A CONVERSATION BETWEEN BUYERS AND SELLERS OF LAND

OR

THE THEORETICAL BASIS FOR ESTIMATING LAND VALUES: A MARKET EQUILIBRIUM APPROACH

By

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ABSTRACT

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This research develops models for determining land prices in Walrasian market settings where land supplied and demanded is dependent on buyers' and sellers' expected costs and benefits. The effects of inflation and taxes are included in statements of expected costs and benefits.

The models, after being logically deduced, are tested empirically. The market model with inflation is validated empirically in estimations for Michigan and Illinois data, and for a time period longer than the original sample period. A model including fixed land supply is rejected.

A previously developed simultaneous equation model of the farm real estate mortgage market is used in conjunction with the inflationary market model in order to trace the effects of inflation on interest rates to the land market. Land values rise rapidly in light of significant increases in inflation because loan interest rate changes lag inflation rate changes. As constant levels of inflation persist, land values stabilize at rates of change equal to inflation.

ACKNOWLEDGMENTS

Without the extra efforts of many friends, this thesis would not have been possible. Several of those friends deserve special acknowledgment.

The patient guidance and generous support of my Major Professor, Dr. Lindon Robison, made the research a valuable learning experience. I would like to thank him for his support over the past year.

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For one whose special friendship helped me make it through the past year, she will never be 'just Cindy'.

Finally, to my parents, Dale and Shirley, I send my love and thanks for unquestioning support during all of my education.

To all of my friends, thank you!

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Land as an economic variable
is exceedingly hard to get at ...

--Theodore W. Schultz, 1953

CHAPTER I

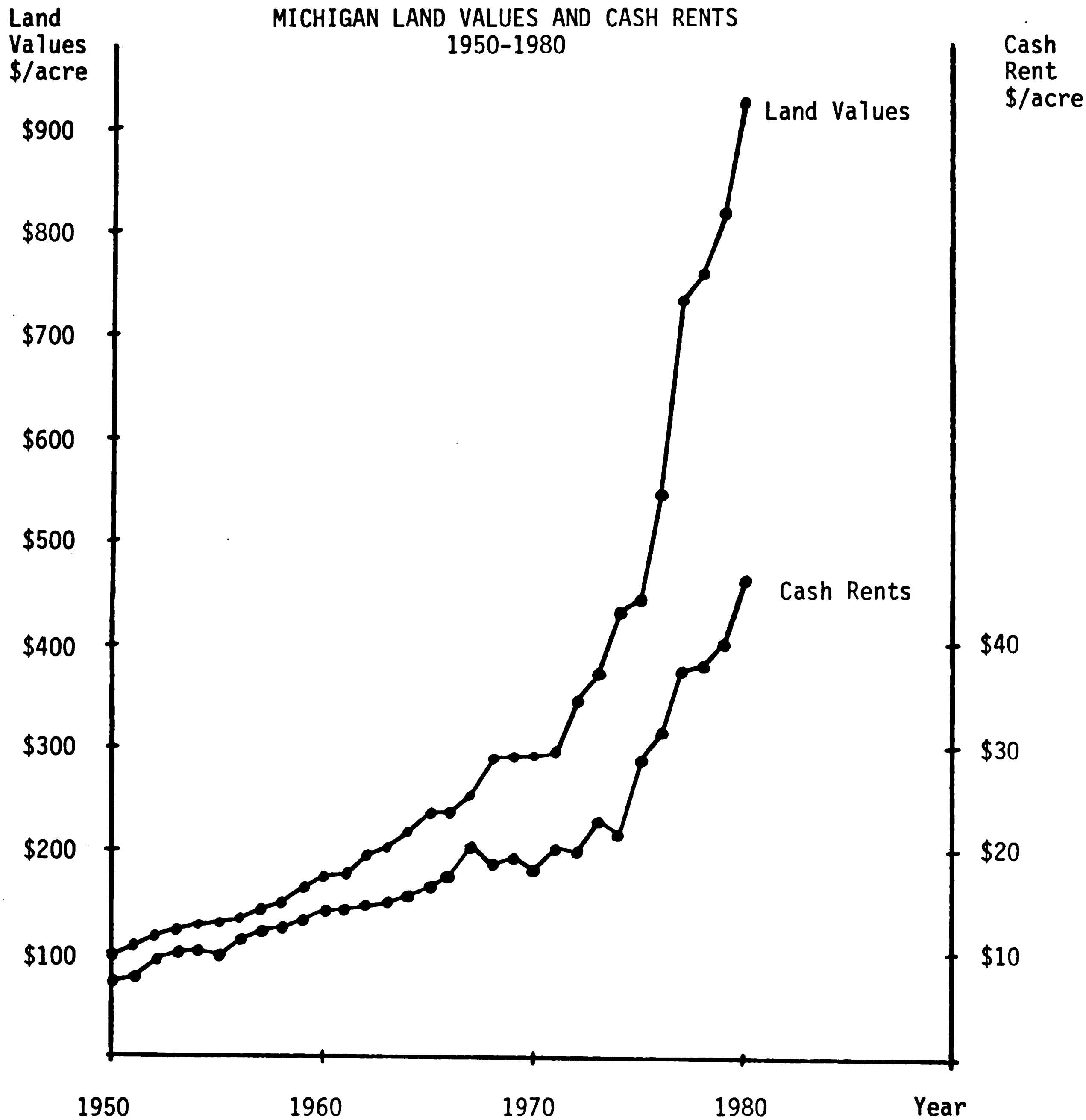
INTRODUCTION

What is farmland worth? Farmers and academicians alike frequently raise this question, hoping for a simple explanation for recently observed land value trends. Since World War II, land prices have posted rather dramatic increases. The decade of the seventies showed rapid price rises followed by declines in the first half of 1980. These declines came about in spite of near record inflation in the general economy. Late 1980 and early 1981, however, saw another round of price increases which wiped out any earlier declines. During the entire period since 1950, there has been just one year in which the average value of farmland in Michigan declined, and then, the decline was minimal. What is fueling these price rises?

A standard technique for assessing values to farmland is to capitalize the expected net benefits of owning land at some discount factor. According to this formula cash returns and land values should be increasing at comparable rates. But at the same time as land values have been experiencing such rapid gains, benefits from owning land, in terms of cash rents, were showing less rapid growth and greater volatility. Figure 1 shows how the general relationship of land values to cash rents in Michigan appears to be changing. Declines and slower increases in cash rents are noted even in periods where land values were increasing

FIGURE 1

MICHIGAN LAND VALUES AND CASH RENTS
1950-1980



rapidly. Such a phenomenon prompts many researchers to question if farmland is not, in fact, becoming overpriced.

If farmland is becoming overpriced, one would expect that land used in farming would be decreasing over time as fewer and fewer people can afford the overpriced asset. In fact, this is happening. Wright (41) reports that the acreage in farms has steadily declined over time, except between the USDA agricultural census years of 1974 and 1978. Figure 2 emphasizes this decline of farmland used for farming and the decline in acres of cropland harvested.

Then what should the price of farmland be? Should it be higher than is justified by current returns? The price of farmland, logically, is simply that price that buyers and sellers agree it is. Demanders and suppliers of land are drawn together and jointly they determine what land is worth for themselves. Thus, if farmland is becoming overpriced, it is a result of this interaction between buyers and sellers.

Unfortunately, such logic does not necessarily clarify the reasons for historical price patterns. As Schultz notes, economic analysis of land is not a simple matter: "The fact that land is open and aboveboard, physical and concrete, and legally divided into neat, carefully described parcels or lots ... does not help one determine the supply of land.[1/] This comment is supported by the varied nature of past attempts at explaining land value patterns.

The questions of how to explain past land price patterns and how to predict future land values is certainly a well-researched topic, particularly since the early 1960s. Well known simultaneous equation models by Herdt and Cochrane, Tweeten and Martin, and Reynolds and

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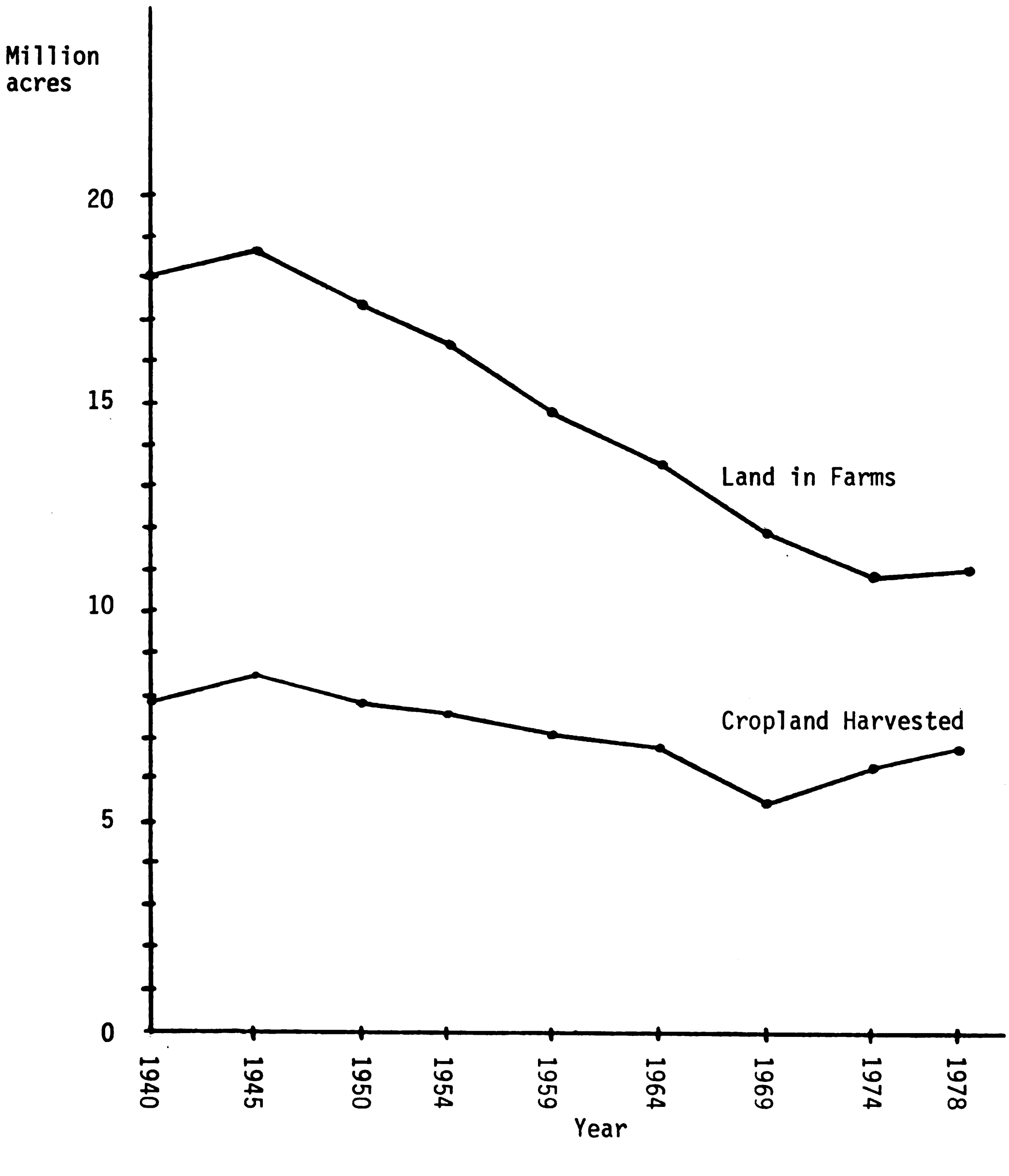
[1/] Schultz, p. 145.

FIGURE 2

LAND IN FARMS AND CROPLAND HARVESTED
1940-1978



Timmons attempted to link several economic factors such as technology, government programs (price supports, land reserves, etc.), and farm wealth concentration to land values. More recent studies by Klinefelter, and Duncan used single equation models trying to capture a similar correlation between economic variables and land values. Other single equation models by Dunford, Hauschen and Herr, and Dobbins, et al. tried to determine maximum bid prices for land.

Many of these earlier research efforts, however, failed to fully explain past land price patterns. And they appear to lack logical deduction which dictates model form and content. Others have not passed the 'test of time' in that statistical measures of their empirical validity decreased when the models were re-estimated over more recent time periods. Some models did not explicitly incorporate the pervasive effects of inflation into their results and most efforts only considered demand factors, failing to include market equilibrium forces. In general, most previous models have not adequately provided both predictive ability and economic structure. One recent study (24) which reviewed and retested several earlier efforts concluded by saying "... if one is concerned with both predictive ability and economic structure, additional research is needed to explain recent movements of farmland prices."[2/] Perhaps one more study of the land market is justified.

Objectives of the Current Study

Buyers and sellers create land prices; therefore it is the behavior of the buyers and sellers which needs to be researched. Most earlier research efforts failed to consider behavioral aspects of the

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[2/] Pope, et al., p. 115.

economic variables that influence land values. They do not ask why there is the correlation between two variables. Thus, a point of departure for the current study is to attempt to capture the behavior of demanders and suppliers of land in a theoretically founded model.

Capital budgeting theory with some modifications is the originating theory for this study. While a simple capitalization approach cannot fully explain recent price patterns, it is instrumental in understanding participant behavior. A market equilibrium approach is followed using equations for quantities of land desired and quantities of land held. In equilibrium, these quantities (and likewise, their equations) are equal.

Logically, however, the land market is rarely, if ever, in equilibrium--at any one time there is land offered for sale that is not purchased. In another sense, there are two 'markets' for land--agriculture and non-agriculture.[3/] In this study, equilibrium refers to the agriculture market. When this market is out of equilibrium, land is either moving out of or into agricultural uses, to or from the non-agriculture market. The quantity of land moving from one market to the other may play a role in pricing land, so this market approach is necessary to capture all factors of the land market.

The first objective of the current study, then, is to incorporate equilibrium (or disequilibrium) conditions in a theoretically deduced model based upon market participant behavior.

Most likely, the market participant behavior which creates land values is strongly influenced by inflationary forces now embedded in the

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[3/] Equilibrium in the total land market is implicit since land is a non-reproducible and non-diminishing asset.

general economy. As a result of inflation, income taxes are playing a greater role in most people's lives due to the so-called 'bracket creep' effect. Neither income taxes nor inflation have been explicitly included in many earlier research efforts, so a second objective of this study is to determine what effect taxes and inflation do have, and to incorporate that effect in an explanatory and predictive model of the farmland market.

A third objective is simply to examine empirical strengths of the theoretically valid model. It is important for any new model to withstand the test of time failed by earlier models, and to be able to accurately forecast land values using data other than that for which a model is initially estimated.

Finally, a fourth objective is to use the model developed in this study to explain past land price trends and to look at what the future might bring. Even a theoretically sound model should be judged on the strengths of its predictive ability, and that ability should be at least as good as or better than previous research efforts.

Data and Methods

In attempting to fulfill the objectives just outlined, models will be estimated using average farmland values, cash rents as a return to land, and Federal Land Bank interest rates which link national money markets and inflation to discount rates. In initial testing, the models are estimated using Michigan farmland data over the period 1960 to 1980. Subsequent estimation includes the longer time period 1941 to 1979 and Illinois farmland data.

When possible, linear equations are estimated using ordinary least squares regression for clarity and simplicity. A simultaneous equation system is employed when using the model for simulations and projections of land values in order to better capture the multiple effects of several variables.

Organization

As a starting point for the current study, Chapter II presents a review of recent land research and literature. Organized in a chronological fashion, the review summarizes the major conclusions, assumptions, strengths, and weaknesses of the various studies. Others' successes and failures provide a valuable learning guide in new research.

In Chapter III, the underlying theory of capital budgeting and market participant behavior is discussed. From this theoretical and behavioral groundwork, models are derived under increasingly realistic assumptions of inflation and taxes.

The empirical support for the most relevant models is described in Chapter IV, making use of Michigan and Illinois data, and testing for weaknesses exhibited by other land value research attempts. Initial conclusions about inflation, taxes, and land supply are discussed.

Chapter V then incorporates a previously developed system of equations describing the farm mortgage market. With minor modifications and additions, this system is used in order to observe the effects of varying assumptions of land values. Situations of what might have happened and what might happen are examined.

Finally, Chapter VI outlines the significant conclusions from the study. Explanations of past farmland value trends and potential future trends are the centerpiece of these conclusions. In addition, some suggestions for possible future research are offered.

This paper presents a modest attempt at explaining a complex issue. The intent of this effort is not to answer all questions about land values. However, it is hoped that some answers to old questions may be achieved while new questions are raised and research directions are pointed out. As part of the overall ongoing research effort to answer "Is farmland overpriced?", this study is one more intermediate step forward.

CHAPTER II

LITERATURE REVIEW

Research and literature explaining past land price variation and predicting future patterns are abundant. Research procedures and tools used vary from study to study, but each seems to have a common objective: to determine the economic relationship between land values and returns to land ownership. The purpose of this chapter is to review several of those studies and to summarize what has been learned about the relationships between land values and returns to land. However, before proceeding to the individual studies, a general survey of the articles to be reviewed is in order.

A General Overview

Nearly every study involving the question of what explains land values begins with a statement like: "Increases in net farm income are no longer sufficient to explain increases in land values." Three studies from the 1960s by Herdt and Cochrane, Tweeten and Martin, and Reynolds and Timmons used that statement as a basis from which to hypothesize correlations between economic variables and land values. Their studies considered technological advances, scale economies, government programs, and land transfers among the key factors explaining land price variations. Each of these studies tested the hypothesized correlations in simultaneous equation systems.

Several more recent studies considered single-equation models of the land market. Klinefelter and Duncan followed an approach similar to those earlier models in attempting to find correlations among variables. Dunford, Hauschen and Herr, and Dobbins, et al. used a capital budgeting approach to determine maximum bid prices for land.

By beginning their research questioning the link from current returns to land and the value of land, most of these studies acknowledge that net farm income is not satisfactory for explaining land value variations. But studies by Herdt and Cochrane, Tweeten and Martin, and Duncan still consider net farm income as an explanatory variable in their land models. Melichar, Hauschen and Herr, and Dobbins, et al. agreed that net farm income is not an appropriate measure of returns for owning land. Rather, it is a measure of returns to operator's labor, management, and equity capital. These authors construct residual income series as more appropriate measures of the returns to land.

A common feature of most previous land studies is their emphasis on the demand for farmland. Herdt and Cochrane use an equilibrium approach to their study which includes equations for land demand and land supply, and Tweeten and Martin build a five equation system model, four equations of which measure various land quantities. The remainder of the studies concern themselves primarily with the factors affecting demand.

This chapter presents nine studies from 1966 to 1981 which are concerned with land values. Three of these models are simultaneous systems of equations while the rest are single equations. One study presents a review and statistical look at four previous efforts. All studies will be discussed in chronological order beginning with Herdt and Cochrane's three equation model from 1966. For each study, a summary of conclusions, assumptions, strengths, and weaknesses will be outlined. Past mistakes and successes are a useful guide for current and future research.

Herdt and Cochrane - 1966

Herdt and Cochrane follow the theme of most recent literature in claiming that land prices are no longer directly explained by income per acre. Instead, the authors base their work on the theory that people purchase land with an expectation of continually increasing income per acre. In support of this theory, Herdt and Cochrane contend that variation in farm income is exhibited on an individual farm level, but on aggregate, the average has remained fairly stable. With that background, Herdt and Cochrane identify three factors causing land value variation: urbanization pressures, government programs, and technological advance.

From their work, Herdt and Cochrane conclude that technological advance has exerted the strongest influence on land prices in two ways. First, technology has reduced unit costs allowing for higher farm incomes (so long as price supports are available) which have been capitalized into higher land prices. Second, technological advances have stimulated demand for land by investors hoping to capture capital gains resulting from the technological improvements. These conclusions rest on the assumption that widespread technological advance, non-decreasing returns to scale, and price support floors continue to exist.

In order to test their theory, Herdt and Cochrane construct a three-equation simultaneous equation model. In the model, equations for land supply and demand and an equilibrium condition are solved. Supply is estimated as a function of land price, non-farm employment, alternative returns on investments, and land in farms. Demand is a function of the price of land, changes in income expectations, the general price level, and the ratio of prices paid by farmers to prices received for output.

An important strength of this model is that it attempts to incorporate supply and demand into an equilibrium model. Because of the nature of land prices--the price of land is that value which buyers and sellers give it--it is useful to consider both supply and demand. In addition, the estimated model is statistically well defined for the sample period in that coefficients are significant and expected signs are obtained on all variables except for interest rates on alternative investments.

The model suffers, however, from unjustified assumptions. Herdt and Cochrane begin their study by simply stating that net farm income fails to explain land values. They do not test the hypothesis that land values are not exclusively determined by farm income. Instead, Herdt and Cochrane hypothesize a relationship between other factors and land values without logically justifying the correlation.

The model rests on the assumption that widespread technological advance and price supports without supply limits continue to exist in the future. In the past two or three years, there has been considerable concern that technological advance has reached a 'plateau,' in which case one supporting assumption would be invalidated. The expectation of continuing price supports without supply limits is also in question. Since Herdt and Cochrane's research there have been several years in which price supports were contingent on supply limits. In addition, the certainty of supports existing is no longer without question, as those supports depend in large part on the current Presidential administration.

The fact that some of Herdt and Cochrane's assumptions, while they were most likely applicable in 1966, are no longer justified causes one to wonder if the model is useful under current circumstances. As one of the models retested by Pope, et al., this question will be looked at more closely in a review of that study.

Tweeten and Martin - 1966

Like Herdt and Cochrane, Tweeten and Martin note that net income has been outpaced by land prices, and therefore, it is not a satisfactory determinant of land values. Instead, Tweeten and Martin consider several other factors important: scale economies which cause expansionary pressures; government programs capitalized into land prices; the excess of young farmers compared to available farms; speculation for capital gains; population growth; non-farm investment in real estate; the changing farm financial situation; and, farm wealth concentration.

