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A maximum bid-price model to evaluate factors influencing farmland values

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by

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INFORMATION TO USERS

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CHAPTER I. INTRODUCTION

The general issue of the future ownership of farmland is one that

has received considerable recent attention in both the popular and

professional literature. One particular aspect of the ownership

question concerns the future size distribution of farms. At issue

is the question of whether or not the recently observed trend to

greater concentration in farming can be expected to continue. A long

promulgated policy of the United States government has been the

preservation of the so-called "family farm". The concentration trend

in farming has led to a critical appraisal of whether or not this

policy remains feasible. Concern also exists for the possible

future relationship between farm ownership and farm operation.

Particular issues in this regard deal with whether or not the

ownership of farmland might become vested in nonfarm individuals, non-

farm corporations, or nonresident alien investors. This absentee land-

lord issue is also seen to threaten the viability of "family farming".

The legal restrictions imposed by many states on farm ownership by

corporations and nonresident aliens (Morrison and Krause, 1975) and

those portions of the Congressional Foreign Investment Study Act of

1974 dealing with farming indicate the nature and extent of public

concern. More generally, the future character of the United States

rural landscape, including both farming and the delivery of

ancillary services by towns, depends largely on the future ownership

structure of farmland.

It is plausible to expect that, in the absence of effective statutory restrictions, the future ownership of farmland will be vested in those individuals or corporations that are currently in a position to offer the highest bid per acre of land. A useful approach to the farm ownership issue, then, becomes one of: (a) isolating those factors which are significant in determining an investor's valuation of farmland, and (b) bringing these factors together into a comprehensive model explaining the determination of an investor's maximum bid for an acre of farmland. Such a model should be designed to relate an investor's maximum per-acre bid to the particular characteristics of his own circumstances and the land under consideration. If these characteristics can be defined in terms of the variables of the model, it can be employed to compare the relative bidding potentials of various investors or types of investors for any kind of farmland. This kind of empirical investigation would serve as a useful first approximation in a consideration of the future ownership issue.

The purpose of this study is to provide a general framework for the determination of the maximum bid prices for an acre of farmland of particular investors or investor types, and to conduct some preliminary tests of the importance of various factors in the determination of relative bidding potentials for farmland. Chapter II examines previous research related to the ownership question. A theoretical maximum bid-price model is presented in Chapter III, and a numerical specification of the model is provided in Chapter IV. Finally, the model is evaluated and the study is summarized in Chapter V.

CHAPTER II. REVIEW OF LITERATURE

This chapter presents a review of recent literature pertinent to

the development of a maximum bid-price model. The literature on

agricultural land valuation provides two ingredients essential to this

study: (a) a catalogue of variables that have been shown to be im-

portant in land pricing, and (b) the examples of previous efforts in

the construction of bid-price models. Three broad areas of research

are discussed in this review because of their relevance to the future

ownership question:

1. Statistical studies on farmland valuation.

2. General investigations pertaining to the firm-size structure

    of the farming industry.

3. Previous versions of maximum bid-price models.

Statistical Studies

Reynolds and Timmons (1969) provide a recent and comprehensive

example of a great deal of the econometric research that has been

directed to the issue of farmland values.[1] Their research was

prompted by the observation that, since the early 1950's, increases

in farmland values have outpaced the growth of net farm income.

Theirs was an attempt to explain, by means of an econometric model,

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[1]The volume of statistical land value studies is prodigious. A
good summary of this literature can be found in Walker (1976).

that portion of the increase in farmland values not explained by changes in net farm income over the period 1933 to 1965.

Reynolds and Timmons identified what they believed to be the important factors influencing farmland values and estimated the impacts of these variables. The variables which they found to be significant (most at the 5 percent level or better) in explaining farmland values over the period were: expected net farm income, government payments for land diversion, conservation payments, expected capital gains, farm enlargement, nonfarm population density, technological advance, the ratio of debt to equity, voluntary transfers of farmland, the capitalization rate, and the expected ratio of farm-to-nonfarm earnings.

