

States	Intercept	RIRG	F	POP	T	R^2	F-Value	Region
Missouri	5.074	0.021	3.484	85.056	-0.072	0.3830	4.035	CB
t-value	0.939	0.396	0.839	0.584	-1.118			
North Dakota	19.086	0.019	-10.474	-1495.480	0.039	0.4352	5.009	NP
t-value	1.962*	0.191	-2.492*	-1.243	1.463			
South Dakota	10.112	-0.029	-0.708	-103.705	-0.045	0.4392	4.895	NP
t-value	2.330*	-0.650	-0.421	-0.200	-3.788*			
Kansas	5.382	0.002	-1.138	129.640	-0.054	0.3338	3.132	NP
t-value	1.764*	0.040	-0.432	0.756	-1.917*			
Virginia	17.779	0.152	-3.251	-53.660	-0.086	0.7264	16.590	AP
t-value	7.589*	1.051	-0.465	-0.289	-0.266			
West Virginia	43.289	0.338	24.197	-285.232	-0.251	0.8425	34.762	AP
t-value	4.139*	1.988*	1.195	-2.231*	-6.856*			
North Carolina	29.299	0.246	7.054	-23.246	-0.313	0.7560	16.364	AP
t-value	6.104*	1.816*	1.382	-0.104	-1.090			
Kentucky	22.418	0.168	8.011	-246.120	0.053	0.7833	23.491	AP
t-value	5.677*	1.794*	1.046	-2.332*	0.737			
Tennessee	23.711	0.344	19.826	-151.731	-0.056	0.9249	80.018	AP
t-value	10.067*	3.697*	2.628*	-1.668	-0.576*			

TABLE XIII (Continued)

States	Intercept	RIRG	F	POP	T	R^2	F-Value	Region
South Carolina	19.485	0.098	-0.332	-52.924	-0.134	0.9270	79.366	SE
t-value	17.083*	1.801*	-0.238	-1.073	-2.402*			
Georgia	26.330	0.062	-0.484	-80.171	-0.186	0.8468	34.546	SE
t-value	13.756*	0.558	-0.079	-0.472	-0.916			
Florida	12.793	0.017	3.234	-44.560	-0.053	0.6589	12.073	SE
t-value	1.135	0.145	0.620	-0.707	-0.192			
Alabama	8.178	0.011	-10.599	470.168	-0.473	0.8780	46.774	SE
t-value	1.484	0.080	-1.564	2.456*	-4.194*			
Mississippi	28.302	0.118	-1.889	112.827	-0.369	0.9081	64.216	DS
t-value	5.132	0.778	-0.221	0.589	-5.487*			
Arkansas	25.982	0.030	24.928	-149.468	-0.215	0.9156	70.559	DS
t-value	10.540*	0.367	2.664*	-1.297	-5.588*			
Louisiana	17.067	0.023	1.567	-60.162	-0.096	0.7131	15.534	DS
t-value	9.018*	0.215	0.340	-0.396	-0.576			
Oklahoma	10.309	-0.027	1.534	-68.467	-0.054	0.9218	76.645	SP
t-value	16.698*	-0.671	0.588	-1.109	-2.010*			

*Significant at 10% level.

TABLE XIV

ESTIMATED COEFFICIENT FOR FARMLAND PRICE MODEL (V)

States	Intercept	RIRG	F	POP	R	T	R^2	F-Value	Region
Maine	-2059.81	-5.82	858.73	81392.83	-0.22	-6.35	0.6059	7.37	NE
t-value	-2.66*	-0.56	2.18*	1.78*	-0.03	-0.53			
New Hampshire	32.36	35.84	28.57	70695.60	4.09	-81.41	0.8717	32.61	NE
t-value	0.08	2.73*	0.10	5.72*	0.56	-4.21*			
Vermont	-1416.73	11.76	184.46	41496.28	8.32	-5.64	0.8650	20.00	NE
t-value	-6.50*	1.68	0.48	2.68*	2.23*	-0.63			
Massachusetts	2090.11	-36.81	606.53	-12012.67	20.71	97.93	0.9015	45.75	NE
t-value	2.68	-1.86*	0.76	-5.59*	2.17*	8.34*			
Rhode Island	-2868.34	-50.88	-382.29	731.80	24.81	42.23	0.7271	13.32	NE
t-value	-1.68	-1.39	-0.34	0.22	2.86	2.11*			
Connecticut	-1454.91	-45.11	1302.80	-3977.39	8.53	62.48	0.9435	83.45	NE
t-value	-5.08*	-2.52*	2.25*	-3.26*	1.46	5.21*			
New York	274.53	3.15	208.27	-3181.72	4.40	15.29	0.9869	376.41	NE
t-value	4.51*	1.48	1.93*	-11.05*	1.41	9.43*			
New Jersey	-2968.87	-3.72	2953.05	-9966.48	-23.48	191.34	0.9807	254.07	NE
t-value	-11.45*	-0.20	3.24	-9.85*	-2.63*	14.69*			

TABLE XIV (Continued)

States	Intercept	RIRG	F	POP	R	T	R^2	F-Value	Region
Pennsylvania	1703.24	-10.96	595.67	-11765.39	54.76	17.74	0.9899	490.50	NE
t-value	1.49	-1.24	1.13	-1.53	5.64*	1.26			
Delaware	-938.88	-11.07	852.52	-9839.96	24.56	51.78	0.9864	363.44	NE
t-value	-1.97*	-1.19	2.18*	-3.97*	6.27*	2.92*			
Maryland	-3842.18	-27.03	-1169.56	-16792.18	4.018	158.27	0.9751	195.80	NE
t-value	-6.42*	-1.96*	-1.29	-4.35*	0.47	5.07*			
Michigan	202.37	-4.42	-238.08	-19801.39	29.02	40.36	0.9770	211.97	LS
t-value	1.27	-0.59	-0.50	-5.03*	4.87*	4.59*			
Wisconsin	-204.43	6.71	1108.58	4161.88	20.83	-4.51	0.9593	113.13	LS
t-value	-0.88	1.30	2.60*	0.37	7.53*	-0.40			
Minnesota	423.30	-4.09	102.28	14832.17	24.02	1.99	0.9548	101.39	LS
t-value	0.94	-0.73	0.24	-0.48	10.68*	0.12			
Ohio	-0.75	-15.69	67.75	4177.26	30.60	-17.33	0.9935	759.81	CB
t-value	-0.01	-2.30*	0.15	1.58	16.00*	-2.01*			
Indiana	119.64	-3.37	-88.62	4829.63	23.24	-13.89	0.9574	107.87	CB
t-value	0.18	-0.36	-0.11	0.28	7.61*	-0.50			
Illinois	110.61	-19.54	690.98	11711.75	31.37	-39.47	0.9797	231.65	CB
t-value	0.24	-2.11*	1.22	1.22	8.94*	-1.64			
Iowa	1286.91	5.32	1713.17	-21999.44	24.46	-6.61	0.9617	120.52	CB
t-value	0.83	0.69	1.93*	-0.53	11.25*	-0.64			

TABLE XIV (Continued)

States	Intercept	RIRG	F	POP	R	T	R^2	F-Value	Region
Missouri	3.64	0.66	-358.83	28.11	19.01	-0.33	0.9977	2167.62	CB
t-value	0.01	0.34	-2.50*	0.01	33.96*	-0.09			
North Dakota	-211.82	2.58	-86.53	41264.27	21.77	-3.26	0.9912	561.85	NP
t-value	-1.00	1.23	-0.90	1.65	20.44*	-4.37			
South Dakota	-56.50	0.74	8.90	10894.85	23.33	-1.34	0.9946	925.82	NP
t-value	-0.71	0.68	0.19	1.10	32.08*	-3.25			
Kansas	-64.86	-1.57	-87.03	10833.77	28.14	-4.54	0.9890	450.74	NP
t-value	-0.52	-0.51	-0.51	1.36	15.96*	-2.36*			
Virginia	-408.05	-6.13	940.18	-17677.32	34.21	32.24	0.9560	108.75	AP
t-value	-2.11*	-0.58	2.08*	-1.66	8.42*	1.64			
West Virginia	-4233.48	-6.967	-344.20	40671.06	3.90	19.63	0.9545	104.79	AP
t-value	-7.72*	-0.79	-0.33	6.31*	0.90	8.19*			
North Carolina	-2014.51	-7.71	-540.38	38805.35	9.35	-25.54	0.9099	48.47	AP
t-value	-8.15*	-0.97	-1.85*	3.28*	3.30*	-1.70*			
Kentucky	-594.70	-10.00	-567.76	14248.22	23.26	-9.69	0.9814	263.19	AP
t-value	-1.09	-1.67	-0.95	1.25	9.04*	-1.80*			
Tennessee	-1089.78	-19.31	-1635.12	29131.17	20.38	-24.20	0.9818	269.17	AP
t-value	-2.77*	-3.47*	-3.29*	2.81*	5.30*	-2.99*			