Tweeten and Martin construct a five equation recursive model to test for correlation between land values and the factors listed above. Their sample period is 1923 to 1963. The five equations used are for land price, land supply, cropland, farm numbers, and farm transfers. Each equation was estimated three different ways using ordinary least squares, recursive and autoregressive techniques. Tweeten and Martin found that these alternative estimation procedures provided comparable results.

Based on the results of their model, Tweeten and Martin conclude that government programs and farm enlargement pressures are the two most significant factors influencing the land market between 1950 and 1963. Evidently, price support programs are being capitalized into land prices and farmers expect those support levels to continue. Farm enlargement pressures are increasing the demand for land as farmers try to keep up with technological advances.

The primary strength of Tweeten and Martin's work is in its econometric validity over the original sample period. Satisfactory R^2 statistics, significant coefficients, and expected signs all support the model used. In addition, the authors include the supply of farmland as an estimated equation. In so doing, Tweeten and Martin are at least acknowledging that factors other than demand related variables influence land values.

Like Herdt and Cochrane, however, Tweeten and Martin do not consider the behavior causing the relationship between variables included in the model and land values. Tweeten and Martin rationalize this weakness by saying their model is only offered to suggest possible correlations, not as a definitive description of the land market. But they also contend that a rigorous study of both supply and demand factors is unwarranted by land market observation. Presenting land supply as an equation and then saying a study of supply factors is unwarranted creates a rather ambiguous approach to the land market. Tweeten and Martin's study would have been better served by explicitly considering the justification for relationships between both demand and supply variables and land values.

Reynolds and Timmons - 1969

Reynolds and Timmons estimate land prices as a function of expected capital gains, predicted voluntary land transfers, government payments for land diversions, conservation payments, farm enlargement pressures, and the rate of return on common stock. The model suggests that expected land price changes, government programs, and returns on alternative investments are capitalized into land values. Enlargement pressures cause an increase in land demand and voluntary transfers are a part of land supply.

A two equation recursive model is constructed to test the hypothesized correlations over the sample period 1933 to 1965. Like previously discussed models, Reynolds and Timmons' model does a good job of 'explaining' land price patterns over the sample period, and the expected relationships (coefficient signs) between the exogenous variables and land values result from estimation.

Another similarity to earlier models, however, is that the Reynolds and Timmons model does not provide a justification for how the hypothesized relationships are obtained, or how the actions of sellers and buyers in a competitive market would yield their estimating equations. For example, using farm transfers in an attempt to include land supply fails to capture the market participants' interaction.

A second weakness of Reynolds and Timmons' model is that no measure of current returns to land is included in the estimating equations. Expected capital gains and common stock returns as a measure of alternative investment returns are included in land values, but most researchers agree that an asset's value should depend, at least in part, on that asset's productive capacity. Consequently, a measure of the current returns generated by land should logically be included in any land value modelling attempt.

Klinefelter - 1973

Klinefelter offers a single equation model with prices estimated as a function of net returns to farming, average farm size, the number of transfers, and expected capital gains. By including net returns and expected capital gains, Klinefelter is including the benefits from holding land. Average farm size and the number of transfers are measures of available farmland.

While Klinefelter's model contains less 'structural content' than earlier multi-equation models, it does provide a good fit for the data from the sample period 1951 to 1970. The primary strengths of the model are its simplicity and its high predictive power. A single equation estimator with good statistical properties (high R^2, significant coefficients, etc.) is easier to understand than a multi-equation model.

However, incorporated in that simplicity should be justification for any hypothesized relationships. Like models previously discussed, that justification is not offered in Klinefelter's model. In addition, Klinefelter uses farm transfers as a proxy for farmland supply as do Reynolds and Timmons, but Klinefelter treats it as exogenous to the land market. Treating land supply as exogenous to the land market assumes that land values are not interdependent with land supply and land demand. Klinefelter has not shown this to be the case.

Pope, et al. - 1979[1/]

Pope, et al. present their study to accomplish two objectives: to re-estimate models developed by Herdt and Cochrane, Tweeten and Martin, Reynolds and Timmons, and Klinefelter over a more recent time period than that for which they were originally estimated; and to compare the predictive abilities of a simultaneous equation model, single equation model, and a naive time series model which is simply a trend line generator.

[1/] Pope, et al. is discussed out of chronological order because it is a summary study of the four preceeding studies.

The major emphasis of Pope, et al.'s study is to determine if previously published models of the farmland market retain their predictive ability, coefficient signs, magnitudes, and statistical significance beyond the period for which they are estimated.

All four models are re-estimated by Pope, et al. over the new sample period 1946-1972. Rather significant results are noted from the re-estimations. The three simultaneous equation models by Herdt and Cochrane, Tweeten and Martin, and Reynolds and Timmons all suffered from coefficient sign reversals, insignificant coefficients, and loss of explanatory power (decreased R^2 statistics). The single equation model by Klinefelter experienced the same problems except that it retained a greater degree of predictive accuracy.

The lack of estimating ability beyond original sample periods exhibited by these four models is a startling result. Along with previously discussed weaknesses such as poor theoretical model justification, lack of a market demand and supply approach, and inconsistent treatment of income to land, this significant change in model structure over time suggests effort is needed to produce a model which does not suffer from such deficiencies.

After having performed model re-estimations, Pope, et al. continue their study with a comparison of model types--a simultaneous equation system, single equation, and naive forecasting (Box-Jenkins) model. Pope, et al. use the Herdt and Cochrane model for the simultaneous equation, a modified version of Klinefelter's model as the single equation, and a time series model of an integrated autoregressive moving average process as the naive model. The naive time series model is used in order to provide a benchmark for comparison against the econometric models of Herdt and Cochrane and Klinefelter.

The results of the forecast testing show that the simultaneous equation model (Herdt and Cochrane) forecasted nearly as well as the Box-Jenkins benchmark model in years since 1946. For tests back to 1913, the benchmark time series was superior to the simultaneous equation model. However, the Klinefelter single equation model outperformed the system and the time series models in both estimation periods.

Pope, et al. had expected the time series model to perform as well as or better than the simultaneous system for short term forecasts because of the nature of land prices. There has been a fairly steady correlation with time in land's upward price trend. But Pope, et al. consider it surprising for a single equation model which has relatively little ability to describe the economic behavior of the land market to perform so well. Because Klinefelter's model is a single equation, Pope, et al. consider it to have little 'structural content' when compared to Herdt and Cochrane's system of equations. Pope, et al. conclude their study by advising that "more study is needed to explain the recent rise in farm prices ..." especially since previous model specifications do not accurately describe current farm land market characteristics.

Duncan - 1977

Without offering conclusive evidence that single equation models are superior to systems of equations, the Pope study does support additional research in single equation models. Duncan provides one such model.

Like earlier studies, Duncan presents a list of variables commonly thought to affect land prices, including inflation, farm income, government payments, capital gains, alternative investment opportunities, land transfers, and farm enlargement pressures. Duncan's list looks familiar after reading several land market studies. From this list, Duncan constructs a single equation model where the value of land per acre is a function of expected realized net farm income per acre, expected personal income from non-farm activities, government payments per acre, expected returns (from capital gains and earnings) per acre, voluntary transfers, expected return on common stock, and average farm size.

Two of the factors Duncan considers most important, expected net income and capital gains and earnings, support the usual price-reutrn relationship found in many land valuation models. But by using expected net farm income as a measure for returns to land, Duncan is also including returns to management, operator's labor, and owner's equity, etc., as well as to land. Duncan does not include a rationale for the relationship of these returns to land values. There is also no rationale offered for including such factors as government payments, non-farm income, voluntary land transfers, common stock return, and farm size. Duncan, like many of his predecessors, is hypothesizing a correlation without exploring the behavioral link which causes the correlation. Perhaps the theory underlying the relationships should be explored.

Dunford - 1980

Dunford constructs a model for determining the maximum bid price an individual can afford to pay for land. The model uses discounted cash flow techniques to estimate land prices as a function of expected changes in land returns, aggregate farmland values, and the general price level. Basically, the model estimates land values as the discounted cash benefits from annual returns plus discounted after tax proceeds from the sale of land. Dunford is basing land values on their expected earning capacity, capital gains, and inflation. Over the short run, Dunford concludes that expected capital gains fuel investor's increased bid prices. The longer run, he contends, is more influenced by the anticipated rate of change in net current returns to land. Dunford's findings show that the implied real rate of return for farmland investment was about 4.3 percent between 1961 and 1965.

Dunford attempts to correct a weakness noted in previously discussed studies. Instead of using net farm income as a proxy for returns to land, Dunford uses Melichar's implicit returns to farm production assets.[2/] This income series is essentially a residual to land after returns to other factors of production have been extracted.

At the same time as Dunford is attempting to correct one weakness, he fails to address another issue. Dunford does not include the influence of land supplier's behavior and their effects on land's value. Even though the primary concern of this study is to determine a maximum bid price for land, the effects of the supply side of the market cannot be ignored. Land prices are, after all, what is agreed upon by both buyers and sellers.

<u>Hauschen and Herr - 1980</u>

Hauschen and Herr's recent study begins by contrasting trends of net farm income and land values. Hauschen and Herr also subscribe to

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[2/] Melichar, p. 16.

Melichar's conclusions about the weakness of net farm income as a measure of returns to land. In order to develop a plausible relationship between income to land and land values, Hauschen and Herr synthesize a net income series designed to more accurately portray the residual return to farm real estate. This series equates returns to farm real estate with returns to production assets minus the interest on non-real estate farm debt times non-real estate production assets. A polynomial distributed lag model is used to explain the impact of these residual net returns on farmland values. The model is essentially a capitalization approach.

Hauschen and Herr achieve empirical support for their model with an adjusted coefficient of determination, $\bar{R}^2$, equal to .987, significant coefficients, and appropriate signs. The authors conclude that the previous three to five years provide the most important impacts on the land buyer's expectations for income.

A significant weakness of the Hauschen and Herr model, however, arises in their support for the capitalization equation. Hauschen and Herr contend that the supply function for land is totally inelastic. As a result, Hauschen and Herr argue that supply considerations do not play a role in determining land values, and the capitalization equation is sufficient as an explainer of land values. Conclusive evidence in support of this argument, however, has not been shown by Hauschen and Herr or any other researcher.

Dobbins, et al. - 1981

Dobbins, et al. investigate the theoretical and empirical relationship between returns to land ownership and the price of farmland. They use a synthesized residual income to land series to construct a modified capital budgeting equation. The model allows for differing inflationary impacts on returns and discount rates and allows for differing returns and differing discount rates from period to period. As a result, the current value of land is equal to current land returns growing by g percent each period and discounted by the constant real cost of capital minus the real growth in returns. The result of the relationship is that, if land returns are growing at 4 percent per year and future returns are to be discounted at 8 percent, then land should be priced at 26 times current earnings.

Based on their findings, Dobbins, et al. conclude that there is, in fact, a close theoretical linkage of current returns to land values. With that basis, three hypotheses are tested: land prices have increased in real terms; real returns have increased in real terms; and, there has been no change in the ratio of returns to land to the price of land. Empirical evidence supports the hypotheses that real returns to land and land values have increased. There is no evidence, however, that there is a statistically different rate of increase in land values and land returns. This last conclusion is in marked contrast to other studies which base their work on the differences in land values and land returns.

Dobbins, et al.'s research, in using a residual income series and theoretically justifying their model, has made progress in correcting weaknesses of earlier research. There is, however, one missing step from this work. Land supply and the rationale for supplier behavior is still not incorporated into the model. While the allowance for differing inflationary impacts on returns and discount rates makes significant progress toward realism, failing to consider the supply of land as a factor leaves out half of the actual land market. Land values are, in reality, determined by demanders and suppliers of land.

Summary

The purpose of this chapter has been to highlight a few important and recent studies of the farmland market. Table 1 summarizes the major features of the studies. Of particular importance are the descriptions and natures of the models and the land quantity and income measures used. For the first four studies, Pope, et al.'s re-estimation results are also significant.

Each of the studies reviewed included several variables considered important in 'explaining' land value patterns. A far too common feature of the studies, however, is that the logic which justifies the correlation between the variables and land values is not made explicit. Only Dobbins, et al. explore the behavior producing the correlation. If a model has a firm theoretical foundation as well as high predictive power, it can only be a better model. Columns 2 and 3 describe the nature of the reviewed models.

An important link in building a theory to describe land values is land supply. The studies reviewed commonly treat farm transfers as a proxy for land supply, but only Herdt and Cochrane and Tweeten and Martin explicitly include a market approach in their model. In a market where prices depend on a consensus of buyers and sellers, supplier's behavior is just as important as demander's in explaining price patterns. After all, the bid price for land must equal the seller's ask price in order for a transaction to occur. Column 6 summarizes the reviewed studies' treatment of land supply.

Table 1

Literature Summary

1 MODEL AND PUBLICATION DATE	2 MODEL DESCRIPTION	3 NATURE OF MODEL	4 TIME PERIOD ESTIMATED	5. INCOME MEASURE USED	6 LAND QUANTITY MEASURE	7 POPE, ET AL., VALIDITY TEST RESULTS
Herdt and Cochrane, 1966	3 Equation System	Explanatory, Market Equilibrium Analysis	1913 - 1962	Ratio of prices received by farmers to prices paid by farmers	Number of farms	Re-estimated 1946 - 72 --change signs --insignificant coefficients --loss of accuracy
Tweeten and Martin, 1966	5 Equation System	Trend Analysis of Land Price and Land Quantity	1923 - 1963	Net Farm Income	Land in farms Number of farms Farm transfers	Re-estimated 1946 - 72 --change signs --insignificant coefficients --loss of accuracy
Reynolds and Timmons, 1969	2 Equation Recursive	Descriptive, not predictive	1933 - 1965	Returns on Alternative Investments	Farm Transfers	Re-estimated 1946 - 72 --4 of 8 coefficients changed --insignificant coefficients --loss of accuracy
Klinefelter, 1973	Single Equation	Predictive, not economically descriptive	1951 - 1970	Net Returns to Farming	Farm Transfers	Re-estimated 1946 - 72 --change signs --insignificant coefficients --no loss of accuracy
Pope, et al., 1979	Time Series (Box-Jenkins)	Integrated auto-regressive moving average	1913 - 1972	----	----	Single equation better within and beyond sample period than B-J or simultaneous system
Duncan, 1977	Single equation	Explanatory correlation	1937 - 1975	Realized Net Farm Income per acre	Voluntary farm transfers	----
Dunford, 1980	Single equation	Maximum bid price	-----	Residual to land[a]	----	----
Hauschen and Herr, 1980	Single equation	Polynomial Distributed Lagged Income Model	1950 - 1977	Residual to land[a]	Inelastic supply	----
Dobbins, et al., 1981	Single equation	Capital Budgeting Not Predictive	1960 - 1977	Residual to land[a]	----	----

[a] Income series calculated similarly to Melichar's residual, Melichar, 1979.

Perhaps the most important explainer of land values is the measure of income to land. Buyers and sellers logically consider the returns when determining bid and ask prices. Column 5 shows the varying income measures used in the studies presented here. Evidently, there is not a definitive income series to use as some studies use net farm income, others use returns on alternative investments, and still others use a residual income to land.

The benefit of reviewing the literature on similar studies is that one can learn from others' successes and failures. The reviews presented here suggest three major findings useful in future research:

(1) A model needs to be logically deduced in order to maximize descriptive power;

(2) Land supply's relationship to land values needs to be explored;

(3) An appropriate measure of income to land needs to be found.

Chapter III develops the theoretical foundations for the current study, keeping in mind the strengths and weaknesses of earlier research.

CHAPTER III

THEORY

In Chapter II, several recent land market studies were reviewed, and the assumptions, strengths, and weaknesses of those models were discussed. It was noted that few land market studies logically deduced the form or content of the models they employed; instead, a correlation between several economic variables and land values was hypothesized. No study explored the behavior producing the correlation.

Four models when re-estimated over a more recent time period than the original sample period suffered sign changes, insignificant coefficients, and loss of accuracy. Other studies, while providing fairly high coefficients of determination, did not fully explain past land value patterns or questions such as why the relationship between land values and income to land is changing. No study explicitly incorporated the supply of farmland or the behavior of farmland suppliers as factors influencing land values.

This chapter explores the theoretical relationships between buyers and sellers under equilibrium conditions. The relationships examined are at first based on the simple capitalization formula. Then the relationships become more complex as the realities of inflation and income taxes are included. Each section begins from the buyer's perspective, then the supplier's, and then includes the market analysis. In addition, the question of an inelastic land supply is addressed under the various assumptions.

A Market Approach

Land's value is just what buyers and sellers agree it is. Exchanges of land for money from seller to buyer are only completed when expected benefits exceed expected costs to the market participants. These transactions between buyers and sellers are the interactions which provide observations on prices for land. Thus, to fully understand land price patterns, a market analysis is required because it is in a market situation that land values are determined.

To begin the analysis, we first look at land transactions from buyer's and seller's perspectives in terms of their perceived costs and benefits. Potential buyers of farmland evaluate their expected returns from holding land and contrast those returns with the opportunity costs of alternative investments. Potential land sellers consider the expected income from selling land as opposed to the current returns from holding land. These expected costs and expected returns are equated when the market is in equilibrium.

It is conceivable that land values may be demand-determined. A seller may face little or no flexibility in a land sale decision due to death, bankruptcy, or forced retirement from injury or failing health. Under such circumstances, the supply of farmland in some transactions may be inelastic. But such conditions do not characterize the entire land market. In general, the market includes a fairly variable land supply justifying a market analysis of factors underlying both the supply and demand for farmland.[1/] This hypothesis will be tested empirically in Chapter IV.

In the next section, a simple land value model is explored--the capitalization formula. Equations for land demand and land supply are generated for individual market participants. Then, market conditions are added and reduced form equations are derived.

A World Without Inflation

The Buyer's Side--Maximum Bid Price

Land is commonly valued by prospective purchasers by equating the expected costs and the expected benefits of holding land. Buyers treat this value as their maximum bid price for land. Capital budgeting theory tells us that an asset's value can be expressed as the sum of its expected returns plus its value at resale. But the value of an asset at resale depends on the income expected by the future buyer, and so on. Thus, in the final analysis, only land's income producing potential matters. These expected returns are 'discounted' or reduced by a factor which equates the expected future stream of income with its present value.

In the simplest of all worlds, no price changes are anticipated; that is, there is no inflation. In addition, this world has no taxes. Let V equal land's present value; let R equal the constant cash returns earned by land in each period; and let r equal the discount rate which compensates savers for the inconvenience of postponing consumption

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[1/] In addition, there are those who believe that the land available for farming is not all being used for farming. "...only about 40 percent (of the nation's 2.3 billion acres) is farmland and less than one-third of this farmland has actually been used for crop production" (7). While the expense of making this excess land tillable is not discussed, it is evident that, given proper economic incentive, there is land available for conversion to crop land.

since there is no inflation.[2/] The relationship between V, R, and r can be expressed as an infinitely long annuity because only future income affects land values.

$$(1) \quad V = R(1 + r)^{-1} + R(1 + r)^{-2} + \ldots + R(1 + r)^{-t}$$

Equation (1) may be rewritten as:

$$(2) \quad V = \lim_{n \to \infty} R[1 - (1 + r)^{-t}]/r$$

Since t, time, approaches infinity, we are left with the capitalization formula:

$$(3) \quad V = R/r \quad \text{3/}$$

Equation (3) summarizes what the capital budgeting theory tells us: an asset's value in a world without inflation or taxes equals the asset's expected returns divided by the discount rate. In other words, the expected returns are 'capitalized' into the value of the asset. At this price V, a propsective buyer of land has expected returns R just equal to the costs of holding the land. The costs of holding the land represent

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[2/]Since there is no inflation, r is the time preference rate for money.

[3/]Another way of considering the relationship of V, R, and r is to let potential purchasers value land based upon its stream of income plus the value of the land when it is resold. Then:

$$(a) \quad V = R(1 + r)^{-1} + R(1 + r)^{-2} + \ldots + R(1 + r)^{-t} + V(1 + r)^{-t}$$

The weighted income series when discounted to the present value of an annuity equals:

$$(b) \quad S = R(1 - 1 + r)^{-t})/r$$

When the right hand side of equation (b) is substituted into equation (a), we have:

$$(c) \quad V = R(1 - (1 + r)^{-t}/r + V(1 + r)^{-t}$$

When equation (c) is solved for V, the simple capitalization formula, equation (3) results.

the foregone opportunities given up by a purchaser of land, V dollars invested at an interest rate of r percent per period.[4/] Thus, V represents the buyer's maximum bid price for land.

The Seller's Side--Minimum Ask Price

Market participants considering selling land are interested in a similar question to the one answered by prospective land purchases: at what price are benefits from the sale of land just equal to the costs, i.e., the returns foregone? We again assume that income from land is expected to continue at a constant R dollars per period. So, if the land is sold, the seller earns rV each period from investing the sale proceeds, foregoing R dollars which could have been earned by holding land.

If V equals the sale price of land and the seller earns rV in each period while giving up the return R, these benefits and costs can be discounted to the present. The result, using a discount rate equal to the time preference rate r, is:

$$(4) \quad (rV - R)(1 + r)^{-1} + \ldots + (rV - R)(1 + r)^{-t} = 0$$

Verbally, this expression states that the difference of the benefits and costs discounted to the present equals zero.

Equation (4) then, is the sum of an annuity, so we can write:

$$(5) \quad (rV - R)[1 - (1 + r)^{-t}]/r = 0$$

As n representing time becomes large, the quantity $(1 + r)^{-n}$ approaches zero and again we are left with the capitalization equation (3). But there is a difference: the value V is now the minimum acceptable price

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[4/] This assumes opportunities exist to invest the purchase or sale price of land at the rate r which we earlier define as a time preference rate.

required to entice a seller to part with the land, since it equates the costs and benefits of selling land.

