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A CONVERSATION BETWEEN BUYERS AND SELLERS OF LAND
OR
A MARKET EQUILIBRIUM APPROACH FOR ESTIMATING LAND VALUES

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ABSTRACT

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This research develops models for determining land values in Walrasian market settings where land supplied and demanded is dependent on buyers' and sellers' expected costs and benefits. Included in the model statements of expected costs and benefits are the effects of inflation. The models, after being logically deduced, are tested empirically using Michigan and Illinois data. The empirical results support the deduced models.

A previously developed simultaneous equation model of the farm real estate mortgage market is used with the inflationary land values model to trace the effects of inflation on interest rates and land values. Land values, it is shown, respond quickly to increases in inflation because returns to land respond more quickly than interest rates. As inflationary impacts on interest rates and returns stabilize, land value increases stabilize at rates of change equal to inflation.

A Conversation Between Buyers and Sellers of Land

or

A Market Equilibrium Approach for Estimating Land Values

Introduction

Farmland is worth what buyers and sellers agree it is. Unfortunately, such a logical statement fails to fully clarify reasons for historical price patterns. Since World War II, land prices in Michigan have posted rather dramatic increases with only a single year of price decline (Robison, 1980b). During the same period, decreases and slower increases in cash rents paid for the use of land are noted (see Figure 1). Such phenomena leave farmers and academicians alike hoping for a more practical explanation for the observed land value and cash rent trends than: its what buyers and sellers agreed upon.

Schultz notes that economic analysis of land is not a simple matter: "Land as an economic variable is exceedingly hard to get at. 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 number of different attempts used to explain land value.

Some examples of past efforts to explain observed land value patterns and to predict future land values include: simultaneous equation models by Herdt and Cochrane, Tweeten and Martin, and Reynolds and Timmons and single equation models by Klinefelter, Duncan, Dunford, Hauschen and Herr, and Dobbins, et. al.

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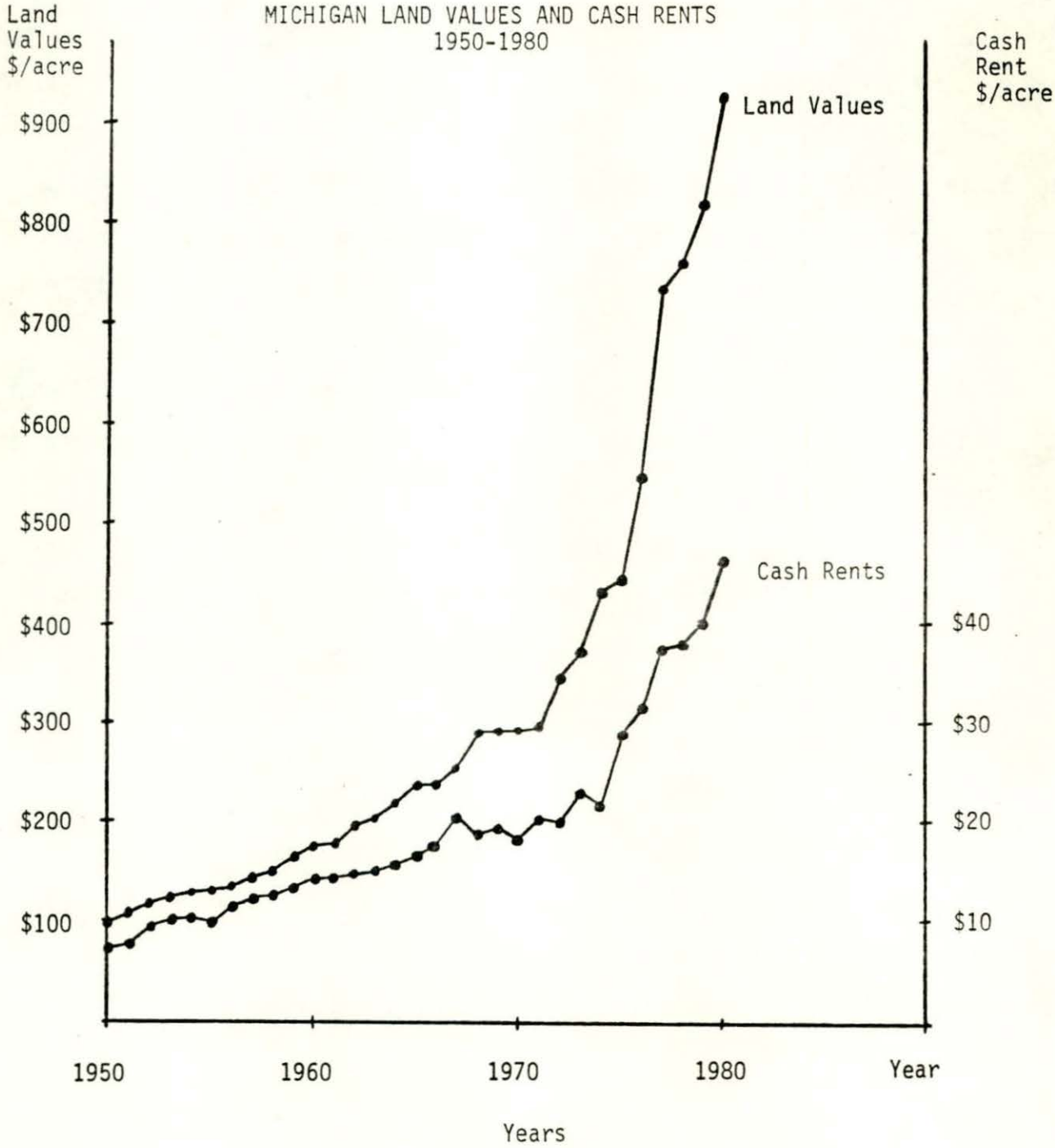
[1]Schultz, p. 145.

FIGURE 1

MICHIGAN LAND VALUES AND CASH RENTS
1950-1980



Source: Robison 1980b.

Many of these research efforts lack a logical deduction from theory to model form and content. Other models did not pass the 'test of time' in that statistical measures of their empirical validity decreased markedly 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 which reviewed and re-tested 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]

Capital budgeting techniques form the basis for the theory developed in this study. While a simple capitalization approach cannot fully explain recent price patterns, it is instrumental in understanding land market participant behavior. Buyers and sellers create land prices; therefore, it is the behavior of these buyers and sellers which needs to be modelled. Many earlier research efforts failed to consider behavioral aspects of the economic variables that influence land values. Using capital budgeting theory to develop expressions for quantities of land held and quantities desired, a market equilibrium approach equating these quantities is followed.