TABLE XIV (Continued)

States	Intercept	RIRG	F	POP	R	T	R^2	F-Value	Region
South Carolina	-617.66	-3.26	-85.00	15127.27	29.59	-11.76	0.9681	151.73	SE
t-value	-3.05*	-0.86	-0.88	3.12*	5.18*	-2.92*			
Georgia	-1099.15	-9.67	-657.26	43784.12	2.57	-29.45	0.9386	73.37	SE
t-value	-5.73*	-1.86*	-2.37*	4.68*	0.47	-3.06*			
Florida	1972.43	-15.70	-414.61	18329.81	29.17	-60.00	0.9741	188.33	SE
t-value	4.58*	-1.669	-1.09	7.46*	5.18*	-5.80*			
Alabama	889.35	5.82	-61.54	-23256.02	37.40	6.23	0.9744	190.65	SE
t-value	2.89*	1.07	-0.22	-2.72*	12.17*	1.38			
Mississippi	-610.02	-0.56	948.25	7309.63	20.31	1.33	0.9428	82.35	DS
t-value	-1.71*	-0.07	1.90*	0.69	5.10*	0.33			
Arkansas	-165.10	3.47	-1221.76	3175.05	29.52	-1.83	0.9829	287.89	DS
t-value	-0.69	0.73	-2.32	0.38	12.22*	-0.82			
Louisiana	-401.92	-0.47	535.08	2997.35	20.33	1.58	0.9783	225.17	DS
t-value	-2.68*	-0.06	1.48	0.32	10.39*	0.16			
Oklahoma	-584.59	-3.01	-399.50	40937.03	26.20	-13.46	0.9891	453.25	SP
t-value	-4.11*	-0.75	-1.61	4.60*	6.92*	-4.71*			

*Significant at 10% level.

equal to zero can be rejected. The performance of this model, in terms of the expected signs, is improved. Eight states have significant coefficients at the 10 percent level for the variable RIRG. Only one of these coefficients does not have the expected sign. The coefficients of variable F are significant at the 10 percent level in 6 states and 4 states show the expected sign. The coefficients of population density (POP) are significant in 14 states and 6 of these coefficients show the expected sign. The coefficients of time variable are significant in 17 states.

Most estimated coefficients in the ratio model show the expected sign even though several are not significant. The empirical results from the econometric model for most states support the theoretical framework in Chapter II. When the real interest rate on farm mortgage loans (RIRG) increases, it causes the rent-farmland price ratio to increase due to the declining land price. The proportion of Federal Land Bank loans made to the total agricultural debt (F) indicates that a greater Federal Land Bank role in farm credit market causes farmland price to increase relative to rent in most states. Increases in population density reduce the rent-farmland price ratio in most states.

The estimated price model in Table XIV without XCIGD shows improvements over the model in Table XII. The values of R^2 remain high. The composite hypothesis of all estimated coefficients except the intercept term equal to zero is rejected in all states. In addition, the number of expected signs increased for all variables, especially variable RIRG. In the latter model, the coefficients of variable RIRG are significant at 10 percent level in 8 states and only

1 of these coefficients show an unexpected sign. The coefficients of variable F are significant at the 10 percent level in 14 states. Nine of these coefficients have the expected sign. The net cash rent variable (R) has significant coefficients in 28 states and only 1 of these coefficients show unexpected signs. The coefficients of the time variable are significant in 21 states.

In summary, coefficients in the price model indicate that increases in real interest rates on farm mortgage loans depress farmland price whereas increases in Federal Land Bank involvement, population density, and net cash rent boost farmland price in most states.

An Alternative Value for Rent Variable in the Price Model

Previously, rent has been used to represent farmland earnings. The cash rent variable measures land earnings imperfectly. Some past studies suggest that farm income is a useful proxy for land earnings. Thus, rent will be replaced by net farm income in reestimating an equation for each state. The results are presented in Table XV. The values of the R^2 in most states are high and the hypothesis that all coefficients equal zero is rejected in all equations. The number of expected signs on variables is reduced when compared to the equations using rent. The coefficients of variable RIRG have the expected sign in 18 states compared to 25 states in the old model. Coefficients of variables F and POP show the expected sign in 13 and 17 states, respectively. The coefficients of net farm income show the expected sign in 14 states compared to 33 states for the rent variable.

TABLE XV

ESTIMATED COEFFICIENT FOR LAND PRICE
MODEL USING NET FARM INCOME

States	Intercept	RIRG	F	POP	RI	T	R^2	F-Value	Region
Maine	-2149.33	-6.62	1734.18	94571.29	-2.99	-10.98	0.8749	34.97	NE
t-value	-5.54*	-0.69	3.54*	4.12*	-4.76*	-1.81*			
New Hampshire	-76.12	31.21	142.01	61861.91	-7.98	-66.76	0.9311	67.57	NE
t-value	-0.28	2.57*	0.56	6.76*	-2.68*	-4.58*			
Vermont	-1494.00	9.85	97.75	45984.22	0.71	-6.70	0.7978	18.93	NE
t-value	-5.32*	1.22	-0.02	2.76*	0.33	-0.72			
Massachusetts	2096.25	-26.17	125.53	-12296.33	-3.81	105.41	0.8983	44.16	NE
t-value	2.64*	-1.25	0.15	-1.94*	-1.94*	8.27*			
Rhode Island	-2976.11	-53.28	534.36	3061.11	-0.51	17.96	0.6380	8.81	NE
t-value	-1.49	-1.19	0.43	0.81	-0.18	0.85			
Connecticut	-1439.29	-46.20	1471.33	-4952.01	-1.46	73.75	0.9408	79.49	NE
t-value	-4.92*	-2.51*	2.38*	-3.91*	-0.96	5.54*			
New York	255.94	1.18	59.71	-3341.82	-1.13	17.57	0.9882	419.60	NE
t-value	4.47*	0.51	0.60	-15.65*	-2.25*	32.53*			
New Jersey	-2934.92	-1.85	3272.69	-8297.67	-1.49	167.33	0.9758	201.90	NE
t-value	-8.99*	-0.08	3.00*	-9.71*	-0.72	16.91*			

TABLE XV (Continued)

States	Intercept	RIRG	F	POP	RI	T	R^2	F-Value	Region
Pennsylvania	7197.56	10.56	1018.88	-50508.88	1.44	91.20	0.9773	215.56	NE
t-value	7.96*	0.88	1.27	-9.64*	0.56	11.21*			
Delaware	-4046.42	-6.16	1120.26	-24765.00	-1.80	166.80	0.9697	159.77	NE
t-value	-15.48*	-0.44	1.96*	-12.04*	-1.94*	14.98*			
Maryland	-3967.38	-24.87	-1240.95	-17914.98	1.79	166.16	0.9758	201.42	NE
t-value	-15.66*	-1.80*	-1.39	-11.92*	0.96	14.56*			
Michigan	-28.25	-1.76	1017.03	-32160.46	-2.40	76.74	0.9392	74.14	LS
t-value	-0.12	-0.23	2.64*	-8.45*	-1.62	12.29*			
Wisconsin	151.51	18.79	2324.39	-36646.53	3.58	40.68	0.9187	54.24	LS
t-value	0.38	1.96*	3.22*	-2.00*	1.49	2.37*			
Minnesota	780.36	11.53	1505.95	-173932.70	-0.31	111.89	0.7804	17.05	LS
t-value	0.67	0.70	1.38	-2.34*	-0.13	3.16*			
Ohio	74.29	2.28	1411.78	-24008.76	0.18	94.67	0.8383	24.88	CB
t-value	0.11	0.14	1.06	-4.83*	0.08	8.30*			
Indiana	2332.08	-16.18	1397.30	-93518.90	2.15	165.57	0.8341	24.13	CB
t-value	2.12*	-1.02	1.02	-4.96*	1.04	6.83*			
Illinois	1683.35	0.11	1739.50	-61392.10	-0.004	159.27	0.8879	38.01	CB
t-value	1.83*	0.01	1.62	-6.09*	-0.003	9.23*			
Iowa	4324.61	22.46	7642.18	-183963.15	0.28	76.31	0.7983	18.99	CB
t-value	0.96	0.91	3.09*	-1.59	0.09	3.49*			