The fact that V is the same for buyers and sellers alike is not a particularly surprising result. The equilibrium condition--that an asset be priced so that supply just equals demand--requires that the value of land for sellers and buyers be equal. If the values were unequal, buyers and sellers would be forced to reassess their positions. If the price was above a market-clearing level and demand for farmland exceeded supply, marginal farmers or farmers who were stretching management and financial resources to bid on land would likely have to withdraw their bids, thereby reducing demand and prices. At the same time, higher prices would entice more suppliers to offer land for sale, increasing supply and reducing prices. At some point, prices would return to an equilibrium level. If the price was below a market-clearing level, the opposite effects would result. Land owners at the margin would reduce their supply of land since returns would no longer justify the costs. Potential buyers would be more interested in buying as their costs of buying land are lower. These reactions would cause the price to rise to some equilibrium level.

The Market--Combining Buyers and Sellers

The results of equation (3) can be used to derive the quantity of land traded. But several assumptions must first be made in order to begin the process. First, consider a market which is comprised, for simplicity's sake, of two individuals. One individual may be thought of as the sum of all net suppliers of land and the other may be thought of as the sum of all net demanders of land. Second, since land inherently exists, i.e., since it is not a reproducible asset, each market participant is originally endowed with some quantity of land Q, (Q greater than or equal to zero). Third, assume the land market is operated by a Walrasian auctioneer who announces an opening trading price and surveys each participant to see how much land that participant would be willing to trade (purchase or sell) at that given price. The auctioneer records the amount for each market participant, then repeats the process at a higher price. The survey is continued until a schedule of price and quantities traded at those prices is determined. Our third assumption will permit us to look at the aggregate market by summing quantities of land held or desired for our two market participants who represent the entire market.

To begin the process of deriving the quantity of land traded, a potential market participant will determine what action to take by consulting his current or expected production function. In panels (a) and (b) of Figure 3, output Y is related to the input land by production functions f_1 and f_2 for farmers one and two, respectively. Initially, a farmer's total output will rise at an increasing rate as economies of size are realized. At some point, however, certain resources such as management will not be expandable in the same proportion as land. Output then begins to increase at a decreasing rate until it finally begins to decline.

Marginal product curves associated with the respective total output curves, pictured in panels (c) and (d) of Figure 3, can be derived. Multiplying these marginal product curves by a given, constant output price P_y allows us to obtain the marginal value product curve (MVP) in Figure 4. Over the relevant range, these MVP curves may be approximated by linear functions. They represent the returns R associated with varying levels of output on the production functions. So, for every acre

FIGURE 3

PRODUCTION FUNCTIONS AND MARGINAL PRODUCT CURVES

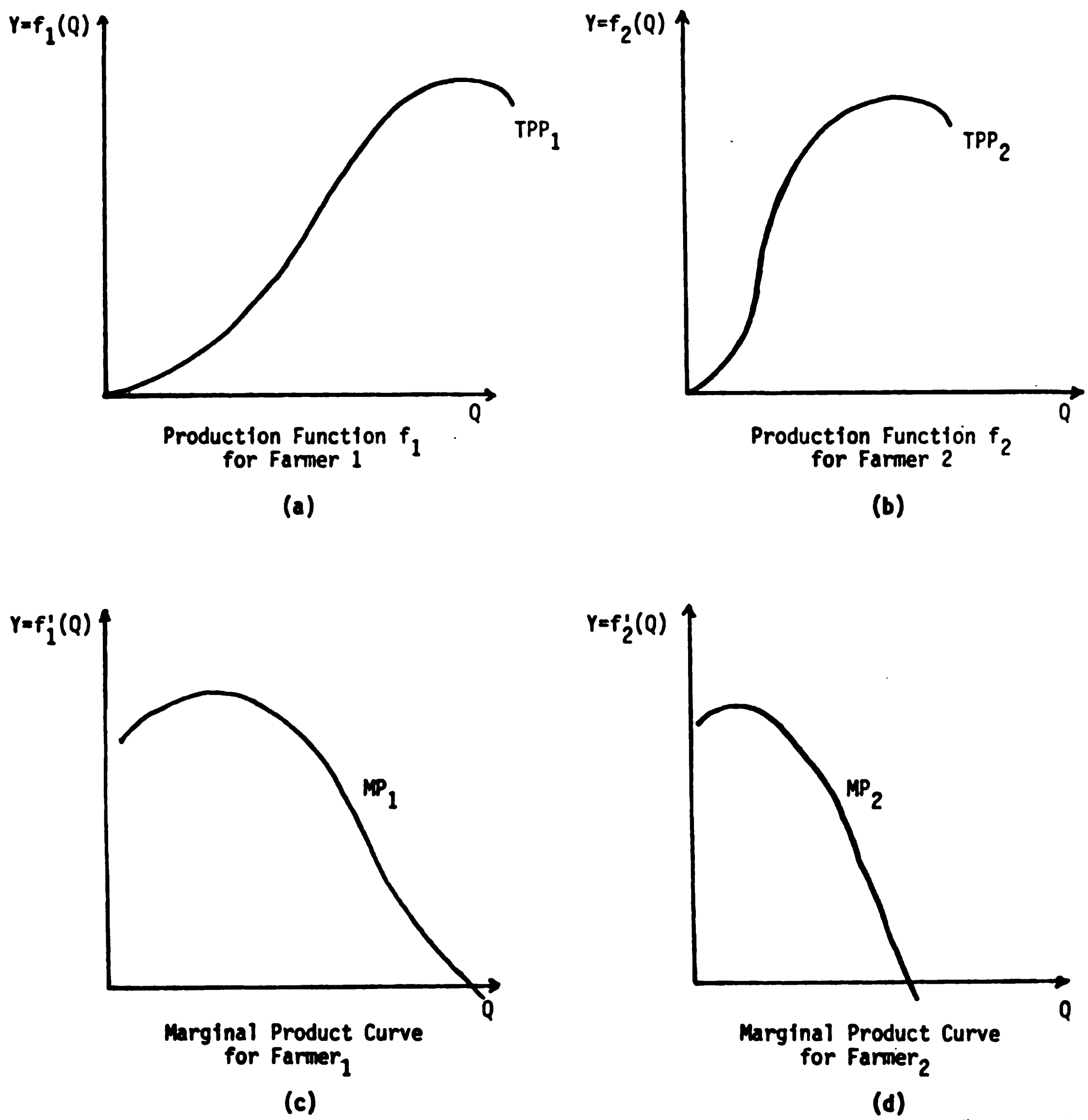
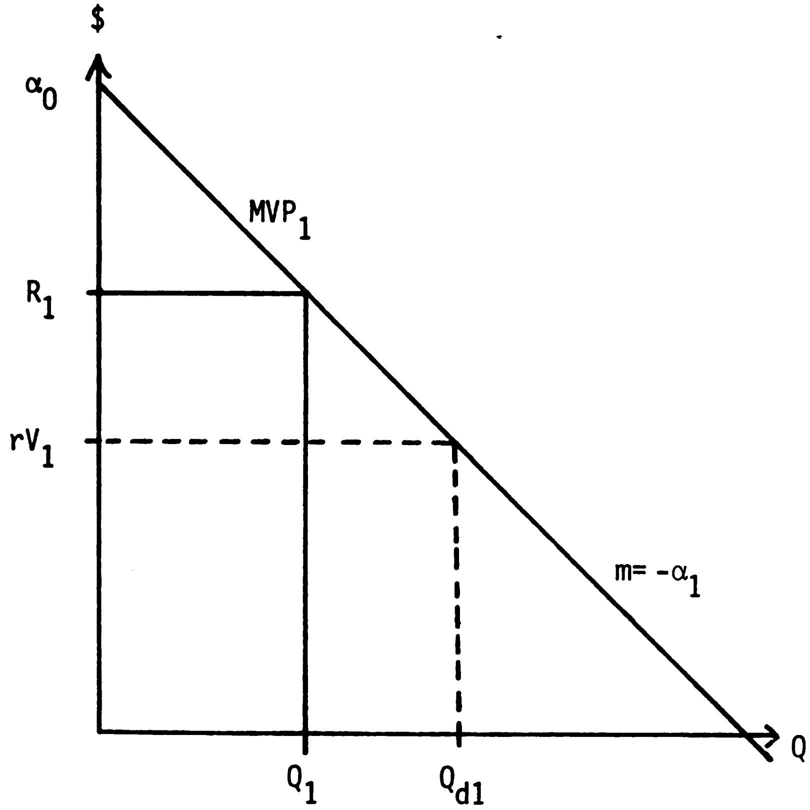


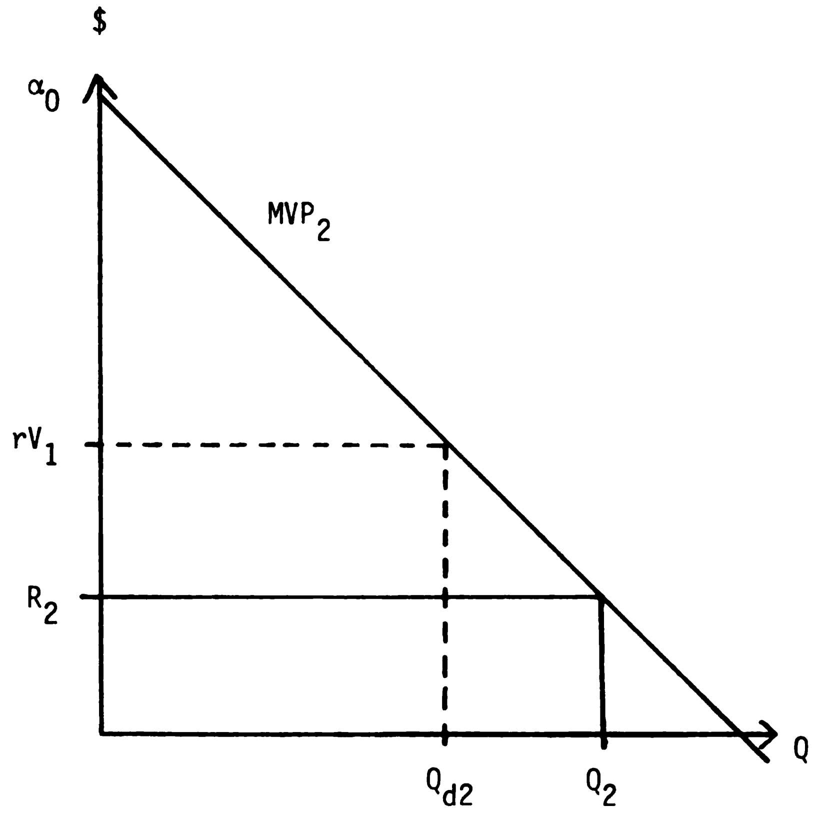
FIGURE 4

MARGINAL VALUE PRODUCT CURVES



Marginal Value Product Curve
for Farmer 1: $MVP_1=(MP_1 * P_y)$

(a)



Marginal Value Product Curve
for Farmer 2: $MVP_2=(MP_2 * P_y)$

(b)

of land used in production there is some output Y which is valued at R dollars per acre.

Individuals considering a purchase of land will consult their production functions and note the returns R they could earn by buying land. These individuals also consider the opportunity cost of making an investment of V dollars per acre. This money could be used elsewhere and earn a return of r percent per period. If the potential benefits from the purchase exceed the expected costs, then it will be profitable for the individual to buy the land.

Consider the case of farmer 1 whose MVP curve is pictured in panel (a) of Figure 4. This farmer is originally endowed with some quantity of land Q_1, with Q_1 greater than or equal to zero, on which he receives an annual income of R_1 per acre. Now the auctioneer announces a price of V_1 at which farmer 1 may buy land if he so chooses. The farmer will compare the cost of buying additional land at V_1 and compares that with his MVP curve. The point where a horizontal line drawn from rV_1 intersects MVP_1, the costs of buying additional land and the potential returns from owning that land are equated. The corresponding quantity Q_{d1} is the total quantity of land farmer 1 desires to hold at a price of V_1. Since for farmer 1 the quantity of land wanted exceeds the quantity held, farmer 1 will demand $(Q_{d1} - Q)$ acres of land at a price of V_1 per acre. At Q_{d1}, costs and benefits for farmer 1 are equal.

Potential sellers of land view their decision similarly, but the benefits and costs are just exactly opposite those for potential purchasers. If an individual sells some quantity of land, he expects to receive the sale proceeds V invested at r percent per year. Consequently, the expected benefit is dependent on the price for which one can sell.

The expected cost of the sale, on the other hand, is the return R foregone by selling, and that R is dependent on the potential seller's production function. As for the potential purchaser, if expected benefits from the sale exceed expected costs, the sale will be profitable.

Farmer 2 in Figure 4 is an example of a potential seller of land. Beginning with an endowment of land Q_2 which returns R_2 dollars per acre per period, farmer 2 will want to sell land so long as the perceived benefits of rV per period exceed the foregone returns R. When the auctioneer announces a trading price of V_1, the farmer considers the quantity of land which will just equate his costs and benefits. Quantity Q_{d2} is associated with the point of intersection between benefits rV_1 and the MVP_2 curve. For farmer 2, the quantity desired Q_{d2} is less than the quantity originally held, Q_2. Therefore, farmer 2 is interested in selling the quantity of land $(Q_2 - Q_{d2})$ at a price of V_1.

These situations where buyers and sellers consider costs and benefits of holding or selling land recur at every announced trading price. Every time costs and benefits are such that Q_d exceeds Q, an individual is a demander. Every time Q exceeds Q_d, an individual is a supplier. So long as there is a disparity between costs and returns, trading will take place. If the costs and returns are just equal, the market is in equilibrium. This situation is expressed mathematically as $rV = R$.

At the point of equilibrium, Q summed for all participants just equals Q_d summed. To determine the aggregate land demand for the entire market, the quantity $(Q_d - Q)$ is summed for all individuals whose Q_d exceeds Q. The aggregate supply may be thought of as the sum of $(Q - Q_d)$ for all individuals whose Q exceeds Q_d.

Assuming m market participants, the net market demand or supply for agricultural uses by agricultural market participants, given price V, equals:

$$(6) \quad \sum_{i=1}^{m} Q_d \; - \; \sum_{i=1}^{m} Q \; = \; W$$

where W is the quantity of land untraded--an excess demand or excess supply. In equilibrium the quantity of land desired just equals the quantity of land held, W is equal to zero and all land is traded.

If W is non-zero, then the land market is out of equilibrium. The land market can be thought of, in a sense, as two distinct markets: agriculture and non-agriculture. By necessity, the overall land market is in equilibrium since land is non-diminishing and non-reproducible. But the subsector land markets are not necessarily fixed as land may move from agricultural to non-agricultural uses, and vice versa. The total land market may be expressed by:

$$(6a) \quad (Q_{dA} - Q_A) + (Q_{dN} - Q_N) = 0$$

where Q_{dA} and Q_A represent the aggregate quantity of land desired and held, respectively, in agriculture, and Q_{dN} and Q_N represent the aggregate quantity desired and held in non-agriculture. In this representation, $(Q_{dN} - Q_N) = -W_A$; that is, the disequilibrium quantity of one market equals the opposite quantity in the other market. Consequently, W is the quantity of land moving between markets or the quantity of land untraded in a market. Within the agriculture market, if W is positive, there is excess demand for agricultural land and either some demanders will go without buying land or land will enter from the non-agriculture sector. If W is negative, there is an excess supply of agricultural land

and either some land will be idled or it will move to the non-agriculture market. For simplicity, W_A is thought of as the disequilibrium factor for agriculture. References to the land market disequilibrium will be referring to the agriculture market unless otherwise stated.

The next step is deriving equations expressing Q_d and Q associated with their costs and returns for each market participant. Each individual starts with quantity of land Q to which there is some benefit according to that individual's production function. The return on the last unit of land added to production can be found with a vertical line drawn from Q which intersects the MVP curve (Figure 4). The MVP curve can be approximated by the formula:

(7) $R = \alpha_0 - \alpha_1 Q$

where α_0 is the y-intercept and α_1 is the slope of the MVP curve. At the intersection of the MVP curve and the vertical line Q in Figure 4 we find the return R associated with the last unit of the land endowment.

The quantity of land desired by an individual is determined by the intersection of his MVP curve with the opportunity cost or borrowing cost of rV of holding land. Then an individual would desire to hold land Q_d which equates the expression:

(8) $rV = \alpha_0 - \alpha_1 Q_d$

Rewriting equations (7) and (8) in terms of Q and Q_d respectively will allow this system of equations to be solved for land values.

(9) $Q = (\alpha_0 - R)/\alpha_1$

(10) $Q_d = (\alpha_0 - rV)/\alpha_1$

Substituting for Q and Q_d in equation (6) the right hand side of equations (9) and (10), we have:

$$(11)\quad -(\alpha_0 - rV)/\alpha_1 + (\alpha_0 - R)/\alpha_1 = W$$

Solving for V yields the reduced form expression:

$$(12)\quad V = R/r - (\alpha_1 W)/r$$

Equation (12) is the reduced form expression combining equations of demand for farmland, supply for farmland, and the market equilibrium condition in a world without inflation or taxes. In such a world, land values are dependent upon the capitalized value of annual returns to land, R/r, and the capitalized quantity of land moving out of agricultural uses, $\alpha_1 W/r$, which must be included in land's price in order for the agriculture market to clear.

Equations may be derived expressing returns and costs, and likewise, quantities of land desired and quantities of land held, in the non-agriculture market as well. Such equations are in exactly the same form as equations (7) and (8). The non-agriculture MVP curve can be approximated by:

$$(13)\quad R = \beta_0 - \beta_1 Q_n$$

The opportunity cost expression is:

$$(14)\quad rV = \beta_0 - \beta_1 Q_{dN}$$

Solving these equations for Q_N and Q_{dN} and substituting them along with equations (9) and (10) into equation (6a), the expression for the entire land market yields:

$$(15)\quad [(\alpha_0 - R)/\alpha_1 - (\alpha_0 - rV)/\alpha_1] + [(\beta_0 - R)/\beta_1 - (\beta_0 - rV/\beta_1] = 0$$

Equation (15) can be simplified to:

$$(16)\quad (\beta_1 + \alpha_1)rV/\alpha_1\beta_1 = (\beta_1 + \alpha_1)R/\alpha_1\beta_1$$

With cancellations, we are left with:

(17) $V = R/r$

the capitalization formula.

This analysis results in interesting implications. The capitalization formula provides an estimate of land's worth within the overall land market which by nature is in equilibrium. But the agriculture land market, which is not necessarily in equilibrium, must include a factor incorporating W, land either untraded within agriculture or land moving out of agriculture. Only when the market clears and all land within agriculture is used in farming does the simple capitalization formula result.

In any event, the implications of W for the agriculture market remain the same. If the announced price V is a market clearing price, that is, a price which just equates ΣQ_{dA} with ΣQ_A, then this difference W will equal zero. If V is not a market clearing price, there will be some untraded quantity of land, or some quantity land moved out of farming. If that quantity W is positive, there is excess demand for land, either for use in farming, or for use out of farming, and therefore, there will be upward pressure on land price. Conversely, if W is negative, an excess supply of land exists either because demand for external uses is diminished, or because returns to holding land do not justify the costs involved. If W is negative, there will be downward pressure on land prices. Either situation causes the land market to move toward equilibrium.

Fixed Land Supply

It has been assumed by other researchers (13) that the supply of land offered for sale is independent of returns and prices; that is, land supply is assumed to be inelastic. Land sales are assumed to depend on factors such as the number of farmer deaths, retirements, and the number of children leaving home. This assumption is used to justify use of the capitalization formula.

In such a model, the price for some participants is determined by demand alone. Some quantity of land, $\bar{Q}_s$, will now be sold regardless of the returns accruing to it, in addition to the quantity of land which is traded dependent on land prices. If we add $\bar{Q}_s$ to the price dependent demand and supply equation given in (6), making the same substitutions from (7) and (8), the result is:

(18) $V = R/r - \alpha_1 W/r - \alpha_1 \bar{Q}_s/r$

In addition to the terms described for equation (12), equation (18) includes the capitalized value of the price inelastic demand land $\bar{Q}_s$ in the value of land. Thus, assuming a fixed quantity of land supplied as is frequently done, does not result in the capitalization formula, even in equilibrium. Therefore, one usual justification for the capitalization equation for estimates of land prices is not justified.

Inflation in the Land Market

Persistent upward pressure on land prices had been the rule in recent years. In Michigan, average values for farmland climbed over $100 in each of the last two years. Accompanying these prices, but not at the same rate, have been increases in returns to land.

Research generally concludes that inflation is largely a result of expectations and the farmers are highly responsive to expectations.[5/] If rising returns to farmland are indicative of expected increases in general, savers will no longer be willing to save at rate r which only

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[5/] Luttrell, p. 17.

compensates them for postponing consumption. In addition, they must be compensated for losses in purchasing power suffered by their savings. As a result of the additional compensation, the discount rate must include an inflation premium in addition to the time preference rate r. We express this market rate r* as:

$$(19)\quad r^* = (1 + r)(1 + i) - 1$$
$$= r + i + ir$$

where i is the inflation rate, and r is again the time preference rate.

The Buyer's Side

In a world with inflation but without taxes, a prospective purchaser will now evaluate the present value of land subscripted by inflation. If we still assume that the current buyer perceives the future sale value of land as its income earning potential, the present value of land is now an infinite annuity:

$$(20)\quad V_I = R(1 + i)/[(1 + i)(1 + r)] + \ldots + R(1 + i)^t/[(1 + i)(1 + r)]^t$$

For the buyer only concerned with his maximum bid price, the forces of inflation exactly cancel out since inflation in equation (20) affects returns and the discount factor equally. As a result, the present value of land for the prospective purchaser becomes the familiar capitalization formula, equation (3).