In one sense, because any market is rarely, if ever, in equilibrium, there are two 'markets' for land--agriculture and nonagriculture. Within

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

either 'market,' there may be land offered for sale which is not purchased, or there may be too little land for all prospective buyers. In either case, a land market is then out of equilibrium. The quantity of land moving from one 'market' to the other in order to take advantage of differing demand and supply conditions may play a role in pricing land. Therefore, a market approach is essential for capturing all factors of the land market.

Our model must also include inflationary forces, which influence market participant behavior because inflation alters participants' views of benefits and costs in the market model. The intent of including as much realism as possible is to develop a model with empirical validity. This validity requires that any new model must stand the 'test of time' failed by earlier land market models; that is it performs well beyond the sample period. This then is our objective: to develop a logically correct-empirically valid land values model and to use the model to explain past land value trends.

In attempting to fulfill this objective, models will be estimated using average farmland values, average cash rents, 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 1979. Subsequent estimation includes the longer time period 1941 to 1979 and Illinois farmland data. In order to better capture the multiple effects of several independent and dependent variables, a simultaneous equation system is employed when using the model for counter factual simulations and projections.

Land Market Research

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. Three researchers considered technological advances, scale economies, government programs, and land transfers among the key factors explaining land price variations. Each study tested its hypothesis in a simultaneous equation system.

More recent studies have considered single-equation models of the land market. Klinefelter and Duncan both followed an approach similar to those earlier models, attempting to find correlations among variables but used simpler models to test their hypotheses. Dunford, Hauschen and Herr, and Dobbins, et. al. each used a capital budgeting approach to determine maximum bid prices for land.

By beginning their research questioning the link between net farm income and the value of land, most of the studies cited 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. agree that net farm income is not an appropriate measure of returns for owning land; rather, they argue 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.

Another common feature of most previous land studies is their emphasis on the demand for farmland. With the exception of Herdt and Cochrane's demand and supply equation model, and Tweeten and Martin's five equation model, the remainder of the studies concern themselves primarily with the factors affecting demand. In order to understand the contributions and limitations of the land values work cited, we review each in some detail.

The first study reviewed was completed by Herdt and Cochrane in 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. 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 conclude that technological advance has exerted the strongest influence on land prices. The conclusion rests on the assumption that widespread technological advance, nondecreasing returns to scale, and price support floors continue to exist.

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 unemployment, 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, because Herdt and Cochrane hypothesize a relationship between other factors and land values without logically justify-

ing the relationship. In addition, the assumption that widespread technological advance and price supports without supply limits will continue to exist in the future is no longer as valid as it may have once been. 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. Since Herdt and Cochrane's research, there have been several years in which price supports were contingent on supply limits and certainly, such supports depend in large part on the current presidential administration.

Like Herdt and Cochrane, Tweeten and Martin (1966), agree that net income is not a satisfactory indicator of land values. 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.

A five equation recursive model measured the correlation between land values and the factors listed above in the sample period 1923 to 1963. Equations are developed for land price, land supply, cropland, farm numbers, and farm transfers. 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, signi-

ficant 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. This study would have been better served by explicitly considering the justification for relationship between both demand and supply variable and land value.

An approach similar to both Herdt and Cochrane's and Tweeten and Martin's is taken by Reynolds and Timmons in their 1969 study. 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, govenment 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.

Another similarity to earlier models, 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.

Klinefelter study, completed in 1973, uses only a single equation model. 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. However, justification for the hypothesized relationships 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 the supply of land offered for sale is not price responsive--an assumption made without empirical support.

In an effort to re-examine these earlier models, a study by Pope, et. al. uses more recent data 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 discussed were re-estimated by Pope, et. al. over the new period 1946-1972. Rather discouraging results were obtained from the re-estimations. The three simultaneous equation models by Herdt and Cochrane,

Tweeten and Martin, and Reynolds and Timmons all suffered coefficient sign reversals, insignificant coefficients, and loss of explanatory power (decreased R^2 statistics). The single equation model by Klinefelter experienced the same problems with the exception that it retained its predictive accuracy.

The lack of estimating ability beyond original sample periods exhibited by these four models is an expected result. Along with previously discussed weaknesses such as weak 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. 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.

The Pope study does support additional research in the area of single equation land value models. A study by Duncan (1977) 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 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 per acre 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-return 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 returns 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, simply hypothesizes correlations without exploring the behavioral link which causes the correlation.

Another single equation approach was published in 1980 by Dunford. 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 bases land values on their expected earning capacity, capital gains, and inflation. Over the short run, Dunford concludes that expected capital gains fuel investor's increases 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.[3]

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[3]Melichar, p. 16.

This income series is essentially a residual to land after returns to other factors of production have been extracted.

While Dunford attempted to correct one weakness, he ignored another. He did 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.

Hanschen and Herr's 1980 study begins by contrasting trends of net farm income and land values. Hauschen and Herr also subscribe to Melichar's conclusions about the weakness of net farm income as a measure of returns to land. In order to develop a plausible relationshp 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, R^2, equal to .987, significant coefficients, and appropriate signs.

A weakness of the Hauschen and Herr model, however, arises in their exclusive use of the capitalization equation. Hauschen and Herr contend that the supply function for land is totally inelastic. As a result, they argue that supply considerations do not play a role in determining land values, and the capitalization equation is sufficient to explain land values. Conclusive evidence in support of this argument was not provided by Hauschen and Herr or any other researcher.

Perhaps the study which came closest to appropriate theoretical foundations was completed in 1981 by Dobbins, et. al. The authors 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 9 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 four percent per year and future returns are to be discounted at eight 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 such as Herdt and Cochrane's, Tweeten and Martin's and Reynolds and Timmen's which base their work on the differences in land values and land returns.

Dobbins, et. al.'s research using a residual income series and theoretically justifying their model, corrects weaknesses of earlier research. There is, however, one missing step from their work: the supply side of the land

market is not incorporated into their model. While the allowance for differing inflationary impacts on returns and discount rates makes significant progress toward realism, failing to consider the supply side of the land market leaves their work incomplete.

Table 1 summarizes the major features of the studies just reviewed. Based on these reviews we make three observations:

(1) a carefully deduced land market model's needed;

(2) this model must include both supply and demand forces in determining land's prices; and

(3) to evaluate such a model an appropriate measure of income to land is needed.

We now proceed to develop such a model: one that is carefully deduced, includes both supply and demand forces, and is validated using an appropriate income to land data series.

A Market Approach

We begin the development of our model by recognizing the fact that 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 costs to both buyer and seller. These transactions between buyers and sellers produced the observed land values data. Thus, to fully understand land value patterns, a market analysis is required because it is in a market situation in which land values are determined. So we look at costs and benefits of land transactions from the buyer's perspectives and then the seller's.