TABLE XV (Continued)

States	Intercept	RIRG	F	POP	RI	T	R^2	F-Value	Region
Missouri	907.21	-4.71	-96.37	-62760.62	-1.18	53.68	0.8037	19.62	CB
t-value	0.91	-0.59	-0.15	-2.32*	-0.51	4.35*			
North Dakota	-1445.18	1.25	219.62	90656.57	-1.20	11.21	0.7771	16.73	NP
t-value	-2.42*	0.24	0.97	1.21	-0.86	5.10*			
South Dakota	-385.02	1.30	-38.25	-13696.63	-1.38	9.92	0.7275	12.81	NP
t-value	-0.94	0.34	-0.29	-0.28	-0.85	7.44*			
Kansas	-369.62	5.38	459.49	-25620.05	-0.53	18.72	0.8008	19.29	NP
t-value	-0.92	0.90	1.38	-1.13	-0.39	4.80*			
Virginia	-1570.14	8.00	-154.43	-8217.25	3.49	41.86	0.7456	14.06	AP
t-value	-6.66*	1.08	-0.43	-0.69	1.35	2.02*			
West Virginia	-4033.02	-8.46	158.84	40125.46	-6.34	17.97	0.9547	105.26	AP
t-value	-6.26*	-0.96	0.15	6.12*	-0.96	4.88*			
North Carolina	-1901.84	-6.92	-879.32	49790.59	4.68	-44.02	0.9436	83.68	AP
t-value	-5.93*	-0.61	-2.17*	3.42*	3.60*	-2.51*			
Kentucky	-3142.26	-10.37	-2492.60	57132.74	7.87	-17.68	0.9458	87.30	AP
t-value	-4.61*	-1.00	-2.77*	3.48*	3.42*	-1.89*			
Tennessee	-3068.38	-19.81	-2866.43	77058.24	-1.659	-54.875	0.9622	127.13	AP
t-value	-14.80*	-2.38*	-4.31*	9.67*	-0.78	-6.53*			

TABLE XV (Continued)

States	Intercept	RIRG	F	POP	RI	T	R^2	F-Value	Region
South Carolina	-1538.72	-3.21	-43.99	31573.95	-2.95	-13.02	0.9456	83.43	SE
t-value	-14.32*	-0.66	-0.35	6.84*	-2.59*	-2.50*			
Georgia	-1213.68	-8.86	-601.41	42459.13	-0.87	-25.46	0.9313	65.06	SE
t-value	-12.23*	-2.10*	-2.49*	5.52*	-1.40	-2.79*			
Florida	1308.76	-38.91	-366.90	10404.86	4.57	-34.47	0.9668	145.46	SE
t-value	2.30*	-4.31*	-0.84	2.67*	3.92*	-2.36*			
Alabama	-1695.20	0.51	-76.17	21109.36	1.24	6.99	0.7805	17.06	SE
t-value	-3.27*	0.05	-0.18	1.28	0.87	0.72			
Mississippi	-1927.00	7.40	782.56	23306.35	-0.94	15.25	0.8323	23.82	DS
t-value	-4.38*	0.78	1.46	1.64	-0.54	3.07			
Arkansas	-2069.47	16.01	390.73	33403.85	1.07	15.65	0.8005	19.26	DS
t-value	-5.67*	1.94*	0.52	2.10*	0.73	2.63*			
Louisiana	-1788.43	1.41	914.06	35360.72	0.45	-11.27	0.8312	23.63	DS
t-value	-7.16*	0.11	1.71*	1.78*	0.22	-0.50			
Oklahoma	-1446.11	-2.72	-91.46	72567.28	-0.27	-15.00	0.9373	71.75	SP
t-value	-13.05*	-0.48	-0.24	6.59*	-0.21	-2.97*			

*Significant at 10% level.

Some Explanations on the Sign Of Estimated Coefficients

In the previous section, mention was made of the expected signs for each variable. However, some coefficients do not show the expected signs. The problem may be caused by many factors. The first factor can be embedded in the methodology used in this study such as the assumption of linearity between dependent and independent variables in the models. This assumption might not be true in all models but it is necessary due to the lack of knowledge of true functional forms. The second can be caused by the theoretical framework in the study. The framework in this study is based on the capitalization formula and incorporates the concept of expectations about future earnings and discount rates. Generally this concept can be used to explain the price of capital stock. Nevertheless, this concept might not hold in some cases. The third factor that can distort the sign of coefficients is the data. Some data cannot be obtained directly. Imperfect proxies must be used. The final factor may be caused by a unique relationship between variables in some areas. Thus the signs of coefficients may be different from the expected. These factors represent only a few possible causes for unexpected signs in the model coefficients. For example, one of the factors that shows a high frequency of unexpected sign of coefficient is the proportion of Federal Land Bank loan made to total agricultural debts. This factor is introduced to capture the share or importance of Federal Land Bank in agricultural credit market. Since the data for total agricultural loans made for each state were not available, the total agricultural debts were used as proxies. Under this scenario, it is assumed that a direct relationship exists between agricultural debts and agricultural loans. In some cases, this relationship might not always hold because the increases in total loans made do not necessarily lead to increases in total agricultural debts due to high rate of repayment of the old loans. The agricultural debts become imperfect proxies for annual agricultural loans made to the farmers. Therefore, the signs of the coefficient can be distorted from the expected ones.

In this chapter, the empirical result for each model was presented. Several equations by state were estimated to use in selecting the most appropriate model. A brief explanation on the polynomial distributed lag model was also presented. In the next chapter, a series of hypotheses will be tested by using the models in this chapter.

CHAPTER V

MODEL STABILITY TEST

The purpose of this chapter is to test the hypotheses advanced in Chapter I. A regression analysis will be applied to explain farmland price behavior. The results will be used for analysis and prediction.

The Stability of Regression Coefficients

Economic Determinants of Farmland Price Over Time

The hypothesis that the economic structure of farmland price determination does not vary over time is tested using the Chow procedure. The data are divided into two sets. The first set covers the period 1952 to 1969 while the second set covers the period 1970 to 1982. The inflation rate was low and government programs strongly influenced commodity prices during the 1952 to 1969 period. General economic conditions, particularly agricultural market prices, were unstable during the second period. In addition, farmland prices rose persistently in most states for most of this latter period. The model structural coefficients could have remained unchanged despite changes in the variables between the two periods. Chow's F-test for structural stability can be calculated as:

$$F = \frac{(ESSR - ESSU)/k + 1}{ESSU/(n_1 + n_2 - 2k - 2)}$$

where

ESSR = error sum squares for restrict model

ESSU = error sum squares for unrestrict model

n_1 = number of observations in the first period

n_2 = number of observations in the second period

k = number of explanatory variables excluding intercept term.

If the calculated F-values exceed the critical F-values the hypothesis postulated is rejected. This implies that the estimated coefficients for the two periods are statistically different. The calculated F-values for the states considered are given in Table XVI.

The first column of Table XVI shows the F-values for the rent-farmland price model. The results indicate that the hypothesis of structural stability is rejected in 12 of the 35 states studied. There are significant changes in the size of coefficients between these 2 periods in 12 states but in 23 states the response of the rent-land price ratio has remained unchanged despite different levels of the real rate of interest, population pressure, and Federal Land Bank involvement.

Column 2 presents the calculated F-values for the price model with rent as the predetermined variable. In contrast to the Ratio model, the hypothesis of structural stability is rejected in most of the states. The price model with net farm income indicates that the coefficients between the periods have changed for 29 states. The conclusion is that the coefficients of price models are less stable over time than the coefficient in the ratio model.