It is important to note, however, that maximum land values are no longer constant over time; rather, they increase in each period by i percent for the prospective purchaser. Recognizing that returns in period t + 1 equal returns in period t multiplied by one plus the inflation rate, we may rewrite the capitalization formula (3) as:

$$(21)\quad V_{I,t+1} = R_t(1 + i)/r$$

where I is the subscript for inflation and t is a subscript for time. Forming the ratio of $V_{I,t+1}$ and V_{It} obtains the percentage annual increase in land equal to:

$$(22) \quad V_{I,t+1}/V_{I,t} = (1 + i)$$

or, i percent. Stated in terms of expectations, each buyer's maximum bid price increases each period by the inflation rate i.[6/]

The Seller's Side

Recall that sellers concerned with the minimum acceptable sale price for land will equate potential returns with potential costs. When land is sold, the seller receives in perpetuity the return on the asset's sale value. That return is equal to the market rate of interest, r*, times the sale price V_I. To receive that return, the seller foregoes returns R_t, which, because of inflation's presence, grow at i percent per period. At a minimum, the expected returns from the sale of land must equal the expected costs in order for the potential seller to be interested in making the sale. The potential seller will look for the minimum sale price V_1 which will equate his discounted costs and benefits. Discounting at a rate equal to the market discount rate, the seller will perceive his costs and benefits as:

$$(23) \quad [r^*V_1 - R(1 + i)](1 + r^*)^{-1} + \ldots + [r^*V_1 - r(1 + i)^t](1 + r^*)^{-t} = 0$$

Collecting terms and solving for r*V allows (23) to be rewritten as:

$$(23a) \quad r^*V_1[1 - (1 + r^*)^{-t}](r^*)^{-1} = R(1 + i)(1 + r^*)^{-1} + \ldots + R(1 + i)^t(1 + r^*)^{-t}$$

[6/]This analysis requires the assumption that all agriculture land market participants hold the same expectations on returns to land.

As t grows large, the left hand side simplifies to V_1. The right hand side, when recognized as the sum of an annuity, may be solved to equal $R(1 + i)(r^* - i)^{-1}$. $(r^* - i)$ may be approximated as r, the time preference rate, because the cross product term ir is negligible. Therefore, the result is the capitalization formula:

(24) $V_I = R_t/r$ [7/]

The Market

Even including inflation, buyers and sellers evaluate their returns and costs using the capitalization formula with returns and land values inflating in each period by i percent, the rate of inflation. Incorporating the effects of inflation does, however, affect the quantities of land desired and the quantities held as determined by market participants. The adjustment requires that returns from the initial endowment Q and the costs of holding Q_d be adjusted for inflation by a vertical shift in the MVP curves. Such an adjustment increases the intercept term α_0 by i percent each period such that $\alpha_{0,t+1} = \alpha_{0,t}(1 + i)$. Rewriting equations (7) and (8) to incorporate the adjustment for inflation yields:

(25) $R_t(1 + i)^{-t} = \alpha_{0,t}(1 + i)^{-t} - \alpha_1 Q$

(26) $rV_t(1 + i)^{-t} = \alpha_{0,t}(1 + i)^{-t} - \alpha_1 Q_d$

Equations (25) and (26) may be solved as before for Q and Q_d, respectively, and substituted into equation (6), the aggregate agriculture land market. Recall that in equation (6) quantities held are subtracted from quantities desired and set equal to some disequilibrium factor W.

[7/] Hauschen and Herr assume that the division on the right hand side is by the market rate of return. Note, however, that it is, in fact, the time preference rate, usually assumed to be between 3 and 5 percent. Dobbins showed it to be 4.3 percent.

Since W is a physical quantity, it need not be adjusted for inflation. Solving equation (6) for land values in the market situation under inflation results in:

(27) $V_t = R_t/r - ((1 + i)^t \alpha_1 W)/r$

Equation (27) is similar to the market result without inflation except that V and R are no longer constant over time; instead they increase each period by the rate of inflation. In addition, the capitalization of untraded land or land moving out of agriculture is also adjusted for inflation compounded for t periods. Thus, under inflation, market participants will evaluate their prospective costs and returns adjusted by inflation using the capitalization formula, but they will also require that a discount or premium be included in land's value equal to $-(1 + i)^t \alpha_1 W/r$.

The Sensitivity of Land Values to Inflation

Returning for a moment to the capitalization equation, Melichar (20) and Robison (28) suggest that land values are highly sensitive when discrepancies in inflation affecting cash returns to land and the discount factor exist. Robison offers this as a possible explanation for the divergence of land values and cash rents experienced in recent history.

The simple capitalization formula may be altered to incorporate different inflation rates. If g equals the rate of increase in R, last period's income, r equals the time preference rate, and i equals inflation, then the value of land equals:

(28) $V^* = R(1 + g)/(i + r + ir - g)$

Using this valuation formula, land values may increase at a rate different than the rate of increase in cash rents.

As an example, suppose that rents increase at six percent per period while interest rates grow at only five percent. If rents are initially \$50 and the time preference rate is 5 percent, V* = \$1247 = 50(1 + .06)/(.05 + .05 + (.05 * .05) - .06). Had rents and the discount rate been affected equally by, say 5 percent, then land values would have equaled \$1000 (V = R/r = 50/.05 = 1000). This difference of 1 percent in the inflation rate represents an increase in land values of roughly 25 percent for a 6 percent increase in cash rents. Table 2 was reported by Robison to emphasize this sensitivity.

If rents and the discount rate are affected equally as we have assumed for simplicity, then there is no effect from inflation on land values, as shown by the diagonal in Table 2. But small variations in the expected rate of increase in cash rents or inflation produce substantial increases in land prices, perhaps accounting for the changing ratio of land values to cash rents over time.

Table 2

The Effects of Inflation and Increases in Net Return to Land on the Percentage Change in Land Values Assuming a Time Preference Rate of Five Percent.[a]

Expected Rate of Inflation	Percentage Increase Expected In Cash Rents				
	0	1	2	3	4
	PERCENT				
0	0	25	65	140	333
1	-17	0	24	63	136
2	-29	-17	0	24	63
3	-38	-28	-16	0	24
4	-44	-37	-28	-16	0

[a]If g equals the rate of increase in income, R equals last periods returns, r equals the time preference rate, and i equals inflation, then the value of land V* = R(l + g) + (i + r + ir − g). Dividing V* by R/r after subtracting 1 produces the numbers in Table 2.

Fixed Land Supply

Incorporating the possibility of a fixed land supply as was done earlier in equation (18), supply is no longer entirely determined in the market by $Q - Q_d$. Now there is some land supplied regardless of the price of sale. The result is a new term capitalizing this fixed quantity into the price of land:

$$(29) \quad V_t = R_t/r - ((1 + i)^t \alpha_1 W)/r - (\alpha_1 (1 + i)^t \bar{Q}_s)/r$$

It is significant to point out that using the simple capitalization formula is only supported for individual market participants or in the aggregate agriculture land market when it is in equilibrium. Fixing the land supply such that it is unresponsive to prices does not justify the equation's use.

Inflation and Taxes

As inflation alters the value of land, so do income taxes. Brake (4) examines the impact of inflation on taxes and he concludes that marginal tax rates are increasing over time simply as a result of 'bracket creep' caused by inflation. Therefore, it is important to explore not only inflation's impact on land values but the effect of taxes as well.

The Buyer's Side

The marginal tax rate θ affects the inflation adjusted discount factor and returns to land. To put returns on an after tax basis is simple enough; income in period t is multiplied by one minus the marginal tax rate. These are the returns the buyer expects. Adjusting the discount rate is somewhat more complex, however. Recall that the market discount rate is composed of the real rate, an inflation premium and the cross product of those two terms. But the rate used in the estimated equation with money illusion eliminated is only the real rate. To account for this fact, an inflation series was constructed assuming a constant time preference rate.

In order to obtain the after-tax real rate, the market rate must be constructed, and then, inflation must be subtracted out as follows:

$$(30)\quad \hat{r}_t = (r + i_t + ri_t)(1 - \theta_t) - i_t$$

This procedure first reduces the market rate for taxes, and then subtracts off inflation, leaving only the after tax real interest rate.

Discounting the buyer's expected stream of income using this after tax real interest rate and after tax returns yields:

$$(31)\quad V_t = R_t(1 - \theta)/\hat{r}_t$$

Inflation's effect no longer cancels out of the numerator and denominator.

The Seller's Side

Potential investment opportunities now do not yield r* but instead, yield an after-tax return of $r^*(1 - \theta)$. Discounting the infinite annuity yields equation (31) also, such that again, inflation's effect does not cancel out.

The Market

Incorporating buyer's and seller's after-tax expectations of land values alters the relationships between land held, land desired, and their respective costs or returns. These changes are noted in equations (32) and (33):

$$(32)\quad R_t(1 - \theta)(1 + i)^{-t} = \alpha_{0,t}(1 + i)^{-t} - \alpha_1 Q$$

$$(33)\quad \hat{r}_t V_t(1 + i)^{-t} = \alpha_{0,t}(1 + i)^{-t} - \alpha_1 Q_d$$

Maintaining the equilibrium condition and solving for the reduced form, the market becomes:

$$(34) \quad V_t = R_t(1 - \theta)/\hat{r}_t - ((1 + i)^t \alpha_1 W)/\hat{r}_t$$

Now, after-tax annual income is capitalized by the after-tax real discount rate as is W, the untraded land. This is not a particularly surprising result, since terms in equation (34) are quite similar to results in equation (27), except that now inflation's effect changes with the tax rate.

Land Value's Sensitivity to Taxes

We saw earlier that land values are highly sensitive to slight variations in inflation rates between cash returns and the discount rate. Likewise, land values are sensitive to a changing tax structure. Brake's (4) research that inflation is causing higher tax rates prompts one to consider this sensitivity.

The general direction of the effect can be seen by constructing the partial derivative of land values with respect to taxes. Using equation (34), the partial is:

$$(35) \quad \partial V/\partial\theta = \frac{iR_t}{\hat{r}_t^{\,2}} - \frac{\alpha_1 W(1 + i)^t(r + i + ir)}{\hat{r}_t^{\,2}}$$

Solving (34) for cash returns permits us to take the partial of R with respect to taxes:

$$(36) \quad \partial R/\partial\theta = -\frac{iV_t}{\hat{r}_t^{\,2}} + \frac{\alpha_1 W(1 + i)^t}{(1 - \theta)^2}$$

Equations (35) and (36) suggest that as taxes increase or decrease, the effects on land values and cash rents are dependent on the disequilibrium factor W. As an example, when W is negative, that is, when there is an excess supply of farmland, equation (35) will be positive. Therefore, land values will change in the same direction as taxes. At the same time, however, equation (36) will be negative for a negative W. That means that returns are inversely related to taxes: as taxes increase, returns decrease. The net effect of an increase in taxes when W is negative is for land values to rise and returns to fall, causing the ratio of land values to returns to rise. Table 3 presents a summary of the direction in which land values, returns, and the ratio change for changes in taxes.

The importance of Table 3 is that it suggests that increasing taxes may be the cause (or part of the cause) for an increasing land value to cash returns ratio. If supported empirically (it will be tested in Chapter IV), this theoretical conclusion will have important ramifications for tax legislation. Changing land values and their relationship to annual returns would be one more consequence of changing taxes.

Table 3

The Effects of an Increase in Taxes on Land Values and Income to Land, Depending on the Equilibrium State of the Agriculture Land Market

If W is:	An increase in the marginal tax rate θ will result in a change in V_t, R_t and V_t/R_t in the following direction.		
	$\partial V_t/\partial\theta$	$\partial R_t/\partial\theta$	$\partial(V_t/R_t)/\partial\theta$
= 0 (Market Equilibrium)	+	-	+
< 0 (Excess Supply)	+	-	?
> 0 (Excess Demand	?	?	?

Conclusion

In this chapter, statements of annual benefits from land and annual costs of land were considered from buyer's and seller's perspectives. These costs and benefits were equated in a market analysis under assumptions of no inflation or taxes, inflation but no taxes, and finally, both inflation and taxes.

The significant theoretical results which now need to be tested are:

1. The simple capitalization formula, $V = R/r$, does not fully explain the land market, unless no land goes untraded.

2. Incorporating inflation and income taxes in a market model yields a price-return relationship between land values and cash rents, but also includes a disequilibrium factor for land leaving or entering farming (equation 34).

3. There is no evidence for treating the supply of farmland as inelastic.

4. Allowing taxes to vary helps explain the phenomena of an increasing ratio of land values to cash rents.

Chapter IV constructs the empirical tests of these hypotheses.

CHAPTER IV

THE EMPIRICAL TESTS

Chapter III offered several hypotheses and models of the land market which were derived from the theoretical relationship between buyers and sellers in a market situation. The major hypotheses from Chapter III are:

(1) The capitalization formula is insufficient for explaining observed phenomena of the land market;

(2) A market model based on equations of expected costs and benefits for potential land market participants and incorporating the effects of inflation and taxes can explain the land market and withstand the 'test of time';

(3) A model which includes an inelastic supply of farmland cannot be justified.

The purpose of Chapter IV is to test these statements for empirical validity--do 'real world' observations support or refute these models?

In order to test these statements, data on land values, cash rents, interest rates, inflation, land supply, and tax rates are required. Before reporting the test results for the hypotheses mentioned above, the appropriate data are explored and discussed.

After discussing such statistical measures as R^2 statistics and significant coefficients, a non-statistical criteria for a good model is considered in relationship to the capitalization formula and the market models. The criteria is the ability of a model to predict the observed changes in the ratio of land values to cash rents. That is an important ability because the capitalization relationship leads us to expect a constant ratio, contrary to observation. After this discussion, initial conclusions from the empirical work are presented.

The Data

Models and hypotheses are tested using Michigan data. The market model with inflation is re-estimated using Illinois farmland data as a test of general applicability. Data used are reported from several sources. The USDA reports survey results of farmers each February 1, including land values and cash rents as reported by landlords. Robison and Leatham (29) report discount rates and new Federal Land Bank interest rates, and farmland supply data is reported by Michigan Agricultural Statistics. Data series for inflation and marginal tax rates are constructed using expected or observed relationships with other data. Each data series is reported in Table 4 and explained in detail below.

Land Values reported by any sources are probably inaccurate because each parcel of land in effect comprises a separate market. Given the distinct properties each parcel holds, there is no truly representative land price. Even though each parcel has separate characteristics, however, all farmland is affected in some fashion by common forces such as inflation, high energy prices, and new international trade developments. Therefore, the average farmland value as reported by the USDA reflects the impacts on the individual tracts of land, making the USDA land value series appropriate for use here.

Determining the appropriate measure for income is not as easy as finding a land value series. Chapter II pointed out some measures such as net farm income and a residual income to land series used in earlier land studies. However, problems exist with either of those income

Table 4

Cash Rents for Cropland, Land Values, Interest Rates, and Land Acreage Data

	1	2	3	4	5	6	7	8	9
	AVERAGE CASH RENTS (Before Tax) Dollars per Acre		MICHIGAN RENT AFTER TAX[c]	AVERAGE LAND VALUES (as of Feb. 1)[d] Dollars per Acre		LAND VALUE TO CASH RENT RATIO MI	FLB INTEREST RATE ADJ. FOR STOCK PURCHASE[a] Percent	ACRES TRANSFERRED IN MICHIGAN[d]	LAND IN FARMS IN MICHIGAN[e] Million Acres
	MICHIGAN[a]	ILLINOIS[d]		MICHIGAN[d]	ILLINOIS[b]				
1960	14.08	19.55	11.50	174	541	12.4	6.3		15.4
1961	14.00	19.75	11.50	176	526	12.6	5.9		15.1
1962	14.58	19.65	11.90	196	541	13.4	5.9		14.8
1963	14.81	21.16	12.10	201	571	13.6	5.9		14.6
1964	15.42	21.85	12.50	217	594	14.1	5.8		14.4
1965	16.12	27.24	13.10	237	640	14.7	5.8		14.1
1966	17.24	30.20	13.90	236	716	13.7	6.1		13.9
1967	20.49	33.05	16.40	254	762	12.4	6.3		13.6
1968	18.48	36.05	14.80	290	792	15.7	7.1		13.3
1969	19.15	36.20	15.30	291	830	15.2	8.1		12.9
1970	18.00	36.35	14.30	292	815	16.2	9.2		12.7
1971	20.21	36.65	16.00	295	823	14.6	8.3		12.5
1972	19.85	38.05	15.60	344	883	17.3	7.8	17,731	12.3
1973	22.77	41.55	17.80	371	983	16.3	7.9	11,000	12.0
1974	26.23	52.60	20.30	433	1318	16.5	8.5	27,000	11.7
1975	28.50	63.53	21.90	446	1592	15.6	9.2	27,060	11.8
1976	31.17	77.11	23.80	546	1980	17.5	9.2	18,270	11.7
1977	37.51	92.41	28.40	735	2689	19.6	8.8	21,756	11.6
1978	38.00	94.65	28.50	761	2970	20.0	8.7	18,135	11.4
1979	40.00	99.73	29.80	820	3359	20.5	9.6	18,816	11.2*
1980	46.40	---	34.20	928	---	20.0	10.8	14,105	11.1*

a/Source: Robison and Leatham

b/Source: Scott, 1979. Values based on Land Index, 1979 = $2,970.

c/Marginal Tax Rate Schedule derived from Brake, 1979.

d/Source: USDA unpublished data on cropland.

e/Source: Michigan Agricultural Statistics, various years, using old definition of farms.

*Estimate

measures. As Melichar notes, net farm income includes not only returns to land, but returns to other factors of production such as management and operator's labor. Therefore, net farm income is not satisfactory as a measure of income to land. Creating a residual income series though, also has stumbling blocks. For one thing, the allocation of returns to resources is not always evident. In addition, a residual income series is not determined in a market setting under forces of supply and demand; rather, it is an 'attributed' return.

Even with these flaws a residual income series is better than net farm income for use as a measure of current returns to land. However, if there is an active cash rent market for land, some researchers support the net rental approach as an estimate for land income.[1/] Using cash rents as reported by landlords avoids the problem of determining how to assign returns to factors of production. Since tenants on a cash rent basis receive only land, the rent they pay is allocated solely to that resource. In addition, these rents are determined in a market setting in that factors of supply and demand do affect the rent charged. For these reasons, cash rent is used in this research as the measure of current returns to land.

Finding the appropritae discount rate for use in the land market is not straightforward either. In practice, an accurate discount rate for all market participants is impossible to derive because each individual is subject to different money costs and different alternative opportunities. Federal Land Bank (FLB) loan rates, adjusted by stock purchase requirements, provide perhaps the best estimate since a very high percentage of land is purchased using borrowed funds and the

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[1/] Lee and Rask, p. 985.

largest lender for real estate mortgages is the FLB. Therefore, FLB new loan rates are considered a proxy for market interest rates (or discount rates).

An implicit measure for inflation is found to be imbedded in market interest rates. As developed in the third chapter, the nominal discount rate is composed of three terms, the real interest rate, inflation, and the product of inflation and the real rate; that is, the market interest rate is: $r^* = r + i + ir$. In practice, the third term, ir, is generally very small and it is often ignored. The time preference rate, r, on the other hand, has been estimated to be about 4.25% by Melichar (20) and is generally concluded by researchers to be between 3 and 5 percent. Thus, if one is using a specific interest rate series as the discount rate, in this case the Federal Land Bank new loan interest rate adjusted for stock purchases, then an implicit measure of the inflation affecting the discount rate can be determined by subtracting the time preference rate from the discount rate (ignoring the term ir). While recognizing that the real time preference rate is not known with complete certainty, this study treats r as a constant four percent in order to clculate the inflation affecting the discount rate. The calculated inflation series, then, equals the adjusted FLB interest rate minus four percent.

By treating the inflation which affects the discount rate as the adjusted FLB interest rate minus four percent also allows for a differing affect of inflation on cash returns than on the discount rate. In Chapter III, the sensitivity of land values to such differences in inflation was emphasized. Permitting a difference in inflationary impacts will let us test Robison and Melichar's assertion that differences in the ratio of V_t to R_t can be explained by inflationary differences on the discount rate and income.

To incorporate income taxes as an effect on land values, it was necessary to develop a time series for the marginal tax rate. Brake (4) points out that a couple earning $10,000 in 1965 would be in a 19 percent tax bracket, but a couple with the same real income after taxes in 1978 would be in a 25 percent bracket, and 28 percent by 1982. Therefore, a time series variable for the marginal tax rate is probably justified. Fitting a curve by hand from the three tax rates reported by Brake, this tax rate series was used to adjust cash rents to an after tax basis.[2/] While inflation and real gains have not pushed cash rents and total income up at a uniform rate from year to year, a series based on these three years provides a fairly accurate approximation of the marginal tax rate trend experienced in recent history.[3/]

One factor not yet discussed is land untraded or farmland leaving agricultural uses. This factor can be handled in two different ways: it can either be treated as a constant amount from period to period, or it can be considered as variable over time. When treated as a constant, W is simply incorporated into the coefficient on the inflation term $(1 + i)^t$ of equation (27). When treated as a variable the difference of

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[2/]Multiplying cash rents by $(1 - \theta_t)$, where θ_t is the marginal tax rate in period t, puts rents on an after-tax basis.

[3/]Another Marginal Tax Rate series was calculated using Gross Farm Income adjusted to equal 10,000 1965 dollars. Then, the appropriate tax payment was taken from IRS tax tables for Married, filing jointly. The tax payment divided by the gross income provided a marginal effective tax rate. Unfortunately, this time series did not meet the needs of the model and was later abandoned.

land in farms in period t and period t-1 is considered the amount of land offered for sale but untraded, or moved into non-agricultural uses.

If we look at column 7 of Table 4, we note that this difference has been maintained at a fairly steady amount of 200,000 to 300,000 acres per year in Michigan. Given the stability of this trend, this study treats W as a constant, to be incorporated as a constant coefficient on inflation.