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 --coefficients changed signs and/or became insignificant --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 --coefficients changed signs and/or became insignificant --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 --coefficients changed signs and/or became insignificant --loss of accuracy
Klinefelter, 1973	Single Equation	Predictive, not economically descriptive	1951 - 1970	Net Returns to Farming	Farm Transfers	Re-estimated 1946 - 72 --coefficients changed signs and/or became insignificant --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 G-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.

The Buyer's Side--Maximum Bid Price

Capital budgeting theory tells us an asset's maximum value can be expressed as the sum of its expected returns plus its salvage value. In a simple world without inflation or taxes, let V equal land's present value, let R equal the constant cash return earned by the land in each period, and let r equal the discount rate which compensates savers for the inconvenience of postponing consumption, and let t represent time. The relationship between V, R, and r can be expressed as an infinity long annuity:[4]

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

Equation (1) may be rewritten as:

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

As time approaches infinity, the expression $(1+r)^{-T}$ approaches zero and we are left with the capitalization formula:

$$(3) \quad V = R/r$$

Equation (3) summarizes what 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, or the asset's returns are 'capitalized' to obtain an asset's value. Thus, V represents the buyer's maximum bid price for land.[5]

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[4]Because the value of an asset at resale depends on the income expected by the future buyer, and so on, in the final analysis, only land's income producing potential matters.

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

The Seller's Side--Minimum Sale Price

Those selling land ask a question similar to the one answered for the prospective land purchaser: at what price are benefits from the sale of land just equal to the costs, i.e., the returns from land foregone? We again assume that income from land is expected to continue at a constant R dollars per period and the discount rate is r. So, if the land is sold, the seller earns rV each period from investing the sale proceeds V at interest rate r. He gives up, however, R dollars in each period which could have been earned by holding land. These benefits and costs in all future periods can be discounted to the present. The result, using a discount rate equal to the time preference rate r, is:

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

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

$$(5) \quad \lim_{T\to\infty} (rv-R)[1-(1+r)^{-T}]/r = 0$$

The V for which the expression in (4) and (5) is zero, equals the seller's minimum sell price. At that price his benefits from the sale just equal the returns or opportunity cost foregone. As T becomes large the quantity $(1+r)^{-T}$ in (5) approaches zero and we are left again with the capitalization equation (3).

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, those 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.

Of course the adjustment in land values is a process which requires time to complete. So, that at any particular instant of time the market may not be in complete equilibrium.

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. Individual one may be thought of as the sum of all net suppliers of land and individual two 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, both market participants one and two are originally endowed with some quantity of land Q_1 and Q_2 respectively (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 give 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 prices and quantities traded at those prices is determined. Later we will derive the results for a market of n participants.

To determine the quantity of land traded in response to trading prices announced by the Walrasian auctioneer, each market participant consults his current or expected production function. In panels (a) and (b) of Figure 2, output Y is related to the input land (Q) 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 2, can be derived. Multiplying these marginal product curves by a given, constant output price P_y allows us to obtain the marginal value product curves (MVP) in Figure 3. 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 of land used in production there is some output Y which earns 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 3. This farmer is originally endowed with some quantity of land Q_1,

FIGURE 2

PRODUCTION FUNCTIONS AND MARGINAL PRODUCT CURVES

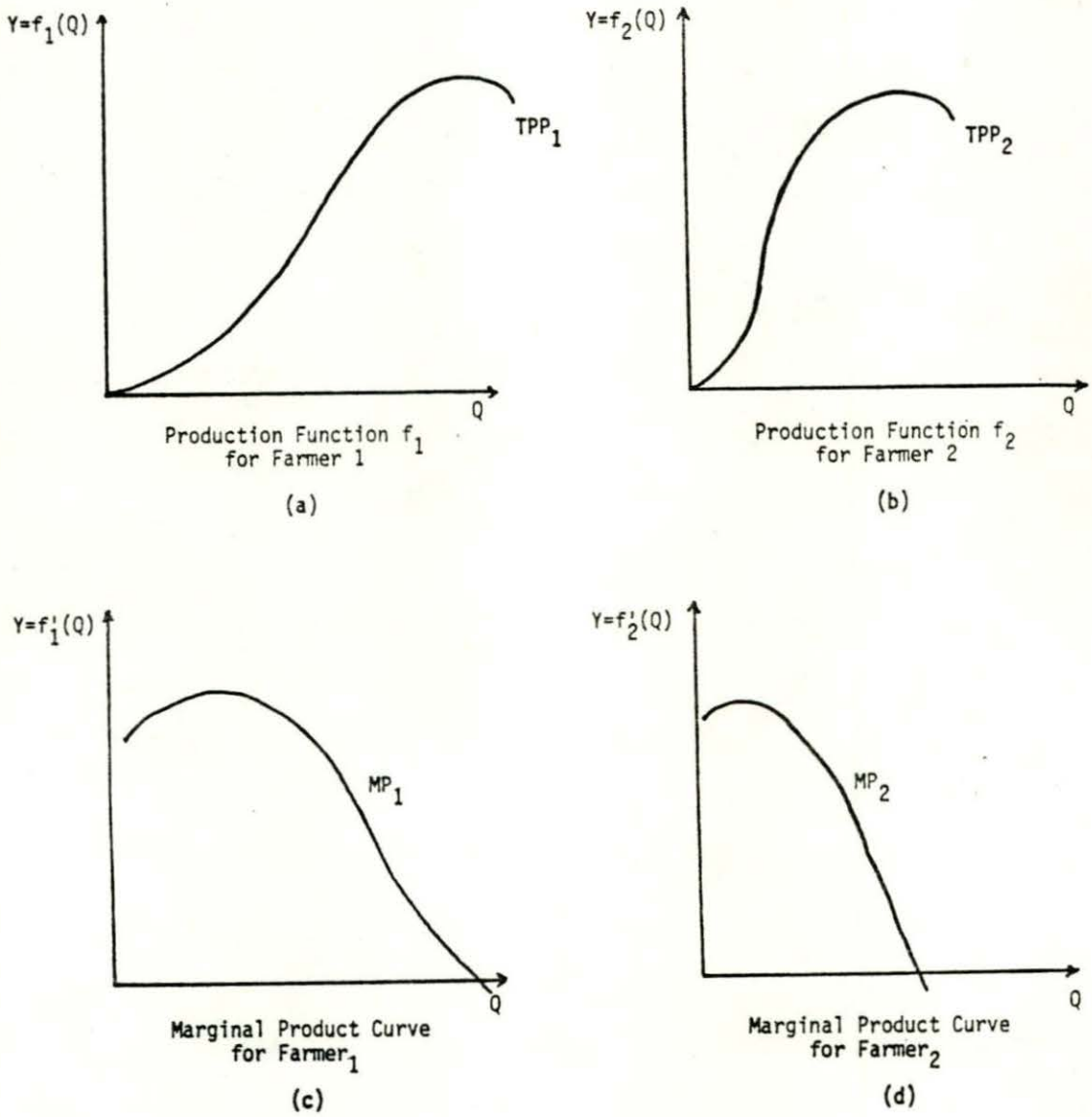
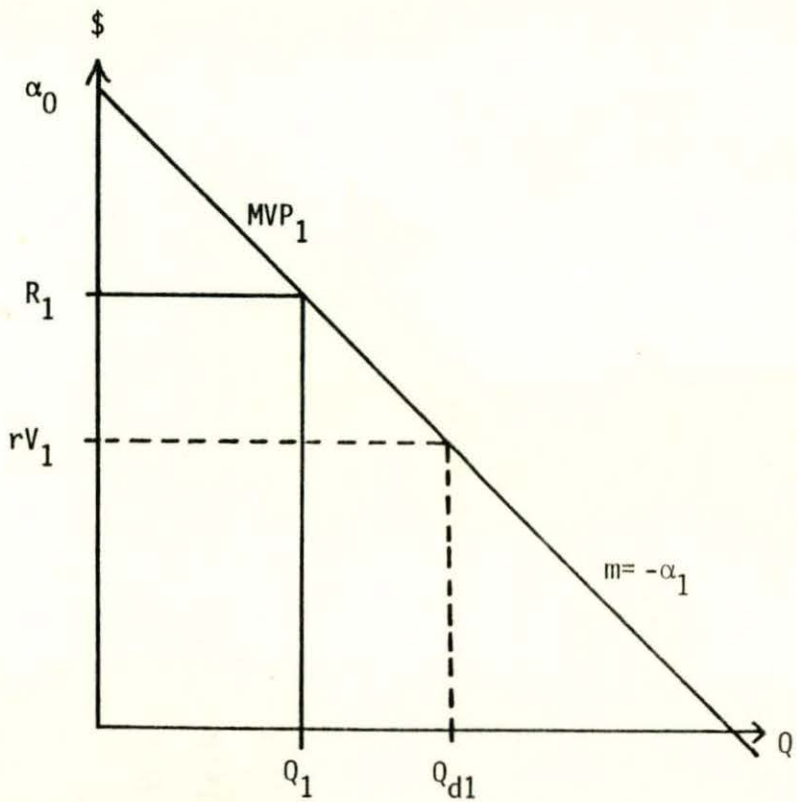