TABLE XVI

TEST OF MODEL STABILITY BETWEEN 1952-1969
AND 1970-1982 PERIODS BY STATES

States	Calculated F-Values		
	Rent-Land Price Model	Price Model With Rent	Price Model With Income
Maine	3.74*	7.28*	5.73*
New Hampshire	0.87	1.48	4.49*
Vermont	0.22	8.83*	9.55*
Massachusetts	0.45	4.22*	2.04
Rhode Island	0.64	3.30*	0.81
Connecticut	0.73	0.73	0.62
New York	1.91	1.66	2.70*
New Jersey	1.19	5.87*	3.26*
Pennsylvania	3.92*	2.56	10.05*
Delaware	3.12*	2.17	3.78*
Maryland	0.59	5.29*	5.36*
Michigan	0.92	2.56	6.52*
Wisconsin	1.04	4.71*	4.08*
Minnesota	5.04*	6.12*	32.35*
Ohio	1.57	3.71*	1.77
Indiana	1.14	3.46*	3.88*
Illinois	1.34	0.53	2.67*
Iowa	1.88	2.78*	11.15*
Missouri	0.17	1.01	13.09*
North Dakota	4.02*	6.32*	56.33*
South Dakota	7.37*	3.46*	21.05*
Kansas	2.05	11.05*	38.63*
Virginia	2.63	32.04*	27.46*
West Virginia	0.11	2.64*	2.15
North Carolina	1.42	20.36*	30.13*
Kentucky	0.52	3.58*	14.60*
Tennessee	3.09*	11.95*	20.58*
South Carolina	2.81*	20.42*	49.20*
Georgia	2.67	9.73*	9.31*
Florida	5.89*	3.36*	1.66
Alabama	1.32	54.00*	82.46*
Mississippi	2.77*	24.93*	26.08*
Arkansas	3.29*	14.20*	28.37*
Louisiana	4.12*	7.77*	41.17*
Oklahoma	2.25	7.01*	7.04*

* = significant at 5% level

Regional Effect on the Structure of Farmland Models

The econometric models in Chapter IV were estimated using pooled data. The models assumed that the coefficients of the explanatory variables were the same in all the states. Chow's approach also is used to test the validity of this assumption.

Table XVII presents the calculated F-values for each model. The results indicate that the coefficients vary across the states. The existence of state differences imply that the estimated coefficients from the state models are more appropriate to use for predicting state level values than those from pooled data models.

Farmland Pricing: 1979-1982

The recent decline in farmland prices have been attributed to its overvaluation of land in the late 1970s and early 1980s. "Overvaluation" may be attributed to speculation and other factors unjustified by prospective future earnings of farmland. A comparison of the actual and predicted values would shed some light on this issue. Higher than predicted values would suggest that the farmland is overpriced in relation to historic standards. The comparison would not indicate the precise deviation from the past trend due to the estimation procedure. The estimated coefficients from OLS method are influenced by actual values during the period under study. However, the differences between actual and predicted values can be considered as lower limits of deviation.

A comparison for price models are shown in Table XVIII and XIX. These tables are limited to only selected farming states. The

TABLE XVII

TEST OF MODEL STABILITY AMONG STATES

Models	Calculated F-Values
Rent-Farmland Price	4.27*
Price Model with Rent	4.14*
Price Model with Farm Income	1.94*

* = significant at 5% level

Northeastern States are omitted because these states have the least reliable data and did not experience significantly declining farmland values.

Table XVIII is derived from price model with rent as an explanatory variable. The data show that in 1979 and 1980 the actual values were higher than the predicted values in most states. However, predicted errors are less than 8 percent in all states. Thus, it does not indicate unusual price differences from the regression trend. The error does not suggest that land was greatly overpriced by historic standards.

The price model with farm income in Table XIX also shows that actual values are higher than predicted values in the same period. The predicted errors are higher than those from the previous model. All states show predicted error less than 10 percent except for Ohio and Indiana. The price models suggest that most states do not show a strong evidence of farmland overpricing during the period of 1979 and 1980. Thus, the sharp recent decline in farmland price can be better explained by changes in variables in the farmland market rather than by over pricing farmland in the past.

Concluding Remarks on Explanatory Variables in Farmland Models

In the earlier chapters, many variables were introduced into farmland models. Some of the variables were important in explaining farmland market behavior but some of them were not. Remarks on some of these variables are made in this section.

TABLE XVIII

FARMLAND PRICES BY STATE AND PREDICTED ERROR
USING FARMLAND PRICE MODEL WITH RENT

	Actual Land Price ($)				Predicted Error ($)				Percentage Error (%)			
States	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
Michigan	885	1039	1202	1196	17	33	67	21	1.92	3.17	5.57	1.75
Wisconsin	746	877	949	1007	26	-22	29	32	3.48	-2.50	3.05	3.17
Minnesota	1015	1221	1328	1384	0	-20	76	-10	0	-1.63	5.72	-0.72
Ohio	1675	1808	1868	1715	-7	108	-25	-22	-0.41	5.97	-1.33	-1.28
Indiana	1622	1929	1986	1840	81	19	121	-49	4.99	0.98	6.09	-2.66
Illinois	2126	2292	2393	2265	70	83	22	-97	3.29	3.62	0.91	-4.28
Iowa	1780	2060	2174	2117	82	89	-2	-27	4.60	4.32	-0.09	-1.27
Missouri	746	866	899	916	16	7	1	6	2.14	0.80	0.11	0.65
North Dakota	360	399	431	468	7	7	1	5	1.94	1.75	0.23	1.06
South Dakota	293	339	359	375	4	17	-9	1	1.36	5.01	-2.50	0.26
Kentucky	854	949	959	1037	64	24	8	-21	7.49	2.52	0.83	-2.02
Tennesee	755	846	877	909	30	26	-5	1	3.97	3.07	-0.57	0.11
Georgia	630	713	739	733	19	17	-6	-7	3.01	2.38	-0.81	-0.95
Alabama	494	580	691	759	-4	-14	16	-3	-0.80	-2.41	2.31	-0.39
Arkansas	702	764	889	1053	37	-10	-7	11	5.27	-1.30	-0.78	1.04
Oklahoma	510	597	620	696	-19	36	-7	-6	-3.72	6.03	-1.12	-0.86

TABLE XIX

FARMLAND PRICES BY STATE AND PREDICTED ERROR USING FARMLAND PRICE MODEL WITH NET FARM INCOME

States	Actual Land Price ($)				Predicted Error ($)				Percentage Error (%)			
	1979	1980	1981	1982	1979	1980	1981	1982	1979	1980	1981	1982
Michigan	885	1039	1202	1196	1	62	-14	3	0.11	5.96	-1.16	0.25
Wisconsin	746	877	949	1007	13	-9	11	70	1.74	-1.02	1.15	6.95
Minnesota	1015	1221	1328	1384	-10	-18	77	-5	-0.98	-1.47	5.79	-0.36
Ohio	1675	1808	1868	1715	281	145	60	-77	16.77	8.02	3.21	-4.48
Indiana	1622	1929	1986	1840	66	238	80	-177	4.06	12.33	4.02	-9.61
Illinois	2126	2292	2393	2265	89	228	75	-188	4.18	9.94	3.13	-8.30
Iowa	1780	2060	2174	2117	76	82	-20	-18	4.26	3.98	-0.92	-0.85
Missouri	746	866	899	916	38	12	22	-16	5.09	1.38	2.44	-1.74
N. Dakota	360	399	431	468	-2	4	-6	8	-0.55	1.00	-1.39	1.70
S. Dakota	293	339	359	375	1	21	-5	-7	0.34	6.19	-1.39	-1.86
Kentucky	854	949	959	1037	65	17	23	-27	7.61	1.79	2.39	-2.60
Tennesee	755	846	877	909	21	42	7	-6	2.78	4.96	0.79	-0.66
Georgia	630	713	739	733	-14	4	-5	-15	-2.22	0.56	-0.67	-2.04
Alabama	494	580	691	759	2	-6	19	-5	0.40	-1.03	2.74	-0.65
Arkansas	702	764	889	1053	24	7	-14	17	3.41	0.91	-1.57	1.61
Oklahoma	510	597	620	696	13	31	-16	-2	2.54	5.19	-2.58	-0.28

Real Interest Rate on Farm Mortgage Loans

This variable is considered as an opportunity cost or discount rate for investing in farmland. In the pooled model (Table X) for rent-farmland price ratio, the estimated coefficient shows for every 1 percentage point increase in real interest rate on farm mortgage loans, the ratio of rent to farmland price increases by 0.3 percent, other things equal. During 1980 the average real interest rate on farm mortgage loans was -1.07 percent at the national level. In 1982 the average real interest rate increased to 3.6 percent or by 4.67 percentage points within 2 years. Therefore, the average value of rent-farmland price ratio was predicted to increase by about 1.4 percent. This result partially explains the increases in the value of the ratio in recent years. If the rent-farmland price ratio is considered as a rate of return on farmland and real interest rate as opportunity cost, then the higher value of the opportunity cost would cause the farmland market to adjust to obtain higher rate of return (ratio). An increase in rate of return can be accomplished by either an increase in rent or a decrease in farmland price or a combination of both.