The last factor is farmland supply as a fixed term. To test the possibility of an inelastic supply, Michigan farmland transfers are considered to be a proxy for land supplied. These transfers are determined outside of the land market by factors other than demand or price.

The Tests

Now that the variables and data have been appropriately difined, the next step is to present empirical findings supporting or refuting the hypotheses of Chapter III. Because a world without inflation certainly does not exist today, nor is it likely ever to happen in the future, theoretical models developed without inflation were largely for tutorial purposes. Therefore, the first test is made on the basic capitalization model with inflation.

Capitalization Formula

In Chapter III the capitalization formula came up several times as the basis for market participant decisions on how much to pay for or accept for land, even with inflation and taxes. It was noted that in equilibrium, the agriculture land market equation reduces to the capitalization formula. Although requiring that a market be in equilibrium is a highly confirming constraint, the capitalization formula is widely used. As such, the formula warrants testing here to see if users are justified by empirical evidence.

In order to test the ability of the capitalization formula to explain land value trends, equation (24) is estimated using Michigan data over the sample period 1960-1980. In equation (24) land values and cash rents are permitted to increase in each period by the rate of inflation, so they are subscripted for time:

$$(24) \quad V_t = R_t/r$$

Equation (24) was estimated using Ordinary Least Squares, assuming the time preference rate r to be a constant between three and five percent. With this assumption, the coefficient on R_t should be the reciprocal of r, between 20 and 33. The statistical results of the estimation are:

$$(37) \quad V_t = 17.7\ R_t$$

$$(30.4) \qquad R^2 = .914 \qquad D.W. = 0.25$$

The results are rather impressive for a simple model: a single variable equation yields a coefficient of determination (R^2) of 91 percent. In addition, the t-statistic (reported in the parentheses below the corresponding coefficient) suggests that the coefficient on R_t is significant at all confidence levels. According to this model, land should be priced at approximately 18 times its current earnings. The coefficient on R_t is not very far out of the expected range, yielding a value for r of about 5.6 percent.

This simple equation, however, treats the ratio of land values to cash rents as a constant, approximately equal to 18. Actual observations shown in column 1 of Table 5 indicate that the ratio has, in fact, varied

Table 5

The Ratio of Land Values to Cash Rents Estimated Using the Capitalization Formula and the Market Models

Year	1 Actual	2 Capitalization Formula	3 Market Model Without Taxes	4 Market Model With Taxes
1961	12.6	↑	13.1	13.4
1962	13.4		14.1	13.9
1963	13.6		13.8	13.8
1964	14.1		14.0	14.3
1965	14.7		14.4	14.8
1966	13.7		15.1	15.8
1967	12.4		17.2	18.6
1968	15.7		15.2	16.0
1969	15.2		15.5	15.9
1970	16.2		13.8	13.8
1971	14.6	17.67	15.0	14.8
1972	17.3		14.3	13.5
1973	16.3		15.8	15.4
1974	16.5		17.1	17.1
1975	15.6		17.5	17.5
1976	17.5		18.0	17.9
1977	19.6		19.6	20.0
1978	20.0		19.3	19.1
1979	20.5		19.3	18.9
1980	20.0	↓	20.1	19.8

from a low of 12.4 to a high of 20.5 in a generally upward trend over the period 1960-1980. Therefore, because equilibrium is a rarely exhibited trait of any market (for which the agriculture land market is no exception), and because empirical results do not fully explain past patterns exhibited by land values, the capitalization formula is rejected as the best model of the land market. The formula does indicate, however, that the land value-cash return relationship which is fundamental in the market models is a significant factor influencing land values.

The Market Model With Inflation

Incorporating inflation into the theoretical equations of expected costs and returns did not affect buyer's or seller's maximum bid price and minimum ask price equations except that land values and cash returns were no longer constant over time. But adding inflation under market conditions produced equation (27) which included the disequilibrium variable $-(1 + i)^t \alpha_1 W/r$ (land leaving farming, inflated at i percent per period) along with capitalized returns R_t/r in the value of land.

$$(27)\quad V_t = R_t/r - (1+i)^t \alpha_1 W/r$$

In equilibrium the variable for land leaving farming, W, goes to zero, and the model reduces to the capitalization formula. When the market is not in equilibrium, W is non-zero and the second variable of equation (27) has some value.

As noted earlier, land leaving farming is considered part of the coefficient on $(1 + i)^t$ since W has remained fairly stable over the past 20 years. The coefficient also includes α_1, the slope of the MVP curve, and 1/r, the inverse of the time preference rate. This leaves as the variable the inflation proxy i compounded for t periods into the future, where t is the difference between the year of estimation and the initial year of the series. As an example of the compounded inflation variable, in 1962 it would equal the 1960 inflation proxy (i_{1960}) plus one multiplied by i_{1961} plus one and i_{1962} plus one:

$$VARIABLE_{1962} = (1 + .023) * (1 + .019) * (1 + .019) = 1.042437$$

The sign on this inflation variable coefficient is expected to be negative since W is a negative; that is, since land is leaving agricultural uses or being idled, the difference between land desired, Q_d, and land held, Q, is negative. The coefficient on the cash returns variable, on the other hand, should be the inverse of the discount rate, between 20 and 33, with a positive sign.

Estimating equation (27) for Michigan data over the recent 20 year period 1961 to 1980 yielded:

$$(38)\quad V_t = \underset{(17.4)}{29.5R_t} - \underset{(-7.0)}{220.1} \prod_{j=1}^{t} (1 + i_j) \qquad R^2 = .978 \quad D.W. = 1.62$$

This two equation market model including inflation provides a correlation of nearly 98 percent between land values and two variables. The t-statistic shows both coefficients are significant at .05 percent confidence intervals and signs on both coefficients are those expected. In addition, the magnitude of the coefficient on cash rents (29.5) is well within the expected range for the inverse of the time preference rate.

These satisfactory statistical results lend support for the underlying premise of this research; that the land market can be described using a market equilibrium approach. In addition to the statistical support for the market model, another benefit is that using this model the ratio of V_t/R_t is allowed to vary over time. Referring to Table 5, expected values of the ratio using the market model are reported. Conclusions drawn from Table 5 will be discussed after empirically testing the remaining hypotheses, but one can clearly see the similarity of the projected series in column 3 and the actual series in column 1 of Table 5.

While the results reported in equation (38) are statistically satisfactory, they do not test the general applicability of the market model with inflation. In an effort to test that applicability, equation (27) was re-estimated using Illinois land market data. The importance of this re-estimation is that statistical support for the market model will be enhanced if test results are satisfactory for a different land market, especially since the magnitude of cash rents and land values is much greater in Illinois than in Michigan (see Table 4). If the model is correct for Illinois data as well as Michigan, we have a general relationship between returns and land values independent of geographical region.

The results of re-estimating equation (27) with Illinois data from 1961-1979, are:

$$(39)\quad V_t = \underset{(16.9)}{36.0}\, R_t - \underset{(-3.9)}{325.4} \prod_{j=1}^{t} (1 + i_j) \qquad R^2 = .969 \qquad D.W. = 0.44$$

(t-statistics are in parentheses below the appropriate coefficients.) These results are again encouraging as the model yields a correlation of nearly 97 percent. The t-statistics show that both coefficients are significant at the .1 percent level and both have appropriate signs. The change in magnitude of the coefficient on the inflation term may be attributed to a different quantity of land leaving farming in Illinois than in Michigan. The coefficient on cash returns (36.03) is nearly within the expected range of a three to five percent time preference rate. Thus, re-estimating equation (27) for Illinois data appears to reconfirm the conclusion that a market approach to the land market is empirically sound.

Another test of the strength of this market approach is drawn from Chapter II. Three of the models reviewed in Chapter II lost accuracy, suffered sign changes, and had coefficients become insignificant when re-estimated over longer time horizons than their initial sample periods. A fourth model suffered sign changes and insignificant coefficients but no loss of accuracy. If equation (27) is a valid model, re-estimating over a longer time period should provide comparable accuracy (R^2), significant coefficients, and the same signs as the initial estimation from 1961 to 1980. Only coefficient magnitude is likely to be sensitive to the sample period, but no other changes should results from the re-estimation.[4/]

To test the strength of equation (27) over time, the equation was re-estimated from 1941 to 1979 using Michigan data. With t-statistics below the corresponding coefficients, the estimation results are:

$$(40)\quad V_t = \underset{(21.0)}{24.1}\, R_t - \underset{(-6.7)}{85.1} \prod_{j=1}^{t} (1 + i_j)$$

$R^2 = 0.967 \qquad D.W. = 0.66$

The t-statistics of 21.0 and -6.7 are both significant at .05 confidence levels. These results suggest that this market model with inflation is not subject to the loss of accuracy, sign changes, or insignificant

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[4/] Pope, et al., p. 115.

coefficients which plagued earlier research attempts. In fact, the only difference in the estimations between 1941-1979 and 1961-1980 is the magnitude of the coefficient on the inflation term. Before the coefficient was -220.1 while here it is -85.1. This difference, however, may be due to omitted variables in the coefficient such as land leaving farming, W.

Summarizing this market approach with inflation, it appears that a rigorously deduced model can be found which not only has intuitive appeal but empirical validity as well. The model is applicable to Illinois data as well as Michigan, and it can withstand a 'test of time' which has been failed by other models.

Fixed Land Supply

Crucial to the development of models within this paper has been the assumption that the supply of farmland along with the demand for farmland jointly affect land values, and that supply and demand are in turn responsive to the price of land. In Chapter II, it was noted that some researchers (13) assume land supply to be totally price-inelastic. In order to test this fixed land supply assumption, equation (29) was derived as a market model including inflation and a fixed supply of land. The equation is:

$$(29) \quad V_t = R_t/r - (1 + i)^t \alpha_1 W/r - (1 + i)^t \alpha_1 \bar{Q}_s/r$$

Treating the transfers of farmland in Michigan as a proxy for the price-inelastic supply of farmland, equation (29) is estimated from 1972 to 1979. If this fixed quantity of farmland is a significant factor in the farmland market, one would expect the coefficient on the fixed supply to be significant. The results of the estimation are:

$$(41)\quad V_t = 9.7\, R_t + 32.7 \prod_{j=1}^{t} (1 + i_j) - .25\bar{Q}_s \prod_{j=1}^{t} (1 + i_j)$$

$$(5.2) \qquad (1.6) \qquad\qquad (-.7) \qquad R^2 = .912$$

$$D.W. = 2.37$$

where the numbers in parentheses correspond to the t-statistics of the coefficients above them.

These empirical results are inconsistent with the theoretical model. Inflation as a variable has an inappropriate sign (it was expected to be negative), and the coefficient on the fixed land supply is insignificant according to the t-statistic even at the 25 percent confidence interval. Equation (29) suggests that land values are not strictly determined by an equilibrium price/return function, but the empirical evidence does not support the same conclusion. Therefore, the supposition that land supply is price-inelastic is rejected; rather, land supply must be simultaneously determined with land demand.

The Market Model With Inflation and Taxes

To this point, we have looked at the empirical results of testing the capitalization formula, the market model with inflation, and the question of an inelastic land supply. That leaves one model derived in Chapter III untested--the market model incorporating income taxes as well as inflation. That model is described in equation (34):

$$(34)\quad V_t = R_t\, (1 - \theta)/\hat{r}_t - (1 + i)^t \alpha_1 W/\hat{r}_t$$

The effects of adding taxes to the market model were to reduce cash income received from holding land, and to reduce the market discount factor by θ, the marginal tax rate, before subtracting out inflation. Thus, land values in a market model with taxes are dependent on after-tax cash returns capitalized by a real after-tax discount factor as well as a factor for land leaving farming, inflated and then capitalized by the real after-tax discount rate.

The effects of taxes cause no change in expected signs of the coefficients. The sign should be positive for after-tax cash returns, and negative for the disequilibrium inflation variable. The tax rate does, however, alter the expected value of coefficient on cash returns. After-tax cash returns are now discounted by an after-tax rate, but the tax effect on cash returns does not equal the tax effect on the discount rate due to the presence of inflation. An approximate magnitude for the expected coefficient on after-tax returns may be found in the inverse of the real after-tax discount factor, $(r + i + ri)(1 - \theta) - i$. Calculating 20 year average values for the market discount rate, the marginal tax rate, and the inflation proxy, the average after-tax discount factor is approximately 2.46 percent with the inverse equal to 40.6:

$$1/[(7.29)(1 - .2112) - 3.29] = 1/2.46 = 40.6$$

This coefficient may vary between 30 and 65 if we allow the time preference rate to vary from 3 to 5 percent. 40-6 is calculated based on a 4 percent rate.

The empirical results of the estimation, using Michigan data from 1961-1980, are:

$$(42) \quad V_t = \underset{(13.8)}{45.4}\, R_t(1 - \theta) - \underset{(-6.9)}{320.8} \prod_{j=1}^{t} (1 + i_j) \qquad R^2 = .966 \quad D.W. = 1.44$$

The R^2 of 96.6 provides nearly as high a correlation as in the model without taxes. In addition, the coefficient of rents (45.4) is very near the expected magnitude or 40.6 and signs on the variables are those espected. T-statistics provided in parentheses show the coefficients are significant at the .05 percent level. The model including taxes seems, then, to follow the pattern set earlier: a market model with inflation and taxes which is rigorously deduced from equations expressing expected costs and returns of holding or selling land for potential market participants can 'explain' a large share of price variation in the land market. In addition, adding taxes to the market model also allows for the variation in the ratio of V_t/R_t. The significance of this variation is discussed in the next section. Figure 5 compares graphs of the actual land values with the Market Model (with taxes) and the capitalization formula.

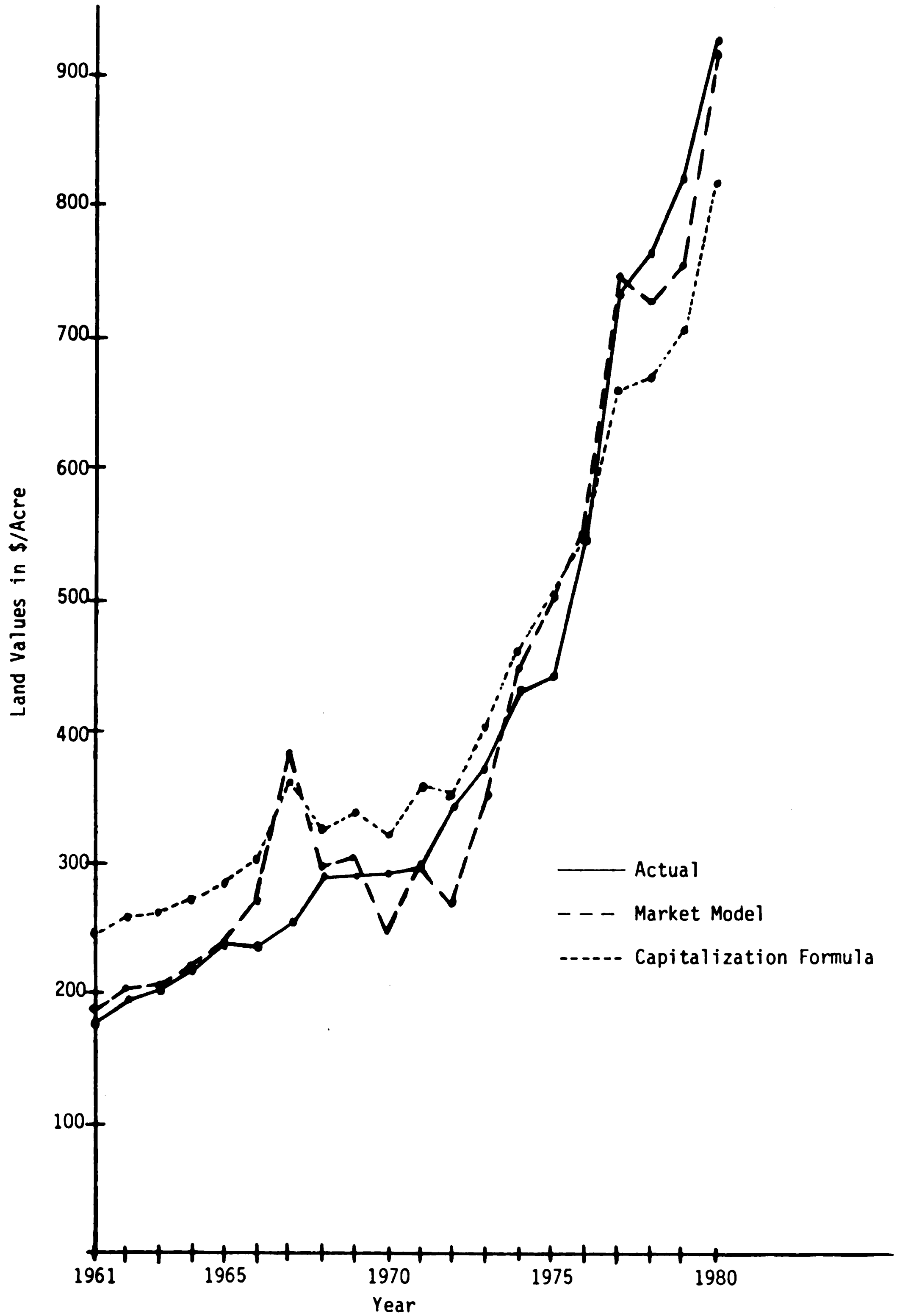
The Ratio of Land Values to Cash Rents

Chapters II and III pointed out the importance of a model's ability to explain the current upward trend in the ratio of land values to cash rents. Table 5 presents this ratio as calculated using the land values estimated by each of the models estimated in this chapter: the capitalization formula; the market model with inflation; and the market model with inflation and taxes.

The ratio of V_t to R_t is necessarily a constant when using land values estimated by the capitalization formula. Since there has been an obvious upward trend in the actual ratio, treating it as a constant does not provide much insight into any possible explanation for the phenomenon. The market models, on the other hand, do allow the ratio to vary. In fact, when the ratio is calculated based on estimated land values from these models, the ratio increases over time in a fashion similar to actual observations. As such, the market models provide a fairly good long run prediction.

FIGURE 5

LAND VALUES PREDICTED BY THE CAPITALIZATION FORMULA AND THE MARKET MODEL



In the short run, however, the market models do not perform as well. There are as many instances of the estimated values increasing when the actual values were decreasing, and vice versa as there are instances of the estimates and actual values moving together. Thus, while the market models do provide a fairly accurate long run trend in the ratio of land values to cash rents, the short run predictions are less accurate.

Summary

From the empirical results presented in this chapter, perhaps the most significant conclusion to be drawn is that the simple and naive capitalization formula is not as successful as market models in explaining the land market. Even though the capitalization formula does predict with a fairly high degree of accuracy (high R^2), the fact that theory leads us to expect the relationship only in equilibrium and the fact that empirically, the formula does not predict a changing ratio of V_t to R_t, suggests that the capitalization formula is not satisfactory in explaining land value patterns.

Market models incorporating cost/benefit statements, inflation, and taxes provide both higher explanatory power and better long run predictions of the V_t/R_t ratio. The model with inflation compared to the model with inflation and taxes yielded similar R^2 statistics, expected coefficient magnitudes, and significant coefficients. Retesting the market model with inflation for general applicability and for a longer time period reconfirmed the initial test results. Model accuracy, significance of coefficients, and model signs were all as expected. These are characteristics of a justified and useful model.

Testing the hypothesis that land supply is fixed confirmed expectations: the hypothesis that supply is insensitive to price is rejected. Given that theory does not lead us to believe supply is inelastic, and that actual observations support the theory, it is difficult to lend credence to model based upon an assumption of a fixed land supply.

With these conclusions about the capitalization formula and the fixity of land supply, it appears that the market approach to the land market is justified. The empirical evidence presented in this chapter supports the justification. As an application of the land model, Chapter V presents an expanded model which adds the real estate credit market to the market model with inflation. Using this system of equations, simulations of the past and future based on data which does not correspond to actual observation are presented to examine the sensitivity of land values to changing variables.

CHAPTER V

SIMULATIONS AND PROJECTIONS

Because farmland values have increased at a faster rate than cash rents, it has been necessary to reconsider land valuation methods. This is not surprising, however, when one considers the empirical results of Chapter IV. The capitalization formula, long considered the premier land valuation technique, suggests the ratio of land values to cash rents should be constant over time. But Chapter IV showed the formula to be empirically inferior as a predictive tool compared to a model which combines market forces of buyer and seller expectations and inflation. The test results of the market model support the conclusion that differing inflationary impacts on cash returns and interest rates help to explain the disparity in increases between land values and cash rents. In addition, the market model was unaffected when re-estimation for a longer time period and for a different data set than the original estimation. This suggests that the model is predictive as well as descriptive.

Because the market model has strong statistical and economic properties, it should be useful in determining the potential sensitivity of farmland values to inflation. This chapter discusses the application of a system of equations simulating the farm mortgage market and the estimated model with inflation (equation 38). The purpose of this application is to construct a simulation model which allows the effects of inflation on farmland values to be traced from inflation's source, thus, demonstrating more clearly how inflation affects the farm real estate market through increasing interest rates and cash rents.

After linking the mortgage market to the land value equation, one may use counter-factual simulations to examine how land values would have changed in recent years under alternative inflation assumptions. The system of equations may then be used to make land value projections to 1985 and 1990 under various inflationary conditions.

The Inflation Connection--The Farm Mortgage Market and Land Values

As modelled by equation (34), land values are dependent on two variables, cash rents (R_t) and the disequilibrium factor (W) which represents land leaving farming.

$$(34) \quad V_t = R_t/r - (1 + i)^t \alpha_i W/r$$

Inflation in the general economy may affect either of these two terms. In the absence of real growth, year to year changes in cash rents, R_t, are caused directly by inflation while inflation affecting land leaving farming is dependent on market interest rates. While it is likely that the inflation affecting cash rents is related to inflation from loan interest rates, these two types of inflation need not be identical, as pointed out by Lins and Duncan (18).