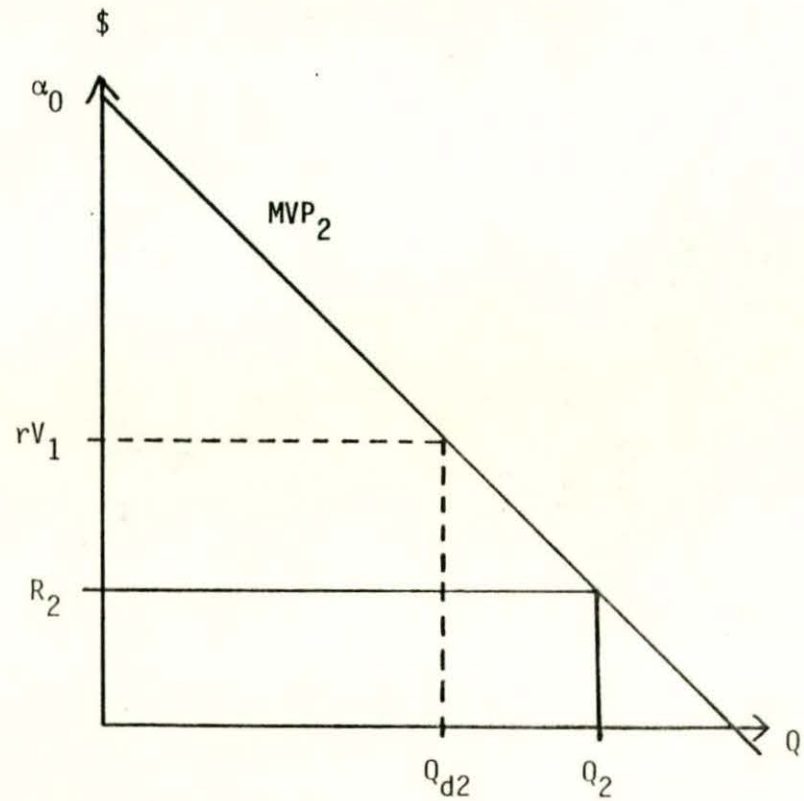
FIGURE 3

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)

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 in Figure 3 where a horizontal line drawn from rV_1 intersects MVP_1 identified the quantity of land Q_{d1} at which 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 $(Q_{d1}-Q_1)$ 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 land. 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. If expected benefits from the sale exceed expected costs, the sale will be profitable.

Farmer 2 in Figure 3 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. There-

fore, 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.

Assuming a market of m participants each with endowment of land Q_j, j=1,...,m, the market's excess demand (supply) for land given price V, can be written as:

$$(6) \quad \sum_{j=1}^{m} Q_{dj} - \sum_{j=1}^{m} Q_j = \sum_{j=1}^{m} W_j$$

where ΣW_j is the excess demand or excess supply of land given price.

In equilibrium the quantity of land desired just equals the quantity of land held and the right hand side of (6) is equal to zero. If W_j 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. The overall land market may be in equilibrium. But the subsector land markets may not necessarily be in equilibrium as land may move from agricultural uses to nonagricultural uses, and visa versa. The total land market in equilibrium may be described by the expression:

$$(6a) \quad \sum_{j=1}^{m} (Q_{dAj}-Q_{Aj}) + \sum_{k=1}^{n} (Q_{dNk}-Q_{Nk}) = 0$$

where Q_{dAj} and Q_{Aj} represent the aggregate quantity of land desired and held by the jth individual in agriculture, and Q_{dNk} and Q_{Nk} represent the aggregate

quantity desired and held by the kth individual in non-agriculture. In this representation, $\sum_{k=1}^{n} (Q_{dNk}-Q_{Nk}) = -\Sigma W_j$ in equation (6); that is, the excess demand (supply) of one market equals the excess supply (demand) in the other market. Consequently, if amount ΣW_j of land were traded between markets each sector would be in equilibrium. Within the agriculture market, if ΣW_j is positive, there is excess demand for agricultural land and either some demanders will be unable to purchase land or land will enter from the non-agriculture sector. If ΣW_j 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, ΣW_j is thought of as the disequilibrium factor for agriculture.