In the price model at the aggregated level, real interest rate on farm mortgage loans did not show the expected sign due to multicollinearity in the estimated model. The sign and the magnitude of the coefficient can be misleading. Therefore, it can not be used to explain the effect of this variable on the price model.

The Share of Credit Institutions on Total Agricultural Loans

This factor is used to represent the importance of the credit institutions on farmland models. In this study only the proportion of Federal Land Bank loans to total agricultural debts showed a significant coefficient. The econometric models indicate that, at the aggregated level, a 1 percent increase in proportion of loans made cause a decline in rent-farmland price by 0.013 percent.

The price model showed that 1 percent increase in the proportion of loans made by the Federal Land Bank enhances the farmland price by 1.85 dollars at the aggregated level. Although this variable is important in farmland models, its effects on the dependent variables are very small. For example, a 10 percent increase in the share of Federal Land Bank causes a decline of 0.13 percent in the value of rent-farmland price ratio and an increase of 18.5 dollars in farmland price.

Urbanization Factor

The population density is used as a proxy for this factor. This variable coefficient is significant in both price and ratio models. At the aggregate level, the ratio model indicated that an increase of 1 person/square mile reduces the value of ratio by 0.0044 percent. The average population density for 35 states studied was 204 persons/square miles and was 206 persons/square mile in 1980 and 1982 respectively. Given an increase of 2 persons/square mile, the population factor should depress the value of the ratio by about 0.009 percent.

In the aggregated price model, a unit increase in population density is predicted to increase farmland price by 1.05 dollars. Hence from 1980 to 1982, the population factor on average increased farmland price by 2.10 dollars. Like the Federal Land Bank variable, population density has little impact on the values of the dependent variables. The variable has a sizable impact on land price in highly urbanized states, however.

Time Variable

This variable is introduced to capture the effect of trend and other excluded factors in the models. The variable is significant in all models when pooled data were used. At the aggregated level, the variable has a negative effect in the ratio model. This means that the rent-farmland price ratio declined during the period under study. The result in Table X, Chapter IV, indicated that in 1 year the time variable reduced the ratio value by 0.133 percent. Therefore, for a 10 year period, the value would decline by about 1.33 percent, given other things equal. The decline in rent-farmland price ratio during that period indicates that the investors are willing to accept a lower rate of return on farmland earnings in terms of the rent-price ratio.

The time variable also shows a positive effect in the price model. The model in Table X showed that a 1 year increase in this variable caused land price to increase by 15.38 dollars. This might be attributable to the declining real interest rate between the 1960s and 1970s due to inflation or other variables not fully accounted for in the model.

Inflation

The results t-test of coefficients from the econometric model do not support the postulate that inflation has an independent effect on farmland price. The inflation indirectly affects the farmland market through the real rate of interest. The high rate of unanticipated inflation can cause a low real rate of interest if creditors are slow to adjust the nominal rate of interest to keep up with inflation. In addition, inflation affects farmland price through its interaction with the marginal tax rate. Although this interaction is significant in the econometric models, it has a problem of multicollinearity with the real interest rate.

The hypothesis (see Chapter I) that a change in anticipated inflation has no impact on the structural coefficients of farmland models was further tested by using the Chow Test as outlines in Chapter II. The data were divided into 2 approximately equal sets using the percent change in GNP deflator as a criterion. By coincidence, the first set fell into the period 1952-67 while the second set fell into the 1968-82 period.

Table XX shows the F-values for the test. The findings indicate that in the ratio model, the hypothesis is rejected in 18 states. The price model incorporating the farmland rent shows that 16 states reject the hypothesis while that incorporating farm income indicates that 24 states reject the hypothesis. According to the criterion, the ratio model shows that about one half of the states have different coefficients in these 2 periods. The price model with rent also shows the same result. On the other hand, the structural coefficients of the price model with net farm income are different in most states. Of

TABLE XX

TEST OF MODEL STABILITY UNDER HIGH AND LOW INFLATION PERIODS BY STATES

States	Calculated F-Values		
	Rent-Land Price Model	Price Model With Rent	Price Model With Income
Maine	4.66*	4.55*	4.75*
New Hampshire	2.85*	0.48	1.66
Vermont	0.26	8.72*	9.62*
Massachusetts	2.19	3.29*	1.42
Rhode Island	1.43	2.70*	0.74
Connecticut	0.83	0.73	0.53
New York	1.43	0.24	1.28
New Jersey	1.71	1.62	2.11
Pennsylvania	3.32*	1.95	9.35*
Delaware	3.56*	1.29	3.80*
Maryland	0.74	5.85*	5.32*
Michigan	3.66*	2.19	6.89*
Wisconsin	3.17*	2.46	1.83
Minnesota	0.25	0.68	20.43*
Ohio	2.22	3.15*	1.70
Indiana	0.57	0.84	3.28*
Illinois	1.53	0.25	2.60
Iowa	1.55	2.04	10.84*
Missouri	1.66	1.83	11.64*
North Dakota	4.43*	0.81	43.32*
South Dakota	4.27*	1.55	15.66*
Kansas	0.13	4.55*	34.93*
Virginia	7.42*	15.53*	20.03*
West Virginia	1.88	1.11	1.15
North Carolina	3.80*	11.56*	27.23*
Kentucky	3.29*	2.29	10.65*
Tennessee	8.72*	13.57*	15.27*
South Carolina	1.36	8.53*	37.98*
Georgia	4.05*	10.70*	9.02*
Florida	4.25*	1.92	1.81
Alabama	3.26*	3.47*	50.79*
Mississippi	1.50	22.67*	19.15*
Arkansas	3.07*	2.34	14.15*
Louisiana	3.70*	4.69*	40.22*
Oklahoma	3.87*	7.77*	6.73*

* = significant at 5% level

course, factors other than inflation which differ between the 2 time periods could also account for observed differences in the structure of the land price models.

In summary, results from the econometric model t-tests indicate that inflation has no independent effect on farmland price models. However, the stability test shows that the structural coefficients of the models may be influenced by the rate of inflation.

Rent

The rent factor shows a significant coefficient in farmland model. An increase in rent raises farmland price. At the state level for the price model, the rent variable has the highest number of significant coefficients. Rent is an important factor determining farmland price.

Net Farm Income

As stated earlier, net farm income was used as a substitute for the rent value at the state level. However, in terms of statistical significance, the variable does not perform as well as the rent variable. Rent is a better proxy than farm income because it reflects changes in land characteristics, return to scale, and substitution effect between land and other inputs. Usually, net farm income does not reflect the above relationships influencing land earnings.

This chapter summarized the results of the econometric models obtained from the previous chapter. The tests for structural stability of the coefficients in each model were performed. Brief remarks on selected variables were presented.

CHAPTER VI

CONCLUSIONS AND LIMITATIONS

This chapter presents a summary of the study and its findings. The problems encountered in this study are briefly mentioned. Finally, recommendations for further study are made.