As stated in Chapter III, inflation is a major element of interest rates. Market interest rates are comprised of at least three factors:

$$(19) \quad r^* = r + i + ir$$

where r* is the market interest rate, r is the time preference rate, i is the inflation rate, and ir is the product of inflation and the time preference rate. In Chapter IV, the inflation factor i is measured by subtracting the time preference rate from market interest rates (which are assumed to equal FLB new loan rates).

New FLB loan rates depend upon the average cost of money to the FLBs. In order to obtain loanable funds, FLBs (as part of the Farm Credit System) enter national money markets several times per year to sell bonds. Average bond costs are altered every time new bonds are sold at different interest rates. The average bond interest rate is the cost of money which FLBs must cover by average interest rates on loans. To insure that average loan rates cover average bond rates, new loan rates are changed every time average bond rates change.

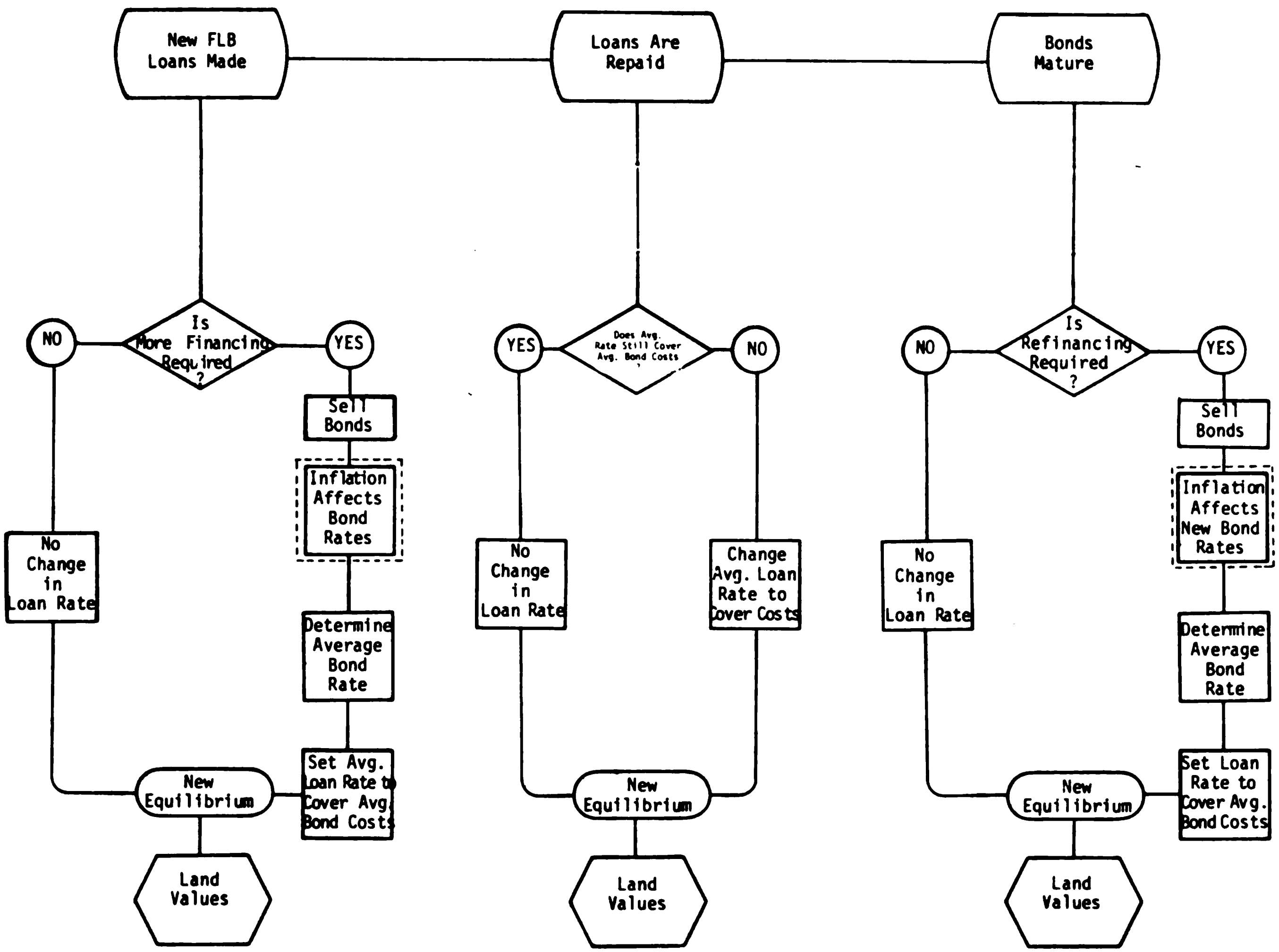
Interest rates on new bonds sold are an expression of money market participant behavior. As such, bond rates are comprised of the constant time preference rate, the market's expectation on inflation, and a risk premium. For FLBs, the risk premium is negligible because FLBs are considered pseudo-governmental by market investors, and government debt is considered risk-free. Consequently, new FLB bond interest rates are comprised primarily of the time preference rate and inflation.

The speed of adjustment between new bond interest rates which fully capture inflation in a given period and new loan rates depends on several factors affecting the number of bonds outstanding; i.e., the rate of repayment on outstanding loans, the amount of new money loaned, and the number of bonds retired. Figure 6 presents a simplified schematic diagram of the way these three factors alter new bond rates, new loan rates, and eventually, land values.

As loans are repaid, the average interest rate on all outstanding loans changes. If this new average cost does not cover the average cost of FLB bonds outstanding, the rate charged on new loans will be changed.

FIGURE 6

INFLATION AND INTEREST RATE 'FILTERING PROCESS'



Because the FLB new loan rate is assumed to equal the market interest rate, and changing market interest rates alters land's value, a new equilibrium condition in the land market will be achieved each time new FLB loan interest rates are set.

As new FLB loans are made, a decision regarding additional financing is required. If enough loans are also being repaid so that no additional funds are needed, there is no change in interest rates to the borrowers. However, if more bonds must be sold to finance the additional loans, then a new bond rate will alter the average cost of money. The average loan interest rate will be reset by charging a new loan rate to borrowers in order for average loan rates to cover average bond costs. The new loan rates cause new land values to result.

As bonds mature and must be retired, a question of refinancing results. If paying off old bonds requires refinancing, inflation becomes a factor in determining interest rates on new bond sales. Average bond costs change and the average loan rate must be adjusted accordingly. With new FLB loan interest rates, a new land market equilibrium results and land values change.

In summary, as new bond rates change with investors' perception of inflation, these rates are filtered through average bond costs, average loan rates, and new loan rates before they affect land values. Thus, there is a lag between a change in inflation and bond interest rates and the establishment of new loan rates. The implicit rate of inflation yielded by FLB loan rates minus the time preference rate is therefore not necessarily the same inflation which affects cash rents. The linkage of money markets (bond rates) to real estate interest rates is exactly what Robison and Love (30) developed in their simultaneous equation model of the real estate mortgage market.

The Simultaneous Equation Model

Robison and Love constructed an 18-equation model describing the farm real estate mortgage market. Several of their equations are useful for tracing interest rates from money markets to FLB new loan rates. These equations describe FLB bonds outstanding, repayment of FLB outstanding bonds, new FLB bonds sold, average cost of all outstanding FLB bonds, new FLB loans made, FLB loans outstanding, loans repaid, average interest rate paid on all FLB loans, and new FLB loan interest rates. Several equations dealing solely with the life insurance (LIC) mortgage market were not used since their relationship to the FLB market is captured simply by interest rates paid on LIC loans.

The only significant alteration of the original Robison-Love model was the addition of a new equation which directly allows inflation to affect bond rates. As mentioned earlier FLB bond rates are primarily dependent on the time preference rate and money market participant perception of inflation. Using the percentage change in the Consumer Price Index (CPI) as a measure of inflation, inflation equals:

$$(43)\quad I_t = (CPI_t - CPI_{t-1})/CPI_{t-1}$$

Because of the risk-free nature of FLB bonds, bond rates (BRFLB) are estimated as a function of a constant (which may be interpreted as an approximation of the time preference rate) and the percentage change in the CPI. The percentage change in the CPI allows bond rates to be directly affected by changes in the inflation rate. Commonly, the CPI is thought to overstate actual inflation. If market investors consider the CPI as an overstatement, they will add a premium to the time preference rate of less than the percentage change in the CPI. As a result, an estimation of bond rates as a function of the CPI rate of change should have a coefficient of less than one on the inflation variable. The coefficient should be positive because as inflation increases, investors demand a higher inflation premium in bond rates. Constant inflation should yield stable bond rates while increasing or decreasing inflation should result in higher or lower bond rates, respectively.

Bond rates, b_t, are estimated over 1961 to 1980 using ordinary least squares regression. The results are:

$$(44) \quad 0.036 + 0.587\ I_t$$
$$(13.9) \quad (13.9) \qquad R^2 = 0.91 \qquad D.W. = 1.20$$

T-statistics are presented below the corresponding coefficient in parantheses. Ninety-one percent of the variation in bond rates can be 'explained' by the rate of change, I_t, in the CPI. The magnitude of the constant is within the generally accepted range for the time preference rate.

Because the coefficient on the inflation term is less than one, it appears that the CPI has historically overstated inflation as perceived by market investors. The implication of this result is that even in long periods of stable inflation, inflation as measured by the CPI will never be fully recognized in new loan interest rates. The lag factor between new bond rates and new loan rates and the overstatement of inflation suggest that the inflation proxy of new loan rates minus the time preference rate will never equal the rate of change in the CPI. If the CPI overstates inflation, inflation which causes cash rents to rise will not equal inflation in loan interest rates. This relationship between the various effects of inflation will have implications for land values.

Other than endogenizing bond rates to directly capture inflation in interest rates, linking the market land value model to the Robison-Love system simply required two additional identities, one to calculate the inflation proxy once interest rates are known, and one to generate the compounded inflation variable. The appendix presents the variables, equations, and data used in the simulations. Fourteen endogenous variables and ten exogenous variables were used. Five structural equations were estimated with equations for bonds outstanding, average loan rates, and loans repaid from the original Robison-Love model, and equations for bond rates and land values estimated by equations (44) and (38), respectively, earlier in this paper. The appendix presents each of the equations with coefficients of determination (R^2) and t-statistics. In addition, the appendix defines nine identity equations, completing the system of equations.

The Solution Process

A Gauss-Siedel algorithm for non-linear systems of equations was used to solve the model because of the presence of non-linear identities, including the average interest rate equation. The statistical computer package GASSP--General Analytical Simulation Solution Program--was used. The solution process was iterative and used 'start up' values for parameters in order to solve each equation. The process continued as each equation was solved and the variables were used in other equations. A convergence criteria of two-tenths of one percent was set so that for each year a solution call was made, equation simulations yielded a change of less than two-tenths of one percent from the preceding iteration in order for convergence to be obtained.

Solving the system using actual data over the sample period 1967-1980 is considered to be a 'base-line' result. By comparing counterfactural simulations (using exogenous data which did not correspond to actual observation) to the base-line results, one can determine the extent of an altered variable's impact on land values. Counterfactual simulations use the all-else-equal assumption, so these results cannot be described as predictions. Rather, counterfactual simulations islolate the effects of altered variables. Forecasts of future trends may be made, however, under differing conditions by specifying exogenous variables over the forecast period. One must recognize that these forecasts are only as good as the specified exogenous variables.

Assumptions

Before proceeding to the results of the counterfactual simulations and projections, certain assumptions must be made with regard to exogenous data during the simulation periods.

First, inflation in the general economy is measured by changes in the CPI. In each counterfactual simulation, inflation was assumed to affect the index of prices received by farmers, equity of the farming sector, and cash rents equally. Rather than developing projections for each of these factors individually, which would require a far more complex model than was used, inflation was used as an approximation of the individual rates of change for the various factors. Every time inflation was changed in a new counterfactual simulation, these variables were also changed by the new inflation rate.

Second, the percentage of FLB bonds maturing each year was assumed to equal 23 percent beyond 1977, which represents an eight-year historical average of bond repayments.

Lastly, interest rates on life insurance company (LIC) mortgages were defined as equaling the FLB new bond rate plus one percent beyond 1980. LIC loans are more closely affected by the supply and demand for money and the interest rates demanded in money markets that are FLB new loan rates. LIC rates are not subject to the same 'filtering' process that FLB loan rates are. As a result, LIC loan rates are generally higher than FLB loan rates, and a one percent premium over bond interest rates is an approximation of the difference.

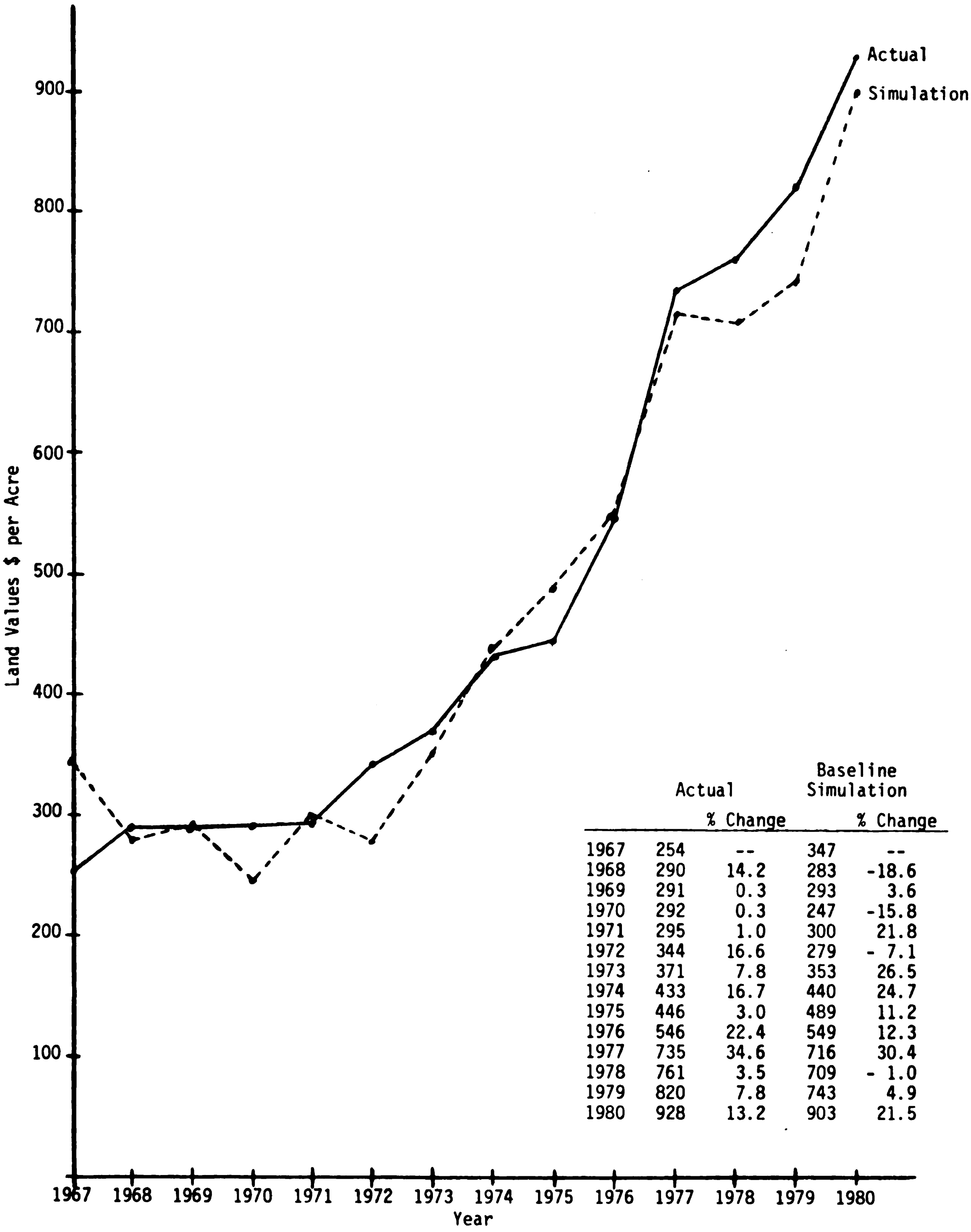
Base-Line Results

Initially, the combined Robison-Love, land value system of equations was solved over a 'base-line' period of 1967-1980. In this simulation, endogenous variables solved for in the model are used as lagged endogenous variables for subsequent solution periods. Exogenous variables correspond to actual data in this base-line period. The results of the simulation can be used in comparison with counterfactual simulations which are solved using data not necessarily corresponding to actual observation.

Figure 7 compares base-line land values with actual values. The 1980 projection for land's value is $903 while the actual value is $928. Over the full sample period, the mean error between simulation and

FIGURE 7

BASE-LINE SIMULATION LAND VALUES, 1967-1980



	Actual		Baseline Simulation	
		% Change		% Change
1967	254	--	347	--
1968	290	14.2	283	-18.6
1969	291	0.3	293	3.6
1970	292	0.3	247	-15.8
1971	295	1.0	300	21.8
1972	344	16.6	279	- 7.1
1973	371	7.8	353	26.5
1974	433	16.7	440	24.7
1975	446	3.0	489	11.2
1976	546	22.4	549	12.3
1977	735	34.6	716	30.4
1978	761	3.5	709	- 1.0
1979	820	7.8	743	4.9
1980	928	13.2	903	21.5

actual land values is 6.5 percent.[1/] Base-line land values grow at an average annual rate of 7.6 percent while cash rents grow at 6.5 percent per year over the period. The projected 1980 land value to cash rent ratio equals 19.5, compared to an actual value of 20.0.

Table 6 compares actual and base-line growth rates in land values, and actual changes in cash rents and the CPI over the base-line period. Base-line land values move closely with actual changes in cash rents however, land value changes are greater than cash rent changes. Average annual rates of change of the CPI and cash rents are similar suggesting that modelling increases in cash rents as equal to increases in the CPI is not a bad approximation.

Counterfactual Simulations and Projections

Unlike base-line simulations which are derived from actual exogenous data, counterfactual simulations are solved using pre-specified exogenous or endogenous variables which do not correspond to actual data. In these simulations, inflation rates are specified at various levels while other factors are held constant. Endogenous variables are then solved based on these pre-specified variables. Simulations may be solved for various time periods and conditions of inflation. Before reporting simulation results, however, it is appropriate to discuss what we expect those results to be.

From information on land values contained in Chapters III and IV and the explanation of the lagtime between changes in inflation and changes in loan interest rates included in this chapter, one could easily speculate on how land values should react to changing inflation rates. For example, the effects of the lag period would cause one to

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[1/]All model equations yield errors of less than 10 percent.

Table 6

Percentage Change in Land Values, Cash Rents, and the Consumer Price Index, 1968-1980

	1 Annual Actual Change in Land Values (percent)	2 Annual Change in Base-Line Results (percent)	3 Annual Change in Cash Rents (percent)	4 Annual Change in the CPI (percent)
1968	14.2%	-18.6%	- 9.9%	4.2%
1969	.3	3.6	3.6	5.4
1970	.3	-15.8	- 6.1	5.9
1971	1.0	21.8	12.3	4.3
1972	16.6	- 7.1	- 1.8	3.3
1973	7.8	26.5	14.7	6.2
1974	16.7	24.7	15.2	11.0
1975	3.0	11.2	8.7	9.1
1976	22.4	12.3	9.4	5.8
1977	34.6	30.4	20.3	6.5
1978	3.5	- 1.0	1.3	7.7
1979	7.8	4.9	5.3	11.3
1980	13.2	21.5	16.0	13.1
Average Annual Change	10.2%	7.6%	6.5%	7.2%

expect land value adjustments to lag inflation rate changes. Only with constant inflation levels will land values increase at the rate of inflation. If inflation is held constant, bond interest rates should also be constant, and nearly equal to new loan interest rates (except for an operating margin) in the long run. Inflation affecting the land no longer used in farming, W, will equal inflation measured by the FLB new loan rate minus the time preference rate. Because bond rates are comprised of inflation and the time preference rate, subtracting the time preference rate from loan rates (now very nearly equal to bond rates) should yield the interest rate proxy for inflation. Therefore, at stable inflation rates, both cash rents and land leaving farming will inflate at the same rate, and land values should also grow at that stable rate. Only if the CPI overstates inflation will the rate of growth in land values be different from cash rents. If the CPI is an overstatement, then the inflation proxy affecting land leaving will be less than the inflation affecting rents, and land values will grow somewhat faster than inflation rates.

If there is a sudden change in inflation, stable growth rates would also change. For example, if inflation is a constant 5 percent for several years but then, it suddenly jumps to 16 percent for a few years, we would expect land values to rise very rapidly for the initial years after the sudden change. Then, as loan interest rates catch up to new bond costs, growth in land values should slow. New bond rates immediately recognize 16 percent inflation levels, but average bond rates react more slowly as other bonds with lower interest are still outstanding. Average loan interest rates move with average bond rates as new loan rates are set. Because of the lag period, land values will grow faster than the CPI for a period of time. As new loan interest rates move closer to bond rates, the growth rate of land values will slow, eventually stabilizing at the level of inflation. This pattern only results if new, higher levels of inflation are maintained for several years and if the CPI is an accurate measure of inflation.

When low levels of inflation persist immediately after several periods of higher inflation, a similar pattern will occur. If inflation declines substantially land value growth rates will decline immediately because loan rates, which are sluggish on the downside as well as on the upside, remain higher than the new inflation level justifies. Low growth in cash rents will be offset by a high inflation proxy affecting land leaving farming. Land value growth rates will slowly adjust to new inflation levels. In the long run, if inflation levels are constant, land values will grow at rates nearly equal to inflation levels.