While the results of the work of Reynolds and Timmons are informative in terms of many of the variables identified, their study offers no insight into individual choice theory. Their study is an ex post summarization of the operation of an entire market – the market for United States farmland.[1] Although the Reynolds and Timmons study is a thorough investigation of the results of the operation of the farmland market over an extensive time period, it does not analyze, at a single point in time, the process that might lead to those results. As such, not all of the variables identified by Reynolds and Timmons are relevant in an individual choice theoretic framework, e.g., nonfarm population density or voluntary transfers of farmland.

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[1] The values for the variables used in their regression analysis were the annual United States averages for each variable for each year in the time series.

Further, a regression analysis contributes to the comprehension of why farmland has been traded at certain prices, regardless of who paid those prices. For an analysis of the farm ownership issue however, it is necessary to develop a comparison of the willingness of various investors to own farmland as represented by the price each would offer. The farmland values that have prevailed are presumably related to the demands of the highest bidder in any particular market. A more comprehensive model would contribute to the understanding of the factors causing that particular investor to be the successful purchaser vis á vis his competitors.

Studies on the Firm-Size Structure
of the Farming Industry

The question of the future firm-size structure of the farming industry has developed what is perhaps the most voluminous popular and research literature of any area related to the future farm ownership issue. This volume is due possibly to the emotionally charged implications of this issue, particularly with reference to the viability of the "family farm".

In two separate studies, Krause and Kyle (1970, 1971) analyze various incentives to the formation of large farming units. Armstrong (1969) also identifies several sources of advantage to the acquisition of large farms. Most of the factors identified by these three studies as contributing to the attractiveness of larger farming units fall under the categories of: technical economies in

production, pecuniary economies, subsidies and tax rates, managerial

talent, nonfarm investment, specialization, and conglomeration.

Whereas all of these factors are pertinent to an investor

decision model, the three studies mentioned do not integrate them into

a single, comprehensive framework to evaluate the relative bidding

potentials of small versus large farm operators. The first study

by Krause and Kyle (1970) and the work of Armstrong serve primarily

to indicate the factors that impinge differentially on various farm-

size classes. Both studies suggest the need for further research

to analyze these factors.

The second contribution by Krause and Kyle (1971) does offer

much more in terms of the quantification and integration of several of

the advantages and disadvantages of large versus small farm operations.

Their comparisons are couched in terms of the differing rates of

return on investment obtained under various farm sizes (500, 1,000,

2,000, and 5,000 acres) considering the influence of such factors

as technical economies, buying and selling advantages, federal

income tax rates, and equity levels. A summary of a portion of the

results is presented in Table 2.1.

The results of Krause and Kyle are a valuable contribution to the

understanding of the incentives to various types of ownership. How-

ever, they are not translated into a comparison of different bidding

Table 2.1. Rate of return on investment after federal income tax
costs considered at three equity levels on corn pro-
duction units of four sizes, Corn Belt, 1969-70[a]

Percentage of equity in the business	Rate of return on investment after federal income taxes for units of:			
	500 acres	1,000 acres	2,000 acres	5,000 acres
100%	5.2%	6.0%	4.9%	5.2%
60%	5.0%	5.9%	5.6%	6.1%
30%	4.0%	6.0%	7.8%	8.3%

[a]Source: Krause and Kyle (1971), Table 17, p. 28.

potentials by the various size and equity classes.[1] Thus, no

specific or quantitative implications with respect to the future owner-

ship of farmland can be drawn from the Krause and Kyle comparisons of

rates of return on investment. An evaluation of the ownership question

requires a model to translate the relative advantages and disadvantages

of various investor classes into a measure of the willingness of the

different investors to purchase farmland. It is this translation

that is the subject of maximum bid-price models.

[1]Indeed, differences in rates of return cannot directly be con-
verted into differences in bid prices unless the investor is risk
neutral.