Summary and Implications

The primary objective of this study is to examine the factors that explain the variation of farmland price and rent-farmland price ratio. The conceptual framework was developed based on stock capitalization. Two basic econometric models were developed. A number of explanatory variables were introduced into each model to identify the important factors. A second degree polynomial lag model was applied to capture the influence of expected increases in farmland earnings. Pooled cross-section and time-series data were used in this step. Based on theoretical and statistical considerations, a set of explanatory variables was selected. State level as well aggregated econometric models were estimated using the selected set of explanatory variables.

The analysis of the farmland model indicated that real rate of interest on farm mortgage loans, share of Federal Land Bank loans made to the total debts, population density, rent, and time trend are important factors explaining farmland price. For the given set of variables in the study, the population density and time were the important non-agricultural factors.

The results from the econometric models indicate that rent as an earning factor has a positive impact on farmland price. In addition, rent is also a better proxy for farmland earnings than is farm income to explain farmland price. Although the involvement of credit institution such as the Federal Land Bank and urbanization factor are significant in the model, their impact on farmland value at the aggregate level is minimal. The real rate of interest on farm mortgage loans is a better proxy for opportunity cost or discount rate for investing in farmland than real rate of return on common stock and long-term government bonds. Recent decline in farmland value can be partially explained by the increase in the real rate of interest on farm mortgage loans.

The analysis did not indicate that farmland was substantially overvalued during 1979-1982. The econometric models did not support the hypothesis that inflation, as a variable, had an independent effect on farmland price. However, unanticipated inflation could indirectly influence farmland price through the real rate of interest on farm mortgage loans.

Theoretically, the expected growth rate of net returns influences the value of the real estate. However, the study did not corroborate the relationship.

This study supports the result derived by Martin and Heady (1982) that the relationship between expected growth rate of real estate earnings and real estate value cannot be established. Unlike some of the past studies, the econometric models from this study do not indicate that speculative capital gain is an important explanatory variable in farmland price model.

Tests for structural stability of the coefficients were carried out. The results of the price and ratio models indicated that there were differences among states in estimated coefficients. The test for the structural stability over time showed that the coefficients of ratio model in most states were more stable than of the price models. When the inflation rate was applied as a criterion for separating the data set, the results of price and ratio models suggested that inflation was associated with differences in the estimated coefficients in most states.

As indicated by the stability tests, using an aggregate model to predict individual state land prices is inappropriated. The test also shows that there are changes in the structural coefficients over time in some states.

Because the real rate of interest on farm mortgage loans influences the farmland value, large government deficits causing high real interest rates reduce farmland price, other things equal. Results of this study do not support the hypothesis that farmland market participants behaved errationally or specutively, drawing land prices or current rates of return to levels unjustified based on conditions in the late 1970s. Rather, the results suggest that sharp changes in land values tend to be caused by factors such as real interest rate changes which appropriate macroeconomic policies can dampen.

Some farmers depend heavily on credit provided by using farmland as collateral. A rapid decline in farmland price can cause liquidity problems to many farmers. A policy which attempts to reduce the budget deficit will be beneficial to the farmers through the alleviation of the lingering effects of the budget deficit on the real interest rate.

Limitations and Further Research

This study had data limitations. The data on farmland price were obtained from USDA unpublished worksheets. Because the land price and rent data for the Northeastern States are based on small samples, the times series are erratic and not very reliable. The data show a stochastic pattern in farmland value unrelated to explanatory variables, especially in the earlier years of the period studied. This problem may be attributable not only to few observations on cash rent but also to the heterogeneous characteristics of farmland in that region and to the strong urban influence on land price. Another data problem is shortcomings in explanatory variables such as a proportion of Farmers Home Administration loans made to total agricultural loans. The proportion at the national level was used due to lack of data at the state level.

The methodology used in this study has several limitations including the assumption of linearity between dependent and independent variables in the models. It is difficult to account for all interactions among variables and for the many possible lagged responses to variables.

Because results from this study showed that the structural coefficients of the econometric model are different among states, further research at the regional or state level is recommended for capturing local differences. Future research that incorporates more information from the 1980s, a period of declining farmland price, will also be useful. A detailed investigation of particular sub-periods will be worthwhile because the structural factors could have changed over time.

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APPENDIX

VALUE OF NET CASH RENT AND FARMLAND

PRICE BY STATES FROM 1952-82

TABLE XXI

DEFINITIONS FOR THE VARIABLE RV IN TABLE XXII

State	Net Cash Rent (RV)	Farmland Price (RV)
Maine	1	2
New Hampshire	3	4
Vermont	5	6
Massachusetts	7	8
Rhode Island	9	10
Connecticut	11	12
New York	13	14
New Jersey	15	16
Pennsylvania	17	18
Delaware	19	20
Maryland	21	22
Michigan	23	24
Wisconsin	25	26
Minnesota	27	28
Ohio	29	30
Indiana	31	32
Illinois	33	34
Iowa	35	36
Missouri	37	38
North Dakota	39	40
South Dakota	41	42
Kansas	45	46
Virginia	47	48
West Virginia	49	50
North Carolina	51	52
Kentucky	53	54
Tennessee	55	56
South Carolina	57	58
Georgia	59	60
Florida	61	62
Alabama	63	64
Mississippi	65	66
Arkansas	67	68
Louisiana	69	70
Oklahoma	71	72

TABLE XXII

FARMLAND PRICE AND NET CASH RENT BY STATES ($/ACRE)

OBS	RV1	RV2	RV3	RV4	RV5	RV6	RV7	RV8	RV9	RV10	RV11	RV12	RV13	RV14	RV15	RV16	RV17	RV18	RV19	RV20	RV21	RV22	RV23
1	9 18	74	3 51	40	3.99	61	10.70	166	10.79	283	8.69	200	3.02	71	5 20	198	5.33	122	4.91	162	8.13	130	8.46
2	7.88	94	5.20	147	2.69	46	7.32	120	12.86	325	1 42	90	4.75	86	5 42	220	5 05	116	5.28	113	6.91	144	9.07
3	9 06	64	3.47	250	4.13	90	5.22	115	16.32	275	8 62	212	4 22	79	6 88	215	5 66	124	5 50	125	7.47	147	9.10
4	5 41	68	4.88	92	3.59	88	5 02	132	6.84	200	12.12	227	3 43	75	7.40	259	5.44	128	5.02	123	8.57	157	8.44
5	6 57	80	4.58	60	3.67	58	5.27	127	20 98	400	4.38	228	4.08	80	6.68	273	5.17	121	7 56	163	8.35	152	9.93
6	3.93	54	5 43	65	5.05	72	4.72	113	19.31	400	4.63	193	4.54	80	6.83	283	5.60	125	11.36	159	10.69	194	10.32
7	6.10	79	5.61	112	3.37	52	6.60	157	12.32	383	4.21	232	5.39	92	8 12	376	6.27	148	12.34	201	8.37	222	10.36
8	5.61	65	6.21	72	6 04	102	3 64	133	14.20	333	5 41	229	5.25	95	8 61	356	6.47	149	12.72	204	8.91	186	11.21
9	8.25	75	7.57	95	6.51	86	1.41	164	13 90	250	3.76	237	5 81	106	6.02	408	6.28	158	10.41	191	10.56	197	11.72
10	8.09	75.	3.42	97	5.27	92	6 32	154	12.83	380	6 23	282	6 05	98	9.85	353	6.34	160	12.56	282	11.27	193	11.57
11	9.84	83	3.26	88	5.58	113	2.25	186	16 10	331	15 64	386	5 59	102	3 74	388	6.38	167	14.28	290	9.39	203	12.02
12	6.71	61	6.06	100	5 80	86	6.59	175	17.57	525	5.03	238	6 64	105	3 61	476	6.34	171	15 74	303	7.70	195	12.21
13	6.08	67	6.70	89	3.79	73	6.37	159	22.64	600	5.61	258	6.50	106	4.73	382	6.26	173	14.92	350	10.26	250	12.69