Counterfactual Results

Several different simulations of the land market under different inflation patterns and different time periods are reported in order to measure how closely the land value expectations described above are matched by model results. The first set of simulations describes how the land market might have performed between 1976 and 1980 and how it might perform between 1980 and 1985 under various inflationary conditions. Tables 7a and 7b list the land values and growth rates from the simulations and Figures 8a and 8b graph the results. Column 1 of Table 7a contains land values from 1981 to 1985 if inflation decreased from 12 percent to 8 percent by 1 percent per year to 1985. Column 2 shows values for the same period but with inflation increasing 1 percent per year.

Table 7a

Simulation Results 1975-1985, Varying Inflation Levels

	1 Inflation Decrease 1% per Year 1981-1985		2 Inflation Increase 1% per Year 1981-1985		3 Inflation Variable 12, 14, 11, 9, 7% 1981-1985		4 Inflation 16% 1976-1980 and 5% 1981-1985		5 Inflation 5% 1976-1980 and 16% 1981-1985	
	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change
1975							$489		$489	
1976							602	23.0%	513	4.9%
1977							730	21.3	538	4.9
1978							878	20.2	564	4.8
1979							1048	19.4	592	5.0
1980	$903		$903		$903		1246	18.9	622	5.1
1981	1033	14.4%	1033	14.4%	1033	14.4%	1287	3.3	768	23.4
1982	1163	12.6	1193	15.5	1208	17.0	1332	3.5	935	21.7
1983	1292	11.1	1391	16.6	1356	12.3	1383	3.8	1126	20.5
1984	1416	9.6	1636	17.6	1484	9.4	1441	4.2	1347	19.6
1985	1533	8.3	1941	18.6	1583	6.7	1505	4.4	1603	19.0

Table 7b

Simulation Results 1975-1985, Constant Inflation Levels

	1		2		3		4		5		6	
	Inflation Constant 0% 1976-1985		5% 1976-1985		8% 1976-1985		10% 1976-1985		13% 1976-1985		16% 1976-1985	
	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change
1975	$489		$489		$489		$489		$489		$489	
1976	472	-3.5	513	4.9	537	9.8	553	13.1	578	18.1	602	23.0
1977	456	-3.4	538	4.9	589	9.6	623	12.5	676	17.0	730	21.3
1978	442	-3.1	564	4.8	643	9.3	699	12.2	786	16.2	878	20.2
1979	430	-2.7	592	5.0	703	9.2	782	11.9	909	15.7	1048	19.4
1980	420	-2.4	622	5.1	767	9.1	873	11.7	1049	15.4	1246	18.9
1981	411	-2.2	654	5.2	837	9.1	974	11.5	1208	15.1	1476	18.5
1982	403	-2.0	689	5.3	912	9.1	1086	11.4	1387	14.9	1744	18.2
1983	395	-1.8	725	5.3	995	9.0	1209	11.4	1591	14.7	2057	17.9
1984	388	-1.8	764	5.4	1084	9.0	1345	11.3	1823	14.6	2422	17.8
1985	382	-1.7	805	5.4	1182	9.0	1497	11.2	2087	14.5	2849	17.6
Average Annual Change		-2.5%		5.1%		9.2%		11.8%		15.0%		19.3%

FIGURE 8a

COUNTERFACTURAL SIMULATION RESULTS, 1975-1985

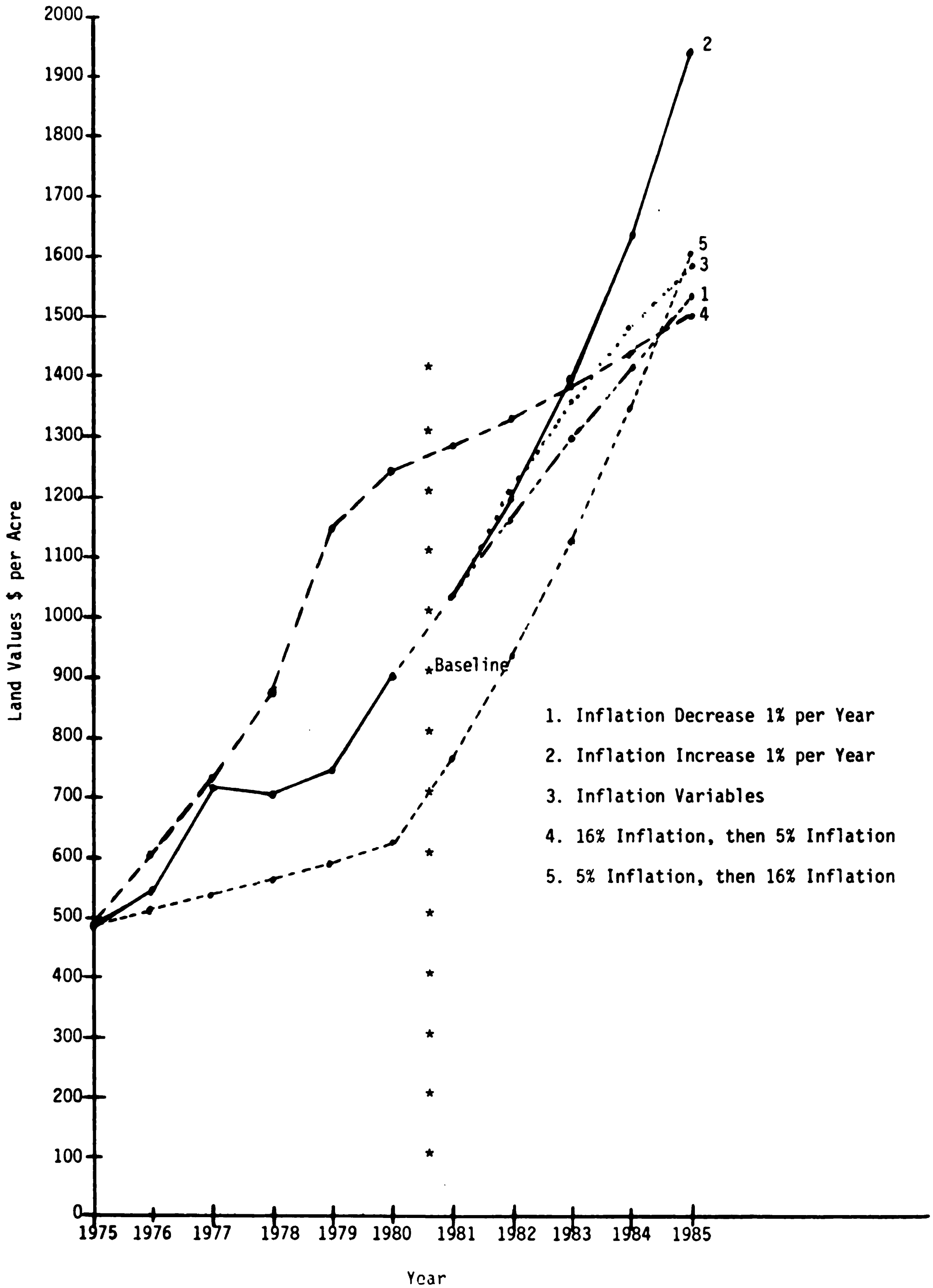
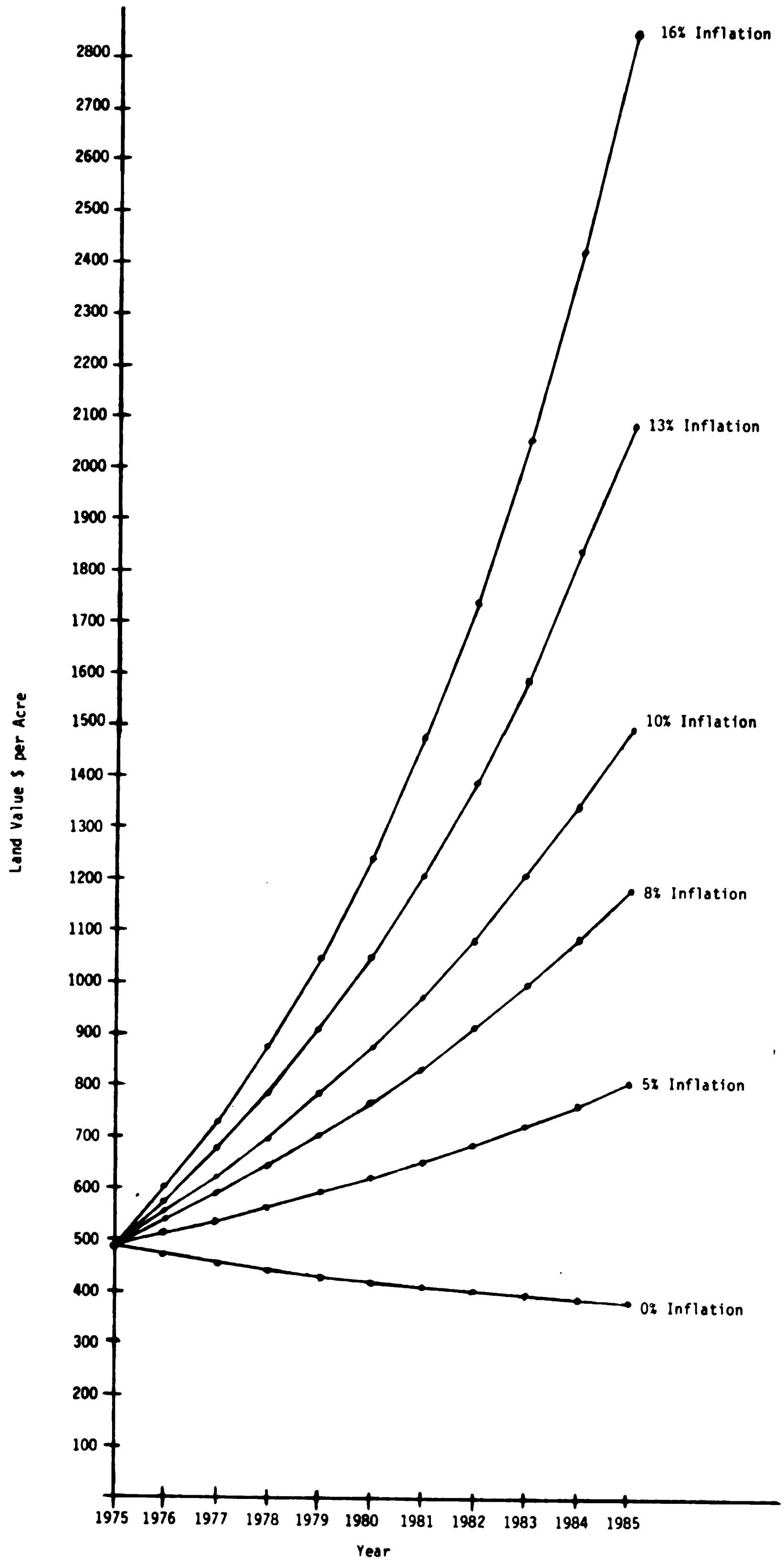


FIGURE 8b

COUNTERFACTUAL SIMULATION RESULTS, 1975-1985



Column 3 lists values if inflation first increased from 12 percent to 14 percent in 1982 and then decreased each period to 1985. Each of these simulations begin in 1980 with base-line values. Column 4 suggests what might have happened if inflation had been constant at 16 percent from 1976 to 1980 and then dropped to 5 percent from 1981 to 1985. Column 5 results are from constant 5 percent inflation which suddenly jumps to 16 percent from 1981 to 1985. Figures 8a and 8b correspond with Tables 7a and 7b respectively.

If inflation followed a pattern of decreasing 1 percent each year for five years (Column 1, 7a), land values would increase from $903 in 1980 to $1533 in 1985 for an annual average change of 11.1 percent. As expected, rates of increase in land values decrease as inflation rates decrease. If inflation grew by 1 percent each period (Column 2, Table 7a), land values would also grow at increasing rates becuase of the inflation lag time. If inflation first grew and then declined (Column 3, Table 7a), land value changes would also increase and decrease, although at a faster rate. As inflation increased, land values would grow faster because the inflation affecting land leaving farming would be less than inflation in cash rents. As inflation declined, interest rates would be sluggish and therefore, land value increases would slow.

If inflation was initially constant at 16 percent for five years (Column 4, Table 7a), land values would grow very rapidly for those five years. But when inflation plummeted to 5 percent, land values would immediately react by slowing increases. As described before, such a sudden change would leave loan interest rates at very high levels until average bond costs dropped to levels more closely aligned with inflation.

The reverse situation would occur if inflation began at 5 percent and suddenly jumped to 16 percent (Column 5, Table 7a). Land values which had been growing by approximately $30 per year would suddenly increase by $146 in 1981. Very high rates of increase in land values would continue as inflation persisted at 16 percent. As time passed and inflation was more accurately reflected in loan interest rates, land value growth rates would stabilize at a level nearly equal to inflation.

Table 7b and Figure 8b show land values and rates of change for the period 1976-1985 if inflation remained constant for the 10-year period. The land market was simulated for 0, 5, 8, 10, 13, and 16 percent inflation rates. Base-line values were used in 1975 to begin the simulations. In 1975, the value of land was $489 per acre.

If inflation had been held at zero percent after 1975 (Column 1, Table 7b), land values would have initially fallen $17 to $472, a 3.5 percent decrease. By 1985, the decline equaled $6, or 1.7 percent. In the later years, the rates of decline would stabilize, but in early years, declines would be more rapid because of the slow response in interest rates. Continuing zero percent inflation long enough would hold land values at a fairly constant level.

Inflation rates of 5 percent and 8 percent from 1976 to 1985 (Columns 2 and 3, Table 7b), show very constant growth levels in land values at rates slightly higher than inflation. This discrepancy exists because of overstated inflation in cash rents. The reason there is little change in the rate of growth at these inflation levels over the 10-year period is that neither inflation level represents a significant change from inflation over the eight preceeding years. Inflation averaged just over 6 percent between 1967 and 1975.

Higher levels of inflation from 1976 to 1980 represent major changes from inflation rates of the preceeding years. Between 1970 and 1975 inflation averaged less than 7 percent. In each of the simulations at 8, 10, 15 and 16 percent inflation (Columns 3, 4, 5, and 6), land values increased faster than inflation initially but then slowed and eventually stabilized at a rate almost equal to inflation as loan interest rates more fully reflected inflation. At these levels of inflation, land values would have equalled $873, $1049, and $1246 in 1980, respectively, compared to the base-line value of $903.

The second set of simulation results cover 1981 to 1990. Land values and rates of change are reported in Table 8 and land values are graphed in Figure 9. The inflation levels of these simulations correspond to Table 7b, 0, 5, 8, 10, 13, and 16 percent, each maintained for the 10-year period. Simulation results for these inflation levels are similar to those in Table 7a.

Any significant change in inflation levels initially results in a substantial change in land values. If the inflation rate were zero in 1981, land values would be $873, a 3.2 percent decline from the 1980 base-line level of $902. By 1990, the decline in values would have stabilized at about 1.5 percent. Inflation of 5, 8, or 10 percent would not cause major changes in land values. At these levels, land values would increase at rates nearly equal to changes in the CPI. Such constant increases would be maintained over the 10-year period. Inflation rates of 13 and 16 percent would cause land value increases substantially greater than inflation. These growth rates would also be expected to stabilize as the late 1980s approached. Under these patterns of high

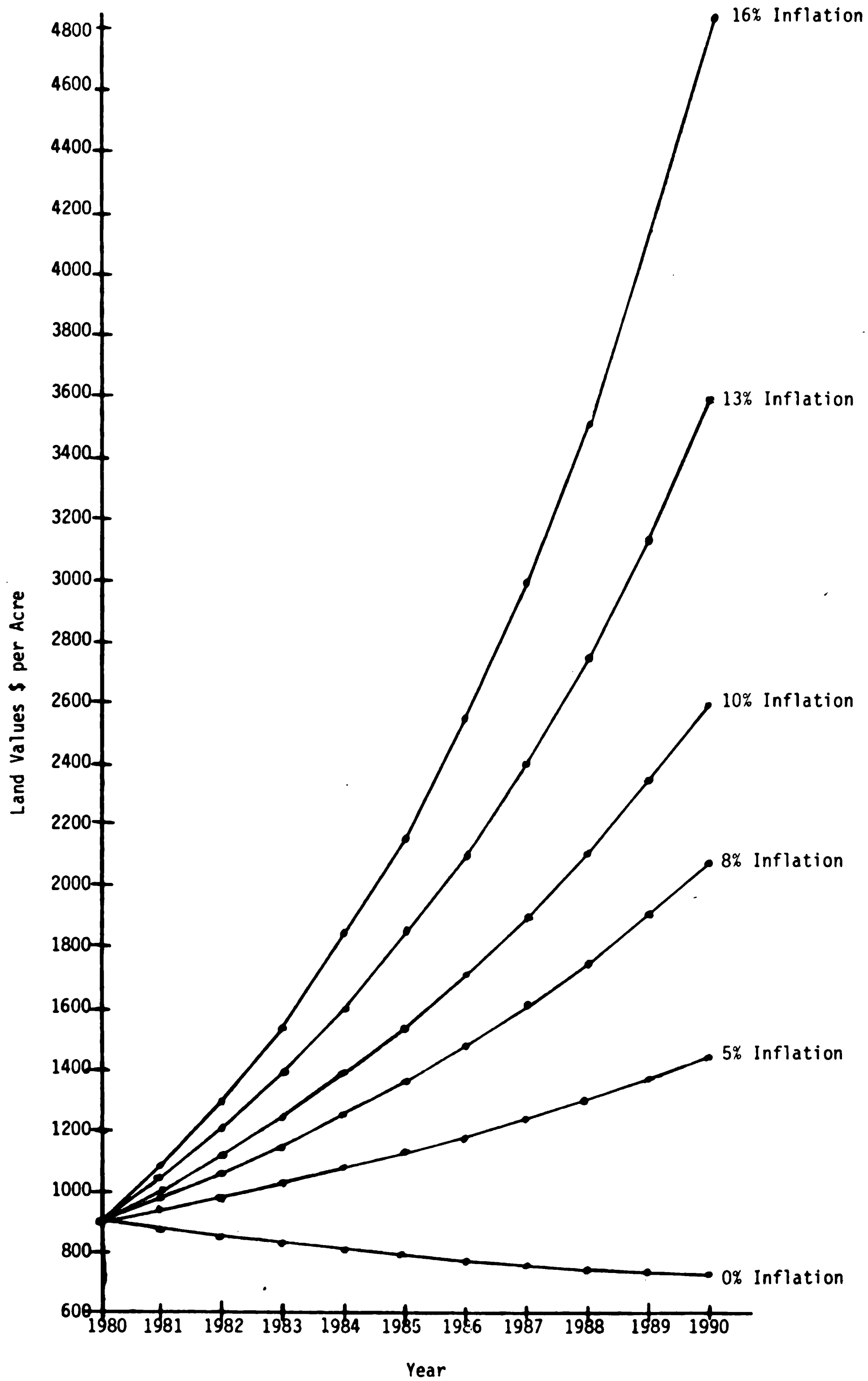
Table 8

Simulation Results 1981-1990, Constant Inflation Levels

	1 0% 1981-1990		2 5% 1981-1990		3 8% 1981-1990		4 10% 1981-1990		5 13% 1981-1990		6 16% 1981-1990	
	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change	Land Value	% Change
1980	$902		$902		$902		$902		$902		$902	
1981	873	-3.2	940	4.1	980	8.6	1006	11.5	1046	15.9	1086	20.3
1982	847	-3.0	980	4.3	1063	8.6	1120	11.3	1208	15.5	1297	19.5
1983	823	-2.7	1024	4.5	1155	8.6	1246	11.2	1390	15.1	1542	18.9
1984	803	-2.5	1072	4.7	1254	8.6	1385	11.2	1597	14.9	1827	18.4
1985	785	-2.2	1124	4.8	1363	8.7	1540	11.1	1831	14.7	2158	18.1
1986	770	-2.0	1179	5.0	1482	8.7	1710	11.1	2098	14.5	2543	17.8
1987	756	-1.8	1239	5.1	1611	8.7	1899	11.1	2400	14.4	2993	17.7
1988	744	-1.6	1303	5.1	1752	8.7	2109	11.0	2744	14.3	3518	17.5
1989	733	-1.5	1370	5.2	1905	8.7	2341	11.0	3135	14.3	4131	17.4
1990	722	-1.5	1442	5.2	2072	8.7	2597	11.0	3580	14.2	4847	17.3
Average Annual Change		-2.1		4.8		8.7		11.1		14.8		18.3
Land Value to Cash Rent Ratio		18.8		19.3		19.6		19.7		19.9		20.2

FIGURE 9

PROJECTION SIMULATION RESULTS, 1980-1990



inflation, land values in Michigan could range from $3500 to $5000 per acre by 1990, compared to $902 in 1980. Such values would represent average compound growth rates of 15-18 percent.

Summary and Conclusions

Simulation results suggest that if inflation rates changed suddenly from previous year's levels, then land values would feel the repurcussions for several years until interest rates achieved levels which adequately reflected inflation rates. If inflation dropped to either an extremely low level (0 percent) or rose to an extremely high level (16 percent), it would take about eight to ten years for growth levels in land values to correspond to inflation levels.

An example of expected changes in land values can be found in current economic indicators. Should President Reagan be successful in his current economic strategy and inflation does slow from 13 percent in 1980, land value gains would also be expected to slow down. As of June 1, 1981, inflation was approximately 8 percent (an adjusted annual rate). If that rate was maintained through the remainder of the year, land values would be expected to increase more slowly in 1981 than 1980. The corresponding ratio of land values to cash rents would also be expected to decline as inflation in interest rates exceeded inflation in cash rents. The projecting land values based on an 8 percent inflation rate, the 1981 ratio would be expected to be 19.6 compared to 20.0 in 1980. These results suggest that inflation's differing impacts in interest rates and cash rents causes much of the variance in land value/cash rent ratios. One's expectations on inflation will indicate the expected relationship of land values to rents.