Previous Versions of Bid-Price
Models

The first maximum bid-price model for farmland was developed by

Harris and Nehring (1976) in response to the lack of a theoretical

framework capable of comparing the land purchasing potentials of

various investors, particularly with reference to farm-size dif-

ferences. In follow-up research, Harris and Hampel (1976)

developed a model to evaluate foreign versus domestic bidding

potentials. The Harris and Nehring model offers important insights

into the construction of a maximum bid-price model, and the Harris

and Hampel research extends the scope of the analysis. However, the

former study is somewhat limited in its applicability, while both

models encounter some difficulties because of the particular form

of their specification.

The Harris and Nehring model has as its genesis the work of

Pratt (1964). In his formulation of a measure of the degree of risk

aversion, Pratt defines the bid price as the largest amount a

decision maker would willingly pay to obtain a risky asset. This

bid price is given by the equation

$$u(x) = E[u(x + \tilde{z} - B)]^1 \qquad\qquad (2.1)$$

where x represents the level of assets held by the decision maker;

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[1] Variables that appear with a tilde are used to denote random
variables, i.e., those whose future values are not known with
certainty.

u, his utility function; E, the expected value operator; $\tilde{z}$, the

risky asset; and B, the bid price.[1] Equation 2.1 establishes the

behavioral assumption that the decision maker will pay a price for

a risky asset such that the expected utility of his resulting wealth

position is no less than the utility of his original wealth position

which did not include the risky asset. In the Harris and Nehring

analysis, x is interpreted as the certain level of net worth of the

decision maker and $\tilde{z}$ as a random variable denoting the value of an

acre of land. Thus the bid price B is the maximum amount, consistent

with the utility level associated with his original wealth position,

that the investor would be willing to pay for an acre of land.

From Equation 2.1, Harris and Nehring develop an equation

capable of analyzing the impacts of the following variables on bid

price: the investor's degree of risk aversion, the expected value and

variance of per-acre land income, the expected rate of growth of

land income, the marginal income tax rate of the decision maker,

and the investor's rate of pure time preference. The variables

included in this analysis are a function largely of the intended use

of the model, i.e., a comparison of the bidding potentials of

various farm-size classes. As such, the application of this model is

essentially limited to the calculation of maximum bid prices of

farm operators.

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[1]Equation 2.1 is as it appears in Harris and Nehring (1976).
The variable B is equivalent to π_b in Pratt's notation.

Although the Harris and Nehring model has certain deficiencies, the technique they derive to compare bidding potentials is an important contribution to the literature on the relationship between farm size and farm ownership. The nature of this contribution may best be noted by a comparison of their results with the results of other studies. A portion of the Harris and Nehring results is presented in Table 2.2. The numbers in rows 1 through 6 appear in a numerical example of the bid-price model provided by Harris and Nehring. Rows 7 and 8 were computed for the purpose of comparing the bid-price results with those of the previously discussed study by Krause and Kyle (1971). Row 7 roughly corresponds to the type of farm-size comparison made by Krause and Kyle as presented in Table 2.1, although the units of measurement differ. While Krause and Kyle computed after tax rates of return on investment for various farm sizes, row 7 presents data on the after-tax net income per acre of various farm size classes. Row 8 is computed by considering after-tax income per acre (row 7) as a growing annual income stream, and finding the present value of that stream using the same discount and expected growth rates as used in the bid-price model. Thus, row 8 may be interpreted as representing the bidding potential comparison over farm sizes that can be directly inferred from studies such as the one conducted by Krause and Kyle. A comparison of row 6 (bid price computed using the Harris and Nehring model) and row 8 (bid price imputed directly from studies reporting rates

Table 2.2. Partial summary of the numerical example in Harris and Nehring (1976)

Farm Class	0	I	II	III	IV
(1) Average Farm Size (acres)[a]	1,307	630	390	254	170
(2) Net Income Per Acre	$36.18	$39.16	$33.95	$26.67	$19.04
(3) Marginal Tax Rate	43%	32%	28%	25%	24%
(4) Discount Rate	.09082	.09082	.09082	.09082	.09082
(5) Expected Growth Rate	.04387	.04387	.04387	.04387	.04387
(6) Per-Acre Bid Price	$429	$533	$485	$403	$231
(7) After-Tax Income Per Acre[b]	$20.62	$26.62	$24.44	$20.00	$14.47
(8) Present Value of After-Tax Net Income Per Acre	$439	$567	$521	$426	$308

[a] Rows 1-6 appear in the Harris and Nehring study.