To obtain an explicit estimating equation which reflects land market conditions, we assume that marginal revenue product curves for the jth market participants, as a function of land used, can be written as:

(7) $R_j = \alpha_{oj} - \alpha_1 Q_j$

where α_{oj} is the intercept and α_1 is the slope of the MVP curve for the j-th individual. At the intersection of the MVP curve and the vertical line Q_j in Figure 3, we find the return R_j associated with the last unit of the land endowment held by individual j.

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

(8) $rV = \alpha_{oj} - \alpha_1 Q_{dj}$

Rewriting equations (7) and (8) is terms of Q_j and Q_{dj} respectively will allow this system of equations to be solved for land values.

(9) $Q_j = (\alpha_{oj} - R_j)/\alpha_1$

(10) $Q_{dj} = (\alpha_{oj} - rV)/\alpha_1$

Substituting for Q_j and Q_{dj} in equation (6) the right hand side of equations (9) and (10) and solving for V yields the reduced form expression:

(11) $V = -\alpha_1 \sum_{j=1}^{m} W_j/rm + \sum_{j=1}^{m} R_j/mr$

(12) $V = -\alpha_1 \bar{W}/r + \bar{R}/r$

where $\bar{W}$ and $\bar{R}$ are average difference between Q_{dj} and Q_j and average returns respectively.

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 average capitalized value of annual returns to land, R/r, and the average capitalized quantity of land in excess demand (supply) in agricultural uses, or $-\alpha_1\bar{W}/r$, is the price which must be added to land's price to clear the agriculture land market--so that no land transactions would occur between the agricultural and nonagricultural land markets.

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:

(7a) $R_k = \beta_{ok} - \beta_1 Q_{nk}$

The opportunity cost expression is:

(8a) $rV = \beta_{ok} - \beta_1 Q_{dnk}$

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

$$(6b)\ \sum_{j=1}^{m} [(\alpha_{oj} - R_j)/\alpha_1 - (\alpha_{oj} - rV)/\alpha_1] + \sum_{k=1}^{n} [(\beta_{ok} - R_k)/\beta_1 - (\beta_{ok} - rV/\beta_1] = 0$$

Equation (6b) can be simplified to:

$$(6c)\ (\beta_1 + \alpha_1)\ rV/\alpha_1\beta_1 = (\beta + \alpha_1)\ \bar{R}/\alpha_1\beta_1$$

With cancellations, we are left with:

$$(6d)\ V = R/r$$

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 $\bar{W}$, 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 $\bar{W}$ for the agriculture market remain the same. If the announced price V is a market clearing price, that is, a price which just equates $\sum_{j=1}^{m} Q_{dAj}$ with $\sum_{j=1}^{m} Q_{Aj}$, then this difference 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 or into farming. If that quantity 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 that difference 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 and there will be downward pressure on land prices. Either situation causes the land market to move toward equilibrium. However, as conditions in the land market are continually changing, this equilibrium may never be reached.

Inflation in the Land Market

Persistent upward pressure on land prices has 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 farmers are highly responsive to inflationary expectations.[6] If rising returns to farmland are indicative of expected increases in general prices, savers will no longer be willing to save at rate r which only compensates them for postponing consumption. They will require, in addition, compensation 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 of return r* as:

$$(13) \quad r^* = (1+r)(1+i) - 1$$
$$= r + i + ir$$

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

The Buyer's Side

In a world with inflation a prospective purchaser evaluates the present value of land as before. 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 can again be expressed as an infinitely long inflating annuity:

$$(14) \quad V = R(1+i)/\ (1+i)(1+r) \ + \ldots + R(1+i)^T/\ (1+i)(1+r)^T$$

For the buyer only concerned with his maximum bid price, the forces of

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[6] Luttrell, p. 17

inflation exactly cancel out since inflation in equation (14) 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:

$$(15) \quad V_{t+1} = R_t(1+i)/r$$

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

$$(16) \quad V_{t+1}/V_t = (1+i)$$

Stated in terms of expectations, each buyer's maximum bid price increases each period by the inflation rate i.[7]

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_t. 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

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

seller will look for the minimum sale price 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:

(17) $r^*V - R(1+i)\ (1+r^*)^{-1} + \ldots + r^*V - R(1+i)^T\ (1+r^*)^{-T} = 0$

Collecting terms and solving for r^*V_t allows (17) to be rewritten as:

(18) $r^*V_t\ 1 - (1+r^*)^{-T}\ (r^*)^{-1} = R(1+i)(1+r^*)^{-1} + \ldots + R(1+i)^T(1+r^*)^{-T}$

As T grows large, the left hand side simplifies to V. The right hand side, after cancelling for inflation, reduces to R/r. Therefore, the result is the capitalization formula:

(19) $V = R/r$[8]

The Market

We now combine the inflationary impacts on buyers and sellers in our market. To begin, we assume that if inflation impacts equally on buyers and sellers, the quantity of land traded remains unchanged. To leave invariant with respect to inflation the difference between initial endowments Q_j and the desired quantities of land Q_{dj} in equation (12), we adjust for inflation by a vertical shift in the MVP curves in Figure 3. Such an adjustment increases the intercept term $_{0j}$ by i percent each period such that in the tth period it equals $\alpha_{oj}(1+i)^t$. Rewriting equations (7) and (8) for R and V in the tth time period to incorporate the adjustment for inflation yields:

(20)

(21)

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[8]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.

Equations (20) and (21) may be solved as before for Q_j and Q_{dj}, 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 $\Sigma_j W$. Since $\Sigma_j W$ 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:

$$(22)\quad V_t = \bar{R}_t/r - (\alpha_1 \bar{W}/r) \prod_{\ell=1}^{t} (1 + i_\ell)$$

Equation (22) is similar to the market result without inflation except that V_t and R_t are no longer constant over time; instead they increase each period by the rate of inflation. In addition, the capitalization of untraded land in excess demand (supply) is compounded for t periods.

Data and Empirical Results

The theoretical results which now need to be tested are:

1. The agricultural land market by itself is in equilibrium so that the simple capitalization formula, $V_t = R_t/r$, fully explains price/return relationships.
2. The agricultural land market by itself is not in equilibrium and equation (22) which incorporates inflation and a disequilibrium factor is required to fully explain price-return relationships.

Models and hypotheses are tested using Michigan and Illinois data. Data used are reported from several sources and are reported in Table 2. The USDA reports survey results of farmers each February 1, including values and cash rents as reported by landlords. Robison and Leathan report discount rates and new Federal Land Bank interest rates.