OBS	RV24	RV25	RV26	RV27	RV28	RV29	RV30	RV31	RV32	RV33	RV34	RV35	RV36	RV37	RV38	RV39	RV40	RV41	RV42	RV45	RV46	RV47	RV48	RV49
1	152	8.65	136	7.42	140	7.98	172	11.03	210	12 24	273	10.51	231	6.50	107	2.33	37	4.17	67	4.92	86	7.73	115	4.79
2	164	9.42	134	7 98	139	7.96	167	11.41	200	12.50	274	11 08	224	6.34	101	2 27	38	3.97	63	5.03	90	9.02	134	6.14
3	163	8 90	123	8 22	139	8.23	187	12.26	200	13 17	287	11 17	220	6.31	103	2 48	39	3 88	61	4.55	84	11.06	122	6.66
4	159	9.33	140	8 56	148	8.90	193	11 19	224	13 54	295	11 78	234	6.45	109	2.21	35	3.99	60	4.73	93	10.56	109	4.83
5	190	9.72	138	9 50	156	9.03	195	12.85	224	14.12	301	12 46	240	6 98	113	2.75	39	4.40	62	5.15	95	10.33	130	6.32
6	195	9.65	136	9.86	172	11.18	218	14 48	229	15.27	327	12 90	247	9.05	120	3.00	43	4.07	63	5.39	96	12.30	133	6.18
7	205	9.99	148	10.49	177	10.44	212	13 65	243	16 28	329	13 43	256	7.30	122	3.27	45	4.24	66	5.44	102	10.74	131	4.21
8	223	10.28	147	11.67	194	10 63	224	15.38	253	15 55	365	13.88	270	9.38	135	3 93	50	4 78	78	5.80	102	11.13	141	6.48
9	228	11.11	157	11.62	194	10.35	229	15.65	270	16 50	379	14.32	280	8.26	127	4.08	53	4.67	72	6.11	111	11.63	134	4.92
10	239	10.25	160	11.63	192	10.80	225	15.79	261	16 59	364	13 87	265	9 18	137	3.87	54	4 86	80	5.89	118	13.64	151	5.22
11	248	10.55	159	11.79	191	10.70	228	16.05	258	16.36	367	14 95	282	8 77	146	3.92	56	4.73	78	6.61	116	11.92	165	5.64
12	241	12.02	171	11.89	193	11.73	260	16.94	277	17.76	390	15 32	281	9.92	154	4.40	60	4.65	80	7.11	121	12.42	158	5.33
13	258	11.57	168	12.98	208	12.35	266	18.38	310	18.25	396	15.81	293	11.47	173	4.57	64	5.65	87	7.21	126	11.90	162	5.92

OBS	RV50	RV51	RV52	RV53	RV54	RV55	RV56	RV57	RV58	RV59	RV60	RV61	RV62	RV63	RV64	RV65	RV66	RV67	RV68	RV69	RV70	RV71	RV72	T
1	69	19.92	143	11.19	147	10 69	111	6.54	76	6.12	56	4.84	59 0	5.51	61	8.44	60	8.20	86	7.51	92	3.66	76	52
2	70	21.38	153	12.01	147	11.05	115	7.02	76	6.05	58	5.39	63.0	6.28	60	8.06	66	8.74	86	8.29	99	4.01	75	53
3	75	24.87	192	9 60	123	10 46	113	7.07	76	5.64	52	8.66	98 0	6 02	60	9 30	76	8.17	85	9.67	107	3.90	71	54
4	56	23.81	189	12.04	167	10.83	112	6 54	81	6.28	62	7.84	83 0	5 80	64	9.88	78	10 17	91	9.26	106	3.95	77	55
5	63	15.22	159	11 90	169	11 00	122	7.34	93	7.46	65	7.60	104 0	7 02	68	12.76	91	9.30	101	8 87	107	4.11	80	56
6	60	16.31	194	12.98	145	12.78	124	7.44	97	8 15	73	7 23	131 0	7 85	71	12 13	88	8.58	94	8.69	102	4.37	85	57
7	64	14.72	163	12.65	148	12.39	122	7 48	102	8 36	77	6.52	119.0	7.39	77	11.92	100	10.87	104	9 65	121	4.28	86	58
8	69	14.99	202	11 81	154	13.47	140	8.25	109	9 06	84	4 92	97 0	8.12,	84	12 42	94	12.08	110	10.42	156	5.00	96	59
9	60	15 66	206	13 03	169	14 24	151	8.73	118	9 16	89	5.48	118 0	8.26	85	12.92	103	10 66	114	10.34	184	4.81	101	60
10	64	19.03	219	13 80	188	14 85	154	9 02	114	9 23	93	3 74	102 0	8.80	89	12.11	105	10.64	123	10 25	152	4.96	103	61
11	63	19.04	245	15.63	197	15.87	168	9 01	121	10 18	101	5 44	119.0	8 10	88	13.70	117	11.17	141	12.29	174	5.08	112	62
12	81	21.49	251	17 65	204	15 85	173	10 10	140	10 69	109	5 14	119 5	8.94	102	13 79	132	13.56	162	13.71	186	5.50	126	63
13	65	21.54	260	14 04	181	16.83	188	10.66	144	11.98	124	4.71	120.0	9 59	103	14.04	122	14.19	177	14.75	213	5.58	137	64

TABLE XXII (Continued)

OBS	RV1	RV2	RV3	RV4	RV5	RV6	RV7	RV8	RV9	RV10	RV11	RV12	RV13	RV14	RV15	RV16	RV17	RV18	RV19	RV20	RV21	RV22	RV23
14	6.57	72	6.63	192	7.00	103	5.56	219	14.35	520	8 43	405	7.86	123 0	3.81	433	6 46	198	17 91	333	10.96	282	13.29
15	6.72	82	4.55	123	4 42	96	5.77	196	23.83	900	4.72	362	6 76	125 0	4.17	515	7.55	227	18.06	327	11.51	314	14.13
16	10 66	117	3.06	145	6.05	124	7.36	259	14.82	500	7.94	432	6.42	134.0	3 39	593	7 95	216	17.31	420	9.48	346	17.11
17	6.94	81	6.58	170	3.69	116	9.11	250	8.95	750	-0.44	405	7 94	156.0	6.12	686	7.95	252	19.79	438	10.68	398	14.65
18	11.51	115	9.79	231	8.55	152	5.90	236	-2.88	500	5.29	483	8.90	174.0	2.79	707	7.96	281	21.02	541	10.05	445	11.93
19	9.60	127	4.55	179	5.21	162	8.27	302	11.33	625	3.87	421	6 86	163 0	5.38	740	7.43	344	21.05	512	10.00	512	10.91
20	14.75	147	14.58	278	6.86	210	0.30	295	19.06	1500	0.04	632	8.37	170.0	7.00	923	8.68	332	21.45	546	10.45	439	14.52
21	15.06	196	12.26	306	5 47	227	8.94	527	15.43	1000	0.35	962	10.26	187 0	2.10	1515	11.75	463	18 93	404	11.94	617	13.59
22	12.14	200	8.58	425	7.56	276	1.03	472	7 27	1000	6.54	1044	7.47	226 0	3.00	1678	12.65	541	20.41	464	12.68	756	14.91
23	14.81	217	10.37	439	10.65	352	2.36	850	19.40	2000	1.16	1304	8.54	268.0	10.21	1650	13.44	646	25.26	682	14.71	684	18.03
24	12.74	232	8.28	333	12.01	357	4.87	692	8 61	1285	5.67	1050	8.65	282 0	7.63	2037	15.30	844	27.46	744	14.33	847	19.41
25	11.19	231	9.50	400	13 22	398	1.68	873	-2 30	1000	5.79	1050	9.36	269.0	2.98	1830	16.59	884	30 81	969	17.16	1157	20.90
26	9.48	303	8.69	667	14.70	378	2.24	677	5.64	1505	15.99	1104	9.82	330.0	6.17	1813	17.74	960	34.34	1072	20.25	1138	24.55