[b] Rows 7 and 8 were computed for this study.

of return) indicates the usefulness of maximum bid-price models.

The particular form of the utility function employed in the numerical example provided by Harris and Nehring exhibits decreasing risk aversion over wealth. Thus the greater degree of risk aversion characteristic of operators of small as opposed to large farms leads to a comparison of bidding potentials in row 6 which differs from that of row 8. The results of the bid-price model indicate a greater difference in the bidding potentials of small versus large farm operators than is the case when the different income streams are simply discounted. The ratio of the bids of the largest to the smallest farm size class in the Harris and Nehring example (row 6) is 1.86. The corresponding ratio for the bids imputed directly from the different after-tax income streams (row 8) is 1.42. However, the Harris and Nehring bid-price model is not initially formulated in terms of any specific utility function. Any type of risk aversion may be incorporated into an empirical specification of the model by using the appropriate utility function. If constant risk aversion over wealth had been assumed in the construction of the numerical example, rows 6 and 8 would have given similar bid-price comparisons.

The use of a bid-price model to compare the willingness of investors to purchase title to different income streams involves the recognition of an important consideration. That is, the transition from different rates of return on investment or net dollar returns

per acre to bid prices requires more than simply discounting the different income streams. Simple discounting does not take account of either: (a) the different risks associated with the different income streams, or (b) the different treatment accorded to risk by various investors. If the present value calculations of several types of investors were to be used to compare bidding potentials, a variety of discount rates reflecting risk considerations would have to be employed. This would require a separate model to determine the discount rates. However, a bid-price model operates in the context of utility maximization, and thereby can take account of such factors as risk aversion in evaluating different income streams.

As a first attempt at the development of a maximum bid-price model for farmland, the work by Harris and Nehring suffers certain important deficiencies. The model, as developed, is applicable only to comparisons of the bidding potentials of different farm operators. A more general approach to the future ownership question should be capable of considering a wider variety of potential investors in the market for farmland. Krause and Kyle (1970) suggest that conglomeration is a possible incentive for the acquisition of farming units by nonfarm operators, or at least by farming firms engaged also in nonfarm enterprises. Thus, the implications to the investor of the possible advantages of diversification resulting from the purchase of farmland should be considered in a more general model.

The model developed by Harris and Hampel reflects an attempt to generalize on the work of Harris and Nehring by incorporating the

aspect of portfolio diversification. The particular context of this study involves an attempt to compare the bidding potentials of foreign and domestic bidders for United States farmland. Since the inclusion of foreign bidders raises the possibility of nonfarm investors bidding for farmland, this second bid-price model takes explicit account of the role of diversification in the formation of an investor's maximum bid.

Harris and Hampel specify their bid-price model with the equation

$$E[u(x+\tilde{v})] = E[u(x+\tilde{v}+\tilde{z}-B)]. \tag{2.2}$$

where E, u, $\tilde{z}$, and B are as defined in the Harris and Nehring model; x represents the beginning-of-period net worth of the decision maker; and $\tilde{v}$ is the random dollar change in this net worth position over the period. The left hand side of the equation represents the utility the individual expects to derive from his original portfolio. The right hand side shows the decision maker's expected utility position if an acre of land has been added to his portfolio at the price B. The interpretation of Equation 2.2 is analogous to that of Equation 2.1.

Both of the bid-price models have shortcomings in the treatment of the financing of land purchases. In the Harris and Nehring study, land is paid for by drawing down the investor's assets. The level of the investor's assets is assumed to be certain. Further, since a rate of pure time preference is employed to determine the investor's

expectation with respect to the value of an acre of land, no opportunity cost in the form of alternate return on assets is considered in the determination of a maximum bid price.