Table 2

CASH RENTS FOR CROPLAND, LAND VALUES, AND INTEREST RATES

Year	Average Cash Rents[1]		Average Land Values (as of Feb.)[3]		Adjusted Interest Rate on Federal Land Bank Loans[2]	Inflation Rate Proxy (Col. 4 - 4%)
	Mich.	Ill.	Mich.	Ill.		
1960	14.08	19.55	174	541	6.3	2.3
1961	14.00	19.75	176	526	5.9	1.9
1962	14.58	19.65	196	541	5.9	1.9
1963	14.81	21.16	201	571	5.9	1.9
1964	15.42	21.85	217	594	5.8	1.8
1965	16.12	27.24	237	640	5.8	1.8
1966	17.24	30.20	236	716	6.1	2.1
1967	20.49	33.05	254	762	6.3	2.3
1968	18.48	36.05	290	792	7.1	3.1
1969	19.15	36.20	291	830	8.1	4.1
1970	17.52	36.35	291	815	9.1	5.1
1971	18.86	36.65	295	823	8.3	4.3
1972	19.38	38.05	344	883	7.8	3.8
1973	22.11	41.55	371	983	7.9	3.9
1974	27.40	52.60	433	1318	8.5	4.5
1975	28.83	63.53	446	1592	9.2	5.2
1976	32.45	77.11	546	1980	9.2	5.2
1977	39.47	92.41	735	2689	8.8	4.8
1978	37.70	94.65	761	2970	8.7	4.7
1979	41.60	99.73	820	3359	9.5	5.5

[1]Source: USDA unpublished data on cropland.

[2]Source: Robison and Leatham. Reported interest rates are divided by .95 to adjust for stock purchases.

[3]Source: Farm Real Estate Market Developments, ERS, USDA, various issues.

Finding an appropriate measure of returns to land is difficult. If there is an active cash rent market for land, the net rental approach as an estimate for land's income can be supported. 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 where supply and demand forces affect the rent charged. For these reasons, cash rent is used in this research as the measure of current returns to land.

Finding the appropriate discount rate for use in the land market is also a problem. 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 FLB borrowed funds since it is the largest supplier of farm real estate funds. Therefore, FLB new loan rates are considered a proxy for market interest rates (or discount rates).

An implicit measure of inflation is found imbedded in market interest rates (in this case, FLB new loan rates). Subtracting the constant time preference rate of 4 percent from the discount rate yields the inflation rate.

The next step is to test hypotheses developed earlier. 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 turorial purposes. Therefore, the first test is made on the basic capitalization model with inflation.

Capitalization Formula

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. It was noted that in equilibrium, the agriculture land market equation reduces to the capitalization formula. Requiring that the agricultural land market be in equilibrium is a highly restrictive assumption, however, and in conflict with the fact that every year the demand for a fixed quantity of land appears to increase. Still 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 (23) below is estimated using Michigan data over the sample period 1960-1979. In equation (23) land values and cash rents are permitted to increase in each period by the rate of inflation, so they are subscripted for time:

$$(23) \quad V_t = R_t/r$$

Equation (23) was estimated using Ordinary Least Squares, assuming the time preference rate r to be a constant between three and six percent. With this assumption, the coefficient on R_t should be the reciprocal of r, between 17 and 33. The statistical results of the Ordinary Least Squares estimation are:

$$(24) \quad V_t = 17.7\ R_t$$

with a t statistic of 30.4, and R^2 of 9 percent and a Durbin Watson statistic of .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 of 30.4 suggests that the coefficient on R_t is signifi-

cant 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 within the expected range, yielding a value for r of about 5.6 percent. But as Durbin Watson statistic of .25 indicates significant positive autocorrelation.

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 3 indicate that the ratio has, in fact, varied from a low of 12.4 to a high of 20.5 in a generally upward trend over the period 1960 to 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. The formula does indicate, however, that the land value-cash return relationship is a significant factor influencing land values.

The Market Model with Inflation and a Disequilibrium Factor

Incorporating the disequilibrium factor and inflation into the theoretical equations of expected costs and returns resulted in equation (22). This equation, a reduced form expression, was then estimated using ordinary least squares using Michigan data from 1961 to 1979 with the results reported below:

$$(25)\quad V_t = 29.5R_t - 220.1 \prod_{k=1}^{t} (1 + i_k)$$

$$(17.4)\ (-7.0) \qquad R^2 = .978 \qquad D.W. = 1.62$$

This single equation reduced for the model including inflation provides a correlation of nearly 98 percent between land values and two variables. The t-statistics shows both coefficients are significant at .05 percent confidence intervals and signs on both coefficients are those expected. In addi-

Table 3

RATIOS OF LAND VALUES TO CASH RENTS

Estimated Using the Capitalization Formula
and the Market Models

Year	1 Actual Ratios	2 Capitalization Formula	3 Market Model Ratios
61	12.6		13.4
62	13.4		13.9
63	13.6		13.8
64	14.1		14.3
65	14.7		14.8
66	13.7		15.8
67	12.4		18.6
68	15.7		16.0
69	15.2		15.9
70	16.2	17.67	13.8
71	14.6		14.8
72	17.3		13.5
73	16.3		15.4
74	16.5		17.1
75	15.6		17.5
76	17.5		17.9
77	19.6		20.0
78	20.0		19.1
79	20.5		18.9
80	20.0		19.8

tion, the magnitude of the coefficient on cash rents (29.5) is well within the expected range for the inverse of the time preference rate. Moreover, the sign on the second variable implies excess demand which is currently observed. Finally, the Durbin Watson statistic indicates the absence of autocorrelation.

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 2, column 3 expected values of the ratio using the market model are reported.

In an effort to examine the general applicability of this market model, equation (22) was re-estimated using Illinois land market data. Support for the model would be enhanced if it had satisfactory test results in a land market with significantly different cash rent and land value magnitudes.

The results of this re-estimation are:

$$(26)\quad V_t = \underset{(16.9)}{36.0R_t} \underset{(-3.9)}{-325.4} \prod_{j=1}^{t}(1+i_j) \qquad R^2 = .969 \quad D.W. = 0.44$$

These results are again encouraging as the model yields a correlation of nearly 97 percent; but the Durbin Watson statistic indicates autocorrelation of the error term. 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 level of capitalized excess demand for Illinois versus Michigan farmland. The coefficient on cash returns (36.03) is nearly within the expected range of a three to six percent time preference rate. Thus, re-estimating equation (22) for Illinois data appears to reconfirm the conclusion that a market approach to the land market is empirically sound.

Three of the models reviewed earlier 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 (22) 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 the second coefficient magnitude is likely to be sensitive to the sample period, but no other changes should result from the re-estimation.[9]

To test the strength of equation (22) over time, equation (22) was re-estimated from 1941 to 1979 using Michigan data. With t-statistics below the corresponding coefficients, the estimation results are:

$$(27)\quad V_t = \underset{(21.0)}{24.1}/R_t \underset{(-6.7)}{-85.1} \prod_{k=1}^{t} (1 + i_k) \qquad R^2 = 0.967 \qquad D.W. = 0.66$$

The t-statistics of 21.0 and -6.7 are both significant at .05 condifence levels. These results suggest that this market model with inflation is not subject to the loss of accuracy, sign changes, or insignificant coefficients which plagued earlier research attempts. In fact, the only difference in the estimations between 1941-1979 and 1961-1979 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, can be explained by the increasing demand for the same physical quantity of land. Autocorrelation, however, was apparently introduced when the estimation was made over longer time periods.