OBS	RV24	RV25	RV26	RV27	RV28	RV29	RV30	RV31	RV32	RV33	RV34	RV35	RV36	RV37	RV38	RV39	RV40	RV41	RV42	RV45	RV46	RV47	RV48	RV49
14	271	11.53	180	13.20	212	12.71	278	19.32	324	19 50	441	16 96	312	10.51	178	4.85	67	5.66	89	7.31	135	13.22	175	6.20
15	301	12.80	188	14.74	228	14.32	311	21.36	367	22.60	478	19 56	357	12 27	205	5.91	75	6.05	93	8.62	168	14.11	185	6.26
16	328	12.41	201	15.37	240	14.08	324	22.82	404	24 14	517	21 46	386	12.52	209	6.09	78	5.86	97	8.14	163	13.92	200	6.25
17	350	12 61	214	17.23	266	15.79	385	24.73	453	27.03	533	23 41	421	12.99	231	7.01	88	6.56	107	8.35	175	13.29	224	6.07
18	303	13.51	245	17.40	273	15.28	381	24:67	448	27 66	586	25.61	440	14.61	256	7.28	90	7.32	111	8.47	175	12.90	235	5.96
19	290	13.87	270	17.88	281	16.49	384	24.18	433	28 49	613	26.69	453	15.15	274	7.31	95	7.23	114	9.89	193	13.13	252	5.10
20	319	14.27	288	18.45	292	18.13	419	25.61	455	29.17	601	27 50	456	16.57	267	7.29	95	7.39	114	10.10	183	14.52	277	8.14
21	363	13 95	260	16.85	265	21.22	458	27.32	465	28 27	565	29 59	466	18 32	301	8.30	111	6.65	104	11.21	198	13.13	318	10.64
22	405	15.68	301	17.75	292	22.49	505	29.88	509	30 56	619	32 73	533	20.09	333	8.83	119	7.21	117	11.79	218	14.32	374	13.29
23	500	17.78	351	24.32	389	26.88	641	36.49	611	39.62	815	46.33	694	24 30	413	13.16	165	9.01	154	14.51	278	15.20	464	11.97
24	518	20.97	397	31.29	484	31.97	742	51 17	761	47.13	954	52.40	836	26.28	430	15 13	219	10.34	173	16.28	323	15.96	492	14.88
25	587	22.43	453	38.36	598	39.11	1010	60.04	962	57.89	1248	60 99	1109	28 42	501	18.36	272	12.26	211	17.50	344	18.43	580	21.02
26	720	27.68	546	43.57	758	45.68	1116	72.83	1330	70.04	1653	69.98	1393	33.63	568	18.40	301	13.71	244	17.66	374	24.37	601	16.64

OBS	RV50	RV51	RV52	RV53	RV54	RV55	RV56	RV57	RV58	RV59	RV60	RV61	RV62	RV63	RV64	RV65	RV66	RV67	RV68	RV69	RV70	RV71	RV72	T
14	80	21.94	290	14.13	217	19.12	204	11.32	160	13.52	136	7.45	152	11.90	111	16.04	158	14.02	194	15.31	255	6.45	152	65
15	92	21.60	308	16.24	207	21.76	230	11 36	162	15 01	152	9 22	175	12.90	126	17.41	184	14.24	202	15.27	272	6 97	164	66
16	94	21.06	298	19.58	260	18.96	236	11.68	174	13 32	165	7 37	182	10.29	132	18 36	199	13 83	211	14.01	300	6.54	166	67
17	91	20.42	305	18.59	336	20.74	278	11 61	188	13 91	175	9.00	273	11 52	151	24.26	201	15.05	237	12.98	262	7.15	189	68
18	147	18.82	297	18.00	263	18 07	279	12.41	218	14.35	196	9.07	261	10.45	168	16.25	223	13 44	235	15.11	318	7.49	191	69
19	119	17.76	334	17.65	290	18.04	283	12.07	220	14 13	237	7 60	306	12 67	169	16.43	226	14.22	262	15.34	338	8.35	212	70
20	131	19.04	326	19.61	264	18.67	318	13 21	230	16.38	250	6 61	229	12 44	194	15 89	244	18.01	282	15.92	355	8.84	227	71
21	166	17.98	368	21.30	336	19.24	305	13.86	265	17.67	296	4 93	289	13.71	218	16.86	289	21.03	323	16.24	379	8.63	216	72
22	265	19.51	448	22.13	363	20.86	346	13.83	302	17 57	358	8 41	421	14.65	267	18 36	309	20.67	347	17.32	391	9.50	239	73
23	274	21.73	499	24.26	404	23 17	401	14.23	342	18.13	436	12.03	650	16 11	311	20.07	366	23.13	390	21.63	406	11.68	299	74
24	453	22.60	573	25:57	447	24.80	459	15 14	419	21 39	483	10 44	732	17.16	328	22 33	393	24 82	405	23.75	491	13 09	347	75
25	427	23.98	615	28.03	542	26.68	519	16.61	432	22 39	527	8 61	582	18.78	362	23 00	414	24 99	453	22.10	512	14.70	399	76
26	448	28.82	667	37.29	624	30.06	571	18.43	510	25.31	558	10.52	683	22.01	415	25.36	433	27.20	519	34.22	616	15.75	431	77

TABLE XXII (Continued)

OBS	RV1	RV2	RV3	RV4	RV5	RV6	RV7	RV8	RV9	RV10	RV11	RV12	RV13	RV14	RV15	RV16	RV17	RV18	RV19	RV20	RV21	RV22	RV23
27	12.25	390	11.89	639	10.58	404	0.43	709	4.42	1660	9 17	1130	12 37	325 0	9 09	2171	19.72	1059	39.14	1347	20.77	1394	24.48
28	13 10	414	11.14	712	10.59	506	5.41	1078	-5.10	500	11.10	1475	14 07	357 0	12 99	2305	21.15	1275	39.49	1451	30.57	1333	25.29
29	15.54	438	16.49	749	16 33	629	1.56	1246	6.72	1075	11 99	1820	13 39	365 0	15.45	2367	22.34	1479	47.49	1606	33.41	1720	28.85
30	12.45	794	12.82	967	7.29	594	10.99	1805	-1.95	1138	11.94	1583	13.98	439 0	15.63	2473	25.32	1465	55.05	1920	36.45	1756	30.46
31	15.03	604	15.16	1250	8.73	725	4.63	1153	-2.15	1186	1 14	1150	15.42	459.9	20.93	2475	27.10	1482	55 32	1638	39.79	1817	28.33

OBS	RV24	RV25	RV26	RV27	RV28	RV29	RV30	RV31	RV32	RV33	RV34	RV35	RV36	RV37	RV38	RV39	RV40	RV41	RV42	RV45	RV46	RV47	RV48	RV49
27	789	30.11	630	44.36	867	51.78	1305	74.76	1434	73 25	1923	73 61	1537	37.20	636	17.96	302	14 41	269	17.83	415	25.33	685	8.74
28	885	31.04	746	49.24	1015	60.73	1675	78.34	1622	79 39	2126	80 04	1780	41 41	746	20 58	360	14.87	293	21.08	455	22.49	712	13.73
29	1039	32.42	877	54.84	1221	63 65	1808	86.57	1929	85.98	2292	86.15	2060	47 58	866	22.10	399	16.62	339	22.41	517	23.97	836	14.72
30	1202	34 67	949	58 05	1328	70.27	1868	93 20	1986	91.72	2393	91.48	2174	49.95	899	23 50	431	18.31	359	24.18	587	26.95	845	17.43
31	1196	37 98	1007	62.71	1384	71.93	1715	90.40	1840	97.81	2265	95.11	2117	49 56	916	25.17	468	18.55	375	25.72	582	32.22	989	16.47

OBS	RV50	RV51	RV52	RV53	RV54	RV55	RV56	RV57	RV58	RV59	RV60	RV61	RV62	RV63	RV64	RV65	RV66	RV67	RV68	RV69	RV70	RV71	RV72	T
27	414	25.50	694	35 83	702	33.22	669	19.30	544	26 08	587	13.15	675	22.80	431	26 68	506	28.79	577	32.04	711	15.09	447	78
28	623	30.97	759	37.94	854	34 10	755	21.70	605	26 25	630	14.95	898	24 68	494	29.16	580	31.22	702	40.01	925	17.98	510	79
29	782	24.07	872	43.70	949	37.75	846	22.48	654	27.24	713	12.01	726	27.40	580	33.29	688	37 56	764	44.61	977	17.32	597	80
30	690	33.65	924	45.85	959	40.38	877	24.68	727	28 80	739	10.67	779	28 10	691	35.34	820	38 62	889	41.77	1086	18.80	620	81
31	763	34.98	1005	50.01	1037	41.36	909	23.33	743	25.88	733	10.74	819	29.15	759	37.34	862	43 08	1053	46.89	1080	19.48	696	82

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VITA

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