By incorporating the role of portfolio diversification in their model, Harris and Hampel avoid the unrealistic assumption of a certain level of investor assets. However, the specification of Equation 2.2 implies that the investor will not alter his original portfolio when he purchases land at the price B, if his bid is accepted. The value of the investor's portfolio at the end of the period is represented by $(x+\tilde{v})$ in this equation. This term appears on both sides of Equation 2.2. Under this specification, it must be implicitly assumed that the amount paid to acquire land comes out of some cash fund such that the original portfolio is not altered. Although there are various possible ways for a bid-price model to treat the financing of land purchases, a more reasonable approach would be to specify the model in such a way that the investor is seen as liquidating a cross section of his original portfolio in order to add the new land asset.

A second problem with both the Harris and Nehring and Harris and Hampel models lies in the treatment of the marginal income tax rate. In both models, the expected value of an acre of land is defined by the equation

$$E(\tilde{z}) = \frac{(1-t)}{(i-g)} E(\tilde{y}) \tag{2.3}$$

where t is the investor's marginal income tax rate; $E(\tilde{y})$, expected net

farm income per acre; i, the decision maker's discount rate for pure time preference; and g, the expected rate of growth of after tax income. Both models, by recourse to Equation 2.3, lead to the conclusion that wealthy investors suffer a bidding disadvantage due to the progressivity of federal income tax rates.

Ignoring the complicating factor of the expected growth rate, g, Adams (1976) has shown that the appropriate method for discounting the perpetual income stream afforded by land ownership should be given by

$$E(\tilde{z}) = \frac{(1-t)E(\tilde{y})}{i(1-t)} = \frac{E(\tilde{y})}{i} \qquad (2.4)$$

In Adams' version of the discounting equation, the tax rate cancels; and hence larger bidders should not be at a disadvantage because of a progressive tax-rate schedule. Although a higher income bidder will probably be subject to a greater marginal tax rate than his smaller competitors, the income generating opportunities he forgoes in order to acquire land would also have been taxed at the same higher rate. The use of Equation 2.3 implies that the investor's opportunity costs of land return are not taxed. That is only the case of investor's whose entire portfolios are held in the form of tax-exempt municipal bonds or cash. Thus, as Adams demonstrates, except in the case of wealth owners who hold a portion of their portfolios in the form of municipals, different tax rates should not act as a source of differentiation in bid-price potentials.

Summary

Statistical land value studies suggest the variables that are important in land valuation. However, these studies are ex post descriptions of entire markets. As such, not all of the variables identified in econometric research on land valuation are applicable to an investor decision model. Research in the area of farm size provides insight into the different sources of incentive to owner- ship by various farm-size classes. However, this type of research does not integrate these incentives into a measure of the willingness to purchase farmland. Harris and Nehring have provided a maximum bid-price model to translate the various incentives to ownership among farm-size classes into bid prices. Harris and Hampel have extended the analysis to include a wider range of investor types. However, these bid-price models require unusual assumptions with respect to the financing of land purchases, and err in the treatment of tax rates.

A respecification of the form of the bid-price model avoids both of the problems of the previous models. In the next chapter, a maximum bid-price model is constructed in such a way that: (a) the investor is assumed to finance land purchases by the liquidation of a cross section of his original portfolio, and (b) the taxation of the investor's original portfolio income is accounted for. This second procedure is consistent with the observations of Adams.

CHAPTER III.   A MAXIMUM BID-PRICE MODEL

FOR FARMLAND

This chapter presents a general model for determining the maximum
bid price that an investor would pay for an acre of land, an analysis
of the comparative statics of the model, and some comments about the
model relative to the existing literature.

The bid price will be expressed as a function of several important
characteristics of both the investor and the land under consideration.
Such a model could therefore be used: (a) to compare the relative
bidding potentials of several investors or investor types for a given
type of land, (b) to compare the different bids of a single investor
for various land groupings, or (c) to provide a set of comparisons of
bidding potential of several investors over various land types.   The
investor and land characteristics to be incorproated in the model
include: (a) the investor's initial net worth position, (b) the
investor's expected return on original portfolio, (c) the investor's
expected net return per acre of land, (d) measures of the riskiness
of land income and portfolio return, (e) the implications of the
relationship between portfolio return and land income on portfolio
diversification, (f) the investor's degree of risk aversion, and
(g) the investor's marginal income tax rate.