Summarizing this market approach with inflation, it appears that a rigorously deduced model can be found which not only has intuitive appeal but

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[9]Pope, et. al., pg. 115.

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.[10]

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. Table 2 summarizes these results. Figure 4 looks at a graphical presentation of land values calculated by the capitalization formula and by the market model.

We can see from these results that the market model is a useful tool for describing the land market. It outperforms the naive capitalization formula and it is applicable to Illinois as well as Michigan data. In addition, the model was shown to be robust when re-estimated for data beyond the original sample period. All of these characteristics combine to make the model useful in determining the potential sensitivity of farmland values to inflation.

To further illustrate the usefulnes of the market model, a simulation model was developed which allows for the effects of inflation on land values to be traced from inflation's source, thus, demonstrating more clearly how inflation enters into the farm real estate market through interest rates and cash rents. The simulation model can be used to determine what land values might do if inflation persists at some given levels.

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[10]Estimating a market model with taxes does not provide substantially different results than without taxes. For the interested reader, see Espel.

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

As modelled by equation (22), land values are dependent on two variables, cash rents $\bar{R}_t$ and the disequilibrium factor $\bar{W}_t$ which represents excess demand (supply). 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 are caused directly by inflation while inflation affecting W_t 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.

Inflation is major element of interest rates. Market interest rates are comprised of at least three factors: the time preference rate r, the inflation rate i, and the product of inflation and the time preference rate ir. Earlier, the inflation factor i was 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 each year to sell bonds. Average bond costs are altered every time new bonds are sold at different interest rates. The average bond rate is the cost of money which FLB's borrowers must pay in order to receivew FLB loans. To insure that loan rates cover average bond rates, loan rates to FLB borrowers are changed regularly to adjust to changes in average bond rates.

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. 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 new bond rates 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 are 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 investor's 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 interst 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 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. Those 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. The percentage change in the Consumer Price Index (CPI) can be used as a measure of inflation. Because of the risk-free nature of FLB bonds, bond rates 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:

$$(28) \quad b_t = 0.036 + 0.587\ I_t$$

$$(13.9) \quad (13.9) \qquad R^2 = 0.91 \qquad D.W. = 1.20$$

T-statistics are presented below the corresponding coefficient in parentheses. Ninety-one percent of the variation in bond rates can be 'explained' by the rate of change in the CPI (I_t). 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 reflected in new loan interest rates.

Other than endogening 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 in Espel 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 (28) and (22) respectively.

The Solution Process

The nonlinear systems of equations just described was solved using the Gauss-Siedel algorithm. For a complete description of the simulation model see Espel. 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 recursively in other equations.

Solving the system using actual data over the sample period 1967-1980 is considered to be a 'base-line' result. By comparing counter-factual simulations (using exogenous data which did not correspond to actual observation) to the base-line results, we determined 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, counter-factual simulations isolate 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.

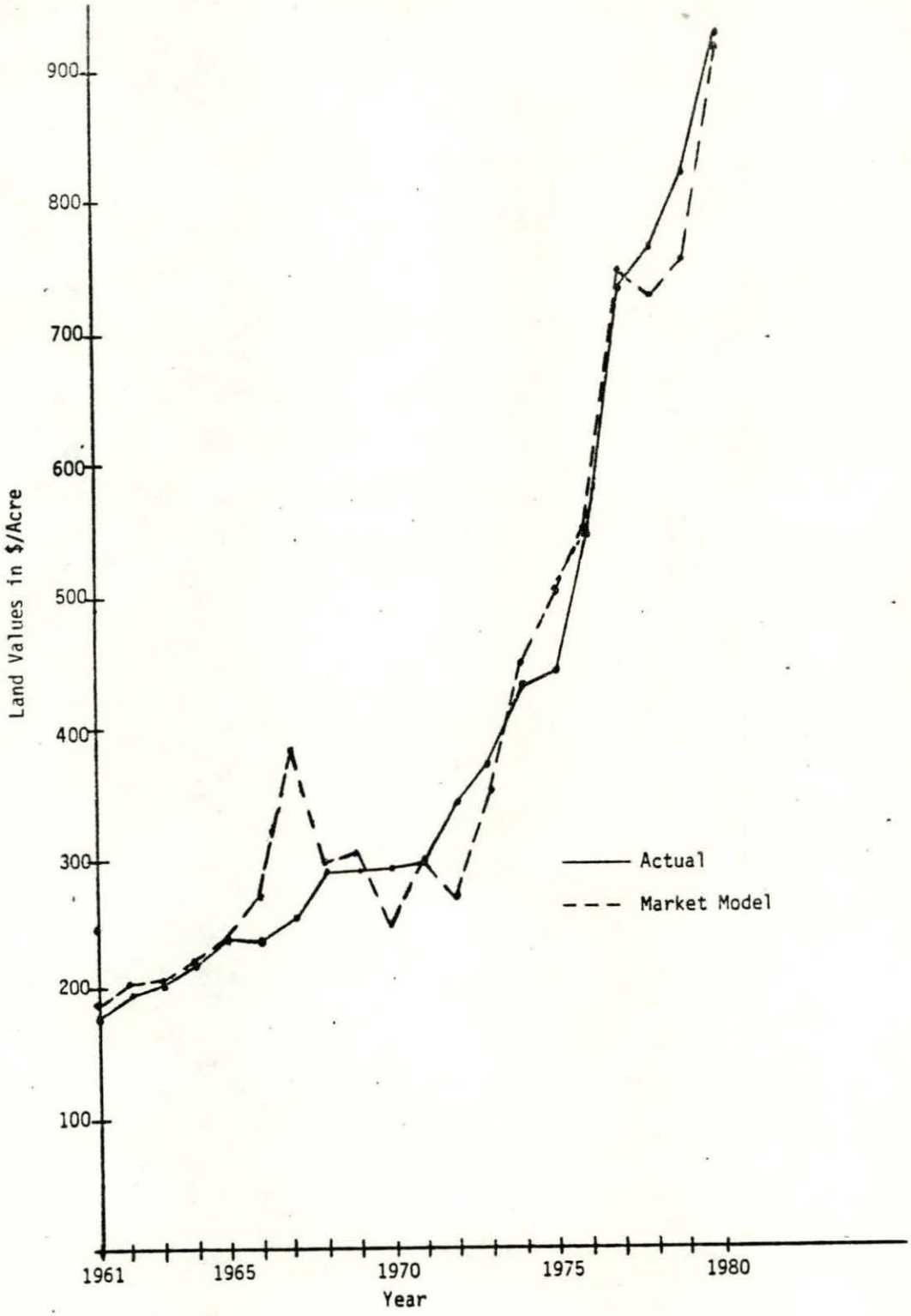
Base-Line Results

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 counter-factual simulations which are solved using data not necessarily corresponding to actual observation.