One note of cuation should be sounded here. We need to recall that this model and these simulations are used under a ceteris parabis assumption. The results here can hardly be considered predictions of land values because it is only inflation which is changing from period to period; the other exogenous variables remain constant at 1980 levels unless they are directly dependent on inflation. This model does not simulate the interaction of individual variable changes except to the extent of changes in inflation. The model is useful for modeling the sensitivity of given variables to others, but land value results are not to be considered actual predictions.

CHAPTER VI

SUMMARY AND CONCLUSIONS

How are cash rents, inflation, income taxes and land values inter-related? The basic goal of this study has been to present a theoretical basis for estimating land values in a market equilibrium approach taking into account the actual complexities of inflation and income taxes. Ultimately, the success of this research will depend on its usefulness in describing past and future land value trends. Inflation, income taxes, and cash rents have proven to be major influences on past land value patterns; undoubtedly, they will continue to affect land values for some time.

The objectives of this research were to develop and test an equilibrium model of the farmland market based upon theoretical justification, to determine the effects of inflation and taxes on farmland values, and to apply the land model in counterfactual simulations and projections in order to observe the effects of changing variables. The purpose of this chapter is to summarize this research in relation to those objectives and to discuss the implications of the conclusions drawn from this research. To conclude the paper, recommendations for further research are discussed.

As a beginning for this research, the market approach to land values was described. Because land's value is what buyers and sellers agree it is, any study of the land market should include both buyer and seller behavior in a market setting. How buyers and sellers perceive expected costs and benefits of holding or selling land should influence land value patterns.

With this market approach to a land value study as the basic theme of the research, several earlier research efforts were reviewed in Chapter II. Past studies have used simultaneous equation systems and single equation models to try to explain land price variations. Three primary problems were encountered with those earlier studies. The first problem was that most studies failed to logically deduce the models they tested; instead, correlations were hypothesized without investigating the behavior which produced the correlation. Second, few studies included land supply as an explanatory variable. Supply was treated as either exogenous or price-inelastic. Only one study attempted an equilibrium approach including demand and supply factors. The third problem was encountered in a re-estimation of several models. Most of the models lost predictive accuracy and suffered coefficient sign changes and insignificance as a result of being re-estimated beyond their original sample period. These three problems suggested a need for a study which justifies the model it tests, includes the supply of farmland as an itegral factor in the model, and withstands the 'test of time.' These suggestions were used as criteria to judge the model constructed in Chapter III.

Chapter III described the theory from which the market model was constructed. Capital budgeting theory holds that equating buyers' bid prices with sellers' ask prices permits land transactions to occur. Those bid and ask prices are determined according to the buyers' and sellers' perceptions of costs and benefits from holding or selling land.

In constructing the market model, statements of costs and benefits were equated and an equilibrium condition was imposed on the land market. The resulting model was not equivalent to the simple capitalization formula used by many researchers.

While building the market model, assumptions on inflation, income taxes, and land supply were altered in order to test the importance to land values of those factors. Inflation and taxes were discussed as possible causes for the changing land value to cash rent ratio, while adding fixed land supply to the market model did not result in the capitalization formula, as some researchers had expected.

Chapter IV presented test results for the various models, including the capitalization formula, the market model, and a model with a fixed supply of land. The capitalization formula was shown to have less predictive ability than the market model. Moreover, the capitalization formula expected a constant relationship between land values and cash rents, contrary to observation, while the market model allowed for the ratio to change over time. The fixed supply model, when tested, led to the rejection of the assertion that land supplies are insensitive to land values. Only the market model without fixed supply provided satisfactory predictive power, explanatory ability and significant variable coefficients.

Re-estimating the market model over a longer time period provided equally high predictive power, the same coefficient signs, and significant coefficients compared to the original estimation. Re-estimating for Illinois data also provided the same statistical properties as the original estimation. These two tests suggest that the model is general in its applicability in addition to being theoretically justified. These characteristics were not observed in many earlier research efforts.

The market model was applied in Chapter V in an examination of land value sensitivity to changing inflation rates. Because of the lag time between changes in inflation and changes in loan interest rates, Chapter V suggested that land values may be subject to windfall gains and losses as inflation increases and decreases significantly. As loan interest rates lagged inflation, the effective rates of inflation entering cash rents and the disequilibrium factor were no longer equal. Differing inflation rates were at least part of the explanation for the changing ratio of land values to cash rents. Only in periods of constant inflation from year-to-year would land values rise at the same rate as cash rents.

Summarizing the conclusions of this research, a model combining the forces of buyer and seller market behavior and incorporating inflation and income taxes appears to be theoretically sound, empirically valid, and useful in application. The simple capitalization formula, while portraying the basic relationship of cash rents to land values from either the buyers' or sellers' perspective, has less predictive ability than the market model. A model with a fixed supply of land can neither be theoretically nor empirically validated.

In the market model, cash rents are the major determinant of land values. While the market model also includes other important factors, it is apparent that buyers' maximum bid prices and sellers' minimum ask prices are largely dependent on capitalized cash rents. It is unlikely that cash rents will become less important in the future.

The effect of inflation on cash rents and interest rates will also continue to be important. In the past, the ratio of land values to cash rents has been altered, at least in part, by inflation. Allowing the differing impacts of inflation on cash rents and interest rates, and depending on what inflation conditions one chooses to believe, the ratio in 1981 could range from 18.8:1 to 20.2:1.

Implications for Agriculture

What are the implications of this land value research for agriculture? The value of land plays a significant role in determining the profitability of farming. Robison and Brake (28) discuss the effects of inflationary land values on farmers' liquidity. High land values and high interest rates create loan repayment problems. Little research, however, has been done on the results of changing inflation rates. An important result of the market model research suggests that as inflation rates rise or fall significantly, loan interest rates lag those changes. Therefore, changes in inflation levels will be met by even larger changes in land value growth rates. If inflation rates fall, land value growth rates would decline even faster and only stabilize once new loan rates fully measure new, low levels of inflation. As inflation increases, land values should rise at rates faster than inflation until interest rates fully reflect new, higher levels of inflation.

Legislators concerned about inflation's impact on farming should be made aware of the potential windfall changes in land values which could result from major changes in inflation levels. Should President Reagan's economic policies successfully reduce inflation in the next two or three years, this model suggests that land value growth rates would be less than rates of change in general price levels. Consequently, the ratio of land values to cash rents would be expected to decline. Such an outcome would also interest investors in land who are primarily concerned with capital gains because less land value gains would be expected.

Further Research

Inevitably, research raises new questions even as other questions are answered. Some questions raised during the course of this research warrent additional study before the full implications of inflation in land markets can be determined. For example, what fuels inflation? In this study inflation is treated as an exogenous factor, but there are forces behind inflation which need to be considered. Some economists are convinced that the cure of all inflationary evils is a controlled money supply. The rate of change in the money supply affects interest rates, investment, the economy's growth, inflation, etc., and each of these factors are dependent on one another. The Federal Reserve Board has substantial control over the supply of money and monetary growth. The implications of money supply changes and Federal Reserve policy for land values need to be studied.

Inflation is also responsive to peoples' expectations. In actuality, bond rates are dependent on market investors' expectations on inflation as opposed to actual inflation. Expectations influence buyer and seller bid and ask prices. Expectations of returns from holding or selling land are dependent, in part, on inflation. Determining what motivates these expectations, for both inflation rates and land returns, may further an understanding of land value movements.

A third future research topic could be the effects of taxes on land values. This study presented an initial look at what effect changing income tax rates may have on land values. Increasing the marginal income tax rate should cause increased land prices when the market is in equilibrium. However, what effect taxes have in a disequilibrium setting and what effect capital gains have on the market model have not yet been researched. Determining implications of the tax structure on land values may provide additional insight into recent historical price patterns.

Final Note

The land market is potentially complex, yet a relatively simple market model captures a significant portion of land price variation. As prime farmland becomes more and more scarce due to a growing population and erosion, etc., it will be interesting to watch land values and their response to inflation and taxes. What will the relationship between land values and cash rents be in twenty years?

APPENDIX

APPENDIX

Endogenous Variables

Definitions of variables treated as endogenous and subscripted for time:

BTFLB = FLB bonds outstanding

ABRFLB = Average interest rate on outstanding FLB bonds

ARFLB = Average interest rate on outstanding FLB loans

RFLB = Interest rate on new FLB loans made

LTFLB = FLB loans outstanding

BTTFLB = New FLB bonds sold

VARWT = Percentage of outstanding FLB loans on variable interest rates

REPYMT = Repayments of outstanding FLB loans

ARLGVT = Average interest rate on outstanding fixed interest rate loans

BNDREP = Outstanding bonds retired

BRFLB = Interest rate on new FLB bonds sold

INFPRX = Inflation proxy based on market interest rates

INFVAR = Inflation proxy compounded over time

LNDVAL = Average value of crop land per acre

Exogenous Variables

Definitions of variables treated as exogenous and subscripted for time:

ZFLB = Percentage of outstanding bonds retired

DUM = Binary variable reflecting effects of FLB adoption of a variable interest rate; equal to 1 before 1970, and equal to 0 after 1969

EQTY = Equity of the farming sector

FCA = Binary variable reflecting the effects of the 1971 Farm Credit Act; equal to 0 before 1971, and equal to 1 after 1970

IFPR = Index of farm prices received

I = Inflation as measured by the rate of change in the Consumer's Price Index

RLIC = Interest rate on new Life Insurance Company real estate mortgage

LTTFLB = New FLB loans made

MTR = Effective marginal tax rate paid by farmers

RENT = Average cash rent per acre, before tax

RAT = Average cash rent per acre, after tax

Structural Equations

The estimated equations are presented below, with the parameter estimates preceeding each variable name. Maximum liklihood (ML), or ordinary least squares (OLS) were used for estimating the equations. The t-statistic esimates are reported below each parameter estimate in parentheses. The coefficient of determination (R^2) and Durbin-Watson statistic (D.W.) appear with each equation. Lagged endogenous variables are subscripted by t-1.

1. Bonds Outstanding equal loan outstand (OLS):

$$BTFLB = -88.50 + 0.8917\ LTFLB$$
$$(-4.87)\quad (408.57) \qquad R^2 = .999 \qquad D.W. = .85$$

2. Average Interest Rate paid on FLB loans (ML):

$$ARFLB = 0.00193 + 0.137\ ABRFLB + 0.861\ ARFLB_{t-1}$$
$$+ (0.278\ VARWT_{t-1})\ (0.014 + ABRFLB = ARFLB_{t-1})$$
$$R^2 = .994$$

3. Repayment of FLB Outstanding Loans:

$$REPYMT = -462.3 - 12420.0\ RFLB + 33830.0\ ARFLB_{t-1}$$
$$(-1.63)\quad (-5.26) \qquad (4.93)$$
$$+ 0.082\ (LTFLB_{t-1})\ (VARWT_{t-1}) + 0.036\ (LTFLB_{t-1})$$
$$(1-VARWT_{t-1}) + 1.4\ IFPR - 2.0\ IFPR_{t-1}$$
$$(3.92) \qquad (-4.40)$$
$$R^2 = .99 \qquad D.W. = 1.4$$

4. Interest Rate on New FLB Bonds (OLS):

$$BRFLB = 0.058 + 0.00358\ CPI - 0.003\ BCPI_{t-1}$$
$$(5.40)\quad (5.57) \qquad (-4.92)$$
$$R^2 = .901 \qquad D.W. = 0.840$$

5. Land Values, after taxes (OLS):

$$LNDVAL = -320.78\ INFVAR + 45.36\ RAT$$
$$(-6.90) \qquad (13.83) \qquad R^2 = .966 \qquad D.W. = 1.44$$

Identities

6. Average interest rate on outstanding FLB bonds:

$$ABRFLB = ((BRFLB)(BTTFLB) + (ABRFLB_{t-1})(FTFLB_{t-1} - BNDREP))/BTFLB$$

7. Interest Rate Paid on New FLB Loans:

$$RFLB = ((LTFLB)(ARFLB) - 0.986\ (ARFLB_{t-1})\ D\ (DUM) - (ARLGVT)$$
$$(1 - VARWT)\ D\ (1 - DUM))/(LTTFLB + (VARWT_{t-1})\ D\ (1 - DUM))$$
where $D = LTFLB_{t-1} - REPYMT$

8. FLB loans outstanding:

$$LTFLB = LTTFLB + LTFLB_{t-1} - REPYMT$$

9. New FLB bonds sold:

$$BTTFLB = BTFLB = BTFLB_{t-1} + BNDREP$$

10. Percent of FLB Loans on Variable Interest Rate:

$$VARWT = (1 - DUM)(LTTFLB + (VARWT_{t-1})\ D)/LTFLB$$

11. Average Interest Rate on Outstanding FLB Fixed Interest Rate Loans:

$$ARLGVT = 1.01\ (ARLGVT_{t-1})(1 - DUM) + 0.986\ (ARFLB_{t-1})(DUM)$$

12. Outstanding Bonds Retired:

$$BNDREP = (BTFLB_{t-1})(LTFLB)$$

13. Inflation Proxy:

$$INFPRX = RFLB/0.95 - 0.04$$

14. Inflation Variable:

$$INFVAR = (1 + INFPRX)(INFVAR_{t-1})$$

15 . Rent After Taxes:

$$RAT = RENT\ (1 - MTR)$$

Appendix Table I

Simulation Model Data

	1	2	3	4	5	6	7	8	9	10	11	12
	BTFLB millions a	ABRFLB percent a	ARFLB percent b	RFLB percent c	LTFLB millions b	BTTFLB millions a	VARWT percent b	REPYMT millions d	ARLGVT percent d	BNDREP millions d	BRFLB percent e	INFPRX percent d
1951	7.85	1.71	4.1	4.1	997.57	700.0	0.	1.63	0.	0.00	2.6	0.39
52	8.62	2.09	4.1	4.2	1,078.49	2,283.0	0.	1.74	0.	1.50	2.7	0.39
53	9.37	2.44	4.1	4.2	1,179.90	3,070.0	0.	1.88	0.	2.33	2.8	0.39
54	10.30	2.37	4.1	4.2	1,280.94	3,781.5	0.	2.05	0.	2.84	2.3	0.39
55	11.91	2.46	4.1	4.2	1,497.17	2,365.0	0.	2.71	0.	0.70	3.0	0.39
1956	14.37	2.83	4.1	4.3	1,744.05	6,050.0	0.	2.76	0.	3.65	3.6	0.54
57	15.99	3.59	4.2	5.2	1,919.28	8,130.0	0.	2.24	0.	6.51	4.4	1.44
58	17.43	3.45	4.4	5.2	2,088.79	8,000.0	0.	2.60	0.	6.56	3.1	1.52
59	20.25	3.90	4.6	5.5	2,359.84	7,380.0	0.	3.01	0.	4.56	4.5	1.80
60	22.10	4.12	4.8	6.0	2,563.72	7,177.0	0.	3.00	0.	9.92	4.6	2.32
1961	24.31	4.08	4.9	5.6	2,827.97	6,772.5	0.	3.68	0.	4.50	4.0	1.94
62	26.28	4.06	5.0	5.6	3,051.97	6,150.0	0.	4.21	0.	4.18	3.9	1.89
63	28.34	4.17	5.1	5.6	3,309.88	7,230.0	0.	4.85	0.	5.17	4.0	1.89
64	31.69	4.19	5.2	5.5	3,718.17	8,390.0	0.	5.90	0.	5.05	4.2	1.89
65	37.10	4.31	5.2	5.5	4,280.67	12,095.0	0.	6.73	0.	6.69	4.6	1.89
1966	43.85	4.84	5.4	5.8	4,957.84	17,012.5	0.	6.60	0.	10.26	5.7	2.13
67	49.04	5.02	5.6	6.0	5,609.27	20,845.0	0.	6.16	0.	15.66	5.6	2.34
68	53.99	5.41	5.7	6.7	6,126.37	20,085.0	0.	5.84	0.	15.14	6.2	3.20
69	59.49	6.21	6.0	7.7	6,714.17	21,174.0	0.	5.78	5.72	15.67	7.7	4.23
70	63.95	6.97	6.4	8.7	7,187.14	27,960.0	14.15	5.44	6.02	23.50	8.1	5.14
1971	70.63	6.45	6.5	7.9	7,918.19	26,330.0	31.01	8.24	6.00	19.65	5.8	4.27
72	80.14	6.38	6.6	7.4	9,110.93	35,240.0	48.07	10.64	5.97	25.73	6.1	3.81
73	98.38	6.59	7.0	7.5	11,073.28	39,736.0	63.47	13.16	5.95	21.50	7.3	3.87
74	124.27	7.36	7.8	8.1	13,863.75	45,248.0	74.65	14.53	5.92	19.36	8.4	4.57
75	147.73	7.60	8.2	8.7	16,563.89	47,530.0	81.40	17.11	5.90	24.07	8.0	5.15
1976	169.01	7.50	8.2	8.7	19,127.00	55,810.0	86.0	21.38	5.87	34.53	7.2	5.12
77	194.71	7.40	8.3	8.4	22,137.17	62,740.0	93.0	24.92	5.85	37.01	6.9	4.83
78	215.89	7.68	8.4	8.3	25,626.46	62,940.0	96.5	28.29	5.84	40.89	8.8	4.74
79	272.28	8.19	8.8	9.1	31,283.74	113,514.0	97.3	31.08	5.83	43.18	10.2	5.58
80	342.77	9.45	9.5	10.3	40,402.34	174,765.0	97.9	37.45	5.82	61.70	12.6	6.84

Data Sources:
a. Farm Credit Administration
b. USDA
c. Agricultural Finance Databook
d. Calculated
e. Agricultural Statistics 1980
f. Estimate
g. Economic Report of the President--1981
h. Robison and Leatham

Appendix Table I (Continued)

	13 INFVAR d	14 LNDVAL $/acre	15 ZFLB percent f	16 DUM units	17 EQTY millions c	18 FCA units	19 IFPR (1914=100) e	20 CPI (1967=100) g	21 RLIC percent c	22 LTTFLB millions b	23 MTR percent f	24 RENT $/acre h	25 RAT $/acre d
1951		108.	.05	1.0	1557.31	0.0	302.	77.8	4.3	214.22		7.66	
52		119.	19.25	1.0	1518.88	0.0	288.	79.5	4.5	254.58		9.41	
53		122.	26.96	1.0	1479.60	0.0	255.	80.1	4.8	289.77		10.10	
54		127.	30.40	1.0	1514.26	0.0	246.	80.5	4.7	306.28		10.26	
55		130.	6.83	1.0	1553.35	0.0	232.	80.2	4.6	487.49		9.85	
1956		132.	30.49	1.0	1638.09	0.0	230.	81.4	4.9	522.36		11.48	
57		143.	45.28	1.0	1711.67	0.0	235.	84.3	5.2	398.99		12.11	
58		148.	41.03	1.0	1851.42	0.0	250.	86.6	5.3	429.42		12.31	
59	1.000	165.	26.16	1.0	1857.76	0.0	240.	87.3	5.3	572.06		13.28	
60	1.017	174.	48.97	1.0	1848.75	0.0	239.	88.7	6.1	503.89	18.0	14.08	11.5
1961	1.037	176.	20.64	1.0	1910.68	0.0	240.	89.6	5.9	632.52	18.1	14.00	11.5
62	1.053	196.	17.20	1.0	1965.08	0.0	244.	90.6	5.8	644.71	18.3	14.58	11.9
63	1.070	201.	19.68	1.0	2014.51	0.0	243.	91.7	5.8	742.86	18.5	14.81	12.1
64	1.087	217.	17.79	1.0	2072.48	0.0	237.	92.9	5.7	998.08	18.8	15.42	12.5
65	1.195	237.	21.08	1.0	2203.91	0.0	245.	94.5	5.8	1,235.15	19.0	16.12	13.1
1966	1.125	236.	27.66	1.0	2303.76	0.0	264.	97.2	6.3	1,337.25	19.3	17.24	13.9
67	1.148	254.	35.69	1.0	2408.71	0.0	250.	100.0	6.7	1,267.59	19.5	20.49	16.4
68	1.180	290.	30.86	1.0	2526.19	0.0	255.	104.2	7.4	1,101.32	19.8	18.48	14.8
69	1.225	291.	29.04	1.0	2622.46	0.0	268.	109.8	8.5	1,165.90	20.0	19.15	15.3
70	1.283	292.	39.50	0.0	2720.92	0.0	274.	116.3	9.3	1,016.82	20.5	18.00	14.3
1971	1.332	295.	30.73	0.0	2940.52	1.0	281.	121.3	8.6	1,555.01	21.0	20.21	16.0
72	1.378	344.	36.43	0.0	3328.46	1.0	313.	125.3	8.3	2,251.04	21.5	19.85	15.6
73	1.426	371.	26.85	0.0	4120.77	1.0	447.	133.1	8.6	3,284.68	22.0	22.77	17.8
74	1.485	433.	19.68	0.0	4456.35	1.0	481.	147.7	9.5	4,243.48	22.5	26.23	20.3
75	1.554	446.	19.24	0.0	5020.15	1.0	463.	161.2	10.0	4,411.27	23.0	28.50	21.9
1976	1.628	546.	22.37	0.0	5682.77	1.0	465.	170.5	9.8	4,700.81	23.8	31.17	23.8
77	1.698	735.	21.92	0.0	6109.00	1.0	458.	181.5	9.3	5,817.00	24.3	37.51	28.4
78	1.778	761.	21.00	0.0	6695.00	1.0	525.	195.4	9.49	6,355.34	25.0	38.00	28.5
79	1.877	820.	20.00	0.0	7627.00	1.0	603.	217.4	10.19	9,118.60	25.6	40.00	29.8
80	2.006	928.	18.00	0.0	8188.00	1.0	653.	245.8	11.39	10,708.00	26.3	46.40	34.2

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