The Model

The construction of the model involves comparing the decision maker's expectation of utility from income derived from original portfolio with the utility he can expect to derive from portfolio income if a portion of the original portfolio has been replaced by land. The after-tax income per period from original portfolio may be written as

$$x\tilde{k}(1-t) \tag{3.1}$$

where x represents the certain level of the investors assets at the beginning of the period; $\tilde{k}$, the random percentage return on original portfolio per period (this return is a composite of both income return and capital gains) and t, the decision maker's marginal income tax rate. If the decision maker were to purchase an acre of land by liquidating a cross section of his original portfolio, the after-tax return per period would appear as

$$[(x-b)\tilde{k} + \tilde{y}](1-t) \tag{3.2}$$

where b represents the purchase price of an acre of land, and $\tilde{y}$ is the random net dollar return per period derived from an acre of land (this return also includes capital gains).

Equating the expected utilities of 3.1 and 3.2 results in an expression for the **maximum** bid price B the investor would willingly offer for an acre of land:

$$E\{u[x\tilde{k}(1-t)]\} = E[u\{[(x-B)\tilde{k} + \tilde{y}](1-t)\}] \qquad (3.3)$$

where E denotes the expected value operator and u, the investor's utility function.

Equation 3.3 represents the equality of the expected utilities of the single-period return of the investor's two alternatives, i.e., with or without the land acquisition. In the more general multi-period case, if the two single-period returns are treated as periodic returns in perpetuity, the two expected utilities would be discounted by a risk free rate of pure time preference. The same risk free rate would be used for both streams since the utility function takes account of risk. The utility function converts the two combinations of risk and return into comparable magnitudes, the expected utilities. Therefore, the streams to be discounted would consist of the periodic expected utilities rather than the periodic returns. The investor is seen as discounting two perpetual streams of risk-adjusted expected utilities by a risk-free rate rather than discounting two income streams by a risk-adjusted rate.

The investor's maximum bid price for the multi-period case is thus given by

$$\frac{E\{u[x\tilde{k}(1-t)]\}}{i} = \frac{E[u\{[(x-B)\tilde{k} + \tilde{y}](1-t)\}]}{i} \qquad (3.4)$$

where i represents the investor's risk-free discount rate for pure time preference. However, since the discount rates cancel, the specification of the single-period case in Equation 3.3 is general.

This formulation does not explicitly take account of liquidity considerations. One of two assumptions must therefore be made: (a) liquidity considerations are not important to the investor, or perhaps more plausibly, (b) the liquidity of a cross section of the original portfolio is sufficiently similar to that of a cross section of the new portfolio with land added to make liquidity differences un-important.

Although Equation 3.3 is specified in terms of periodic returns rather than the dollar value of the investor's net worth as was the case in the previous bid-price models, the interpretation of Equation 3.3 is similar to that of Equations 2.1 and 2.2. The maximum bid price, B, represents the greatest amount a decision maker could pay for an acre of land while maintaining the expected utility level associated with his original portfolio. The present specifi-cation, however, incorporates the taxation of the investor's income from original portfolio. This leads to results consistent with the observations of Adams (1976).

In order to solve for an approximation of the maximum bid price, the function u is expanded around $\overline{xk}(1-t)$ by a Taylor expansion (Yamane, 1968, pp. 280-281) on both sides of Equation 3.3. The use of the Taylor expansion requires that B is small relative to x. Performing the expected value operation, this procedure results in the quadratic equation:

$$\frac{1}{2}(1-t)u''(a)E(\tilde{k}^2)B^2$$

$$- \{\overline{ku'}(a)-(1-t)u''(a)[E(\tilde{k}\tilde{y})+xE(\tilde{k}^2)-x\overline{k}^2]\}B$$

$$+ \frac{1}{2}(1-t)u''(a)[E(\tilde{y}^2)+2xE(\tilde{k}\tilde{y})-2x\overline{ky}] + \overline{y}u'(a) = 0. \qquad (3.5)$$

where $a = x\overline{k}(1-t)$ is the center of the Taylor expansion; $u'(a)$ and

$u''(a)$ are the first and second derivatives of the utility frunction;

and $\overline{k}$ and $\overline{y}$ are the expected values of original portfolio return and

per-acre net land income respectively.