Figure 4 compares base-line land values with actual values. The 1980 projection for land's value is $903 while the actual value is $928. Base-line

FIGURE 4

A COMPARISON OF ACTUAL LAND VALUES AND THOSE PREDICTED BY THE MARKET MODEL



land values grow at an average annual rate of 17.6% while cash rents grow at 6.5% per year over the period. The projected land value to cash rent ratio equals 19.5 compared to an actual value of 20.0.

Counter-factual Simulations and Projections

Unlike base-line simulations which are derived from actual exogenous data, counter-factual simultions are solved using prespecified 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 for based on these prespecified 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.

One could easily speculate on how land values should react to changing inflation rates. For example, the effects of the lag period between changes in inflation and loan rates would cause one to expect land value adjustments to lag inflation rate changes. Only with constant 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 $\bar{W}$ 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% for several years but then, it suddenly jumps to 16% 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% 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 excess demand for farmland. 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.

Counter-factual Results

Several different simulations of the land market under different inflation patterns are reported in order to measure how closely the land value expectations described above are matched by model results.

Results cover 1981 to 1990. Land values and rates of change are reported in Table 4 and land values are graphed in Figure 5. 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.

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 annual decline in values would have stabilized at about 1.5 percent. Inflation of 5, 8 or 10 percent would not cause major changes in rates of change 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 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.

Simulation results suggest that if inflation rates changed suddenly from previous year's levels, then land values would feel the repurcussion 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 8-10 years for growth levels in land values to correspond to inflation levels.

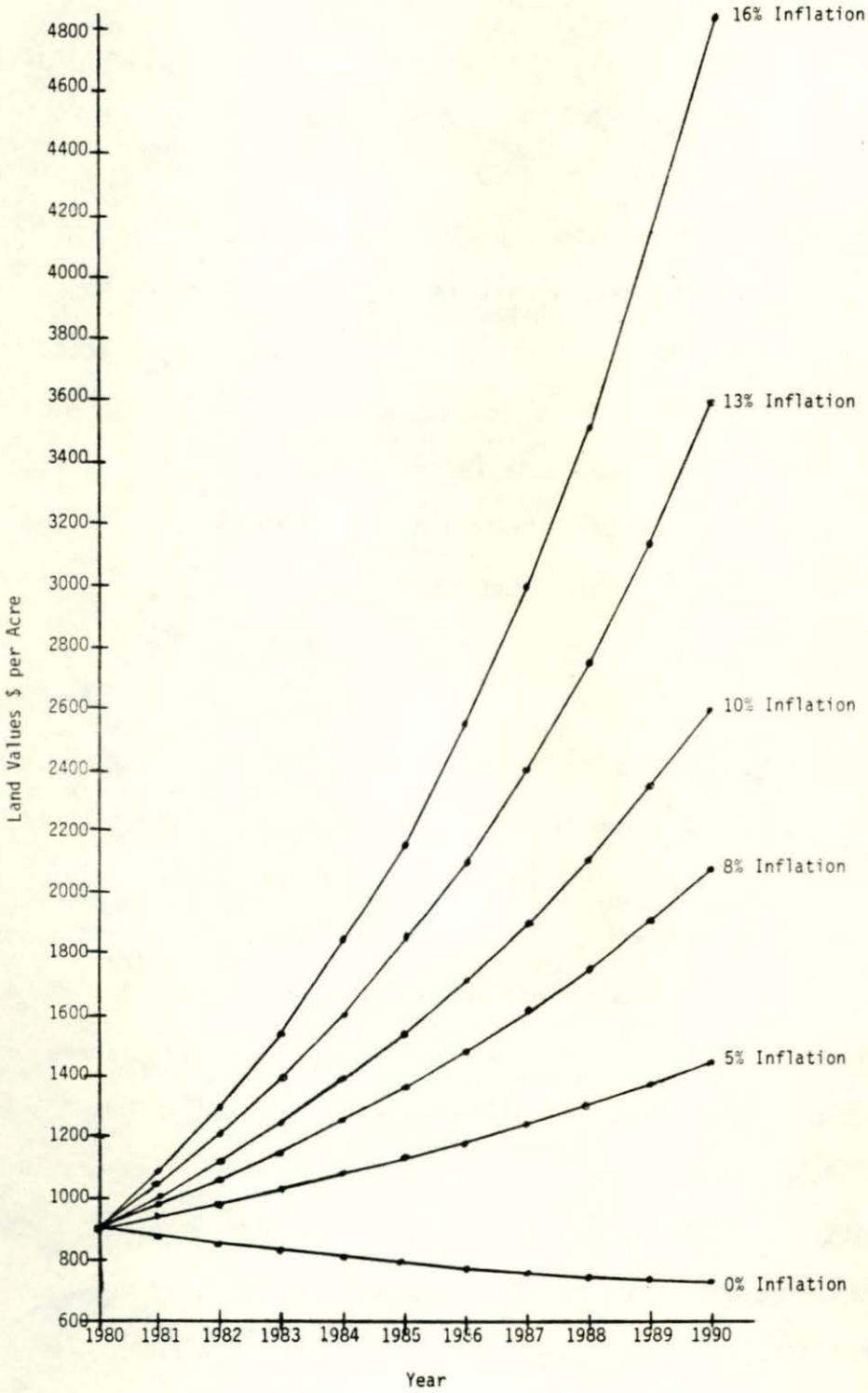
Table 4

SIMULATION RESULTS 1981-1990, CONSTANT INFLATION LEVELS

	Simulation Runs											
	1		2		3		4		5		6	
	Constant Inflation Rate											
	0% 1981-1990		5% 1981-1990		8% 1981-1990		10% 1981-1990		13% 1981-1990		16% 1981-1990	
Year	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	1303	5.2	1905	8.7	2341	11.0	3135	14.3	4131	17.5
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 5

PROJECTION SIMULATION RESULTS, 1980-1990



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 its 1980 level of 13 percent, land value gains would also be expected to slow down. As of June 1, 1981, inflation was approximately 8% (at 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 projection 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 on 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.

Conclusions

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. 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 ex

planatory 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.

Summarizing the conclusions of this research, a model combining the forces of buyer and seller market behavior and incorporating inflation 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.

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 or inflation will become less important in the future. 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 populaton 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?

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