Pratt (1964) has defined a measure of an investor's local degree

of risk aversion as

$$r(a) = - \frac{u''(a)}{u'(a)} \qquad (3.6)$$

This measure of the degree of risk aversion may be incorporated into

the model by dividing both sides of Equation 3.5 by $-u'(a)$ to give

$$\frac{1}{2}(1-t)r(a)E(\tilde{k}^2)B^2$$

$$+ \{\overline{k}-(1-t)r(a)[E(\tilde{y}\tilde{k}) + xE(\tilde{k}^2)-x\overline{k}^2]\}B$$

$$+ \frac{1}{2}(1-t)r(a)[E(\tilde{y}^2) + 2xE(\tilde{k}\tilde{y}) - 2x\overline{ky}]-\overline{y} = 0 \qquad (3.7)$$

The solution of this equation would result in an expression for

B in terms of t, $r(a)$, $\overline{k}$, $\overline{y}$, x, $E(\tilde{k}^2)$, $E(\tilde{y}^2)$ and $E(\tilde{y}\tilde{k})$. However, in

order to make the model more meaningful to the decision making process,

the last three of these variables may first be transformed.

Substituting the identities

$$E(\tilde{k}^2) = \sigma_k^2 + \bar{k}^2 \tag{3.8}$$

$$E(\tilde{y}^2) = \sigma_y^2 + \bar{y}^2 \quad \text{and} \tag{3.9}$$

$$E(\tilde{k}\tilde{y}) = \rho\sigma_k\sigma_y + \overline{ky} \tag{3.10}$$

into Equation 3.7 and simplifying results in

$$\frac{1}{2}(1-t)r(a)(\sigma_k^2+\bar{k}^2)B^2$$

$$+ [\bar{k}-(1-t)r(a)(\rho\sigma_k\sigma_y+\overline{ky} + x\sigma_k^2)]B$$

$$+ \frac{1}{2}(1-t)r(a)(\sigma_y^2+\bar{y}^2+2x\rho\sigma_k\sigma_y)-\bar{y} = 0 \tag{3.11}$$

where σ_k^2 and σ_y^2 represent the variances of original portfolio return and net per-acre land income respectively; σ_k and σ_y, the corresponding standard deviations; and ρ, the correlation coefficient between original portfolio return and net per-acre land income.

The solution of this quadratic equation yields the expressions:

$$B = \frac{\rho\sigma_k\sigma_y+\overline{ky}+x\sigma_k^2}{\sigma_k^2+\bar{k}^2} - \frac{\bar{k}}{(1-t)r(a)(\sigma_k^2+\bar{k}^2)}$$

$$\pm \frac{[\bar{k}^2+2(1-t)r(a)\phi + (1-t)^2r(a)^2\theta]^{\frac{1}{2}}}{(1-t)r(a)(\sigma_k^2+\bar{k}^2)} \tag{3.12a}$$

for $r(a) \neq 0$.[1]

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[1] Since the bid price is defined as the _largest_ amount a decision maker would willingly pay for a risky asset, the solution value for B in in Equation 3.12a requires selection of the positive square root.

$$B = \frac{\bar{y}}{\bar{k}} \quad \text{for } r(a) = 0. \tag{3.12b}$$

where

$$\phi = \sigma_k^{\,2}(\bar{y}-x\bar{k}) - \bar{k}\rho\sigma_k\sigma_y \tag{3.13}$$

$$\theta = (\rho^2-1)\sigma_k^{\,2}\sigma_y^{\,2} + x^2\sigma_k^{\,4} + 2\rho\sigma_k\sigma_y\bar{k}(\bar{y}-x\bar{k})$$

$$+ (2\bar{k}\bar{y}x-\bar{y}^2)\sigma_k^{\,2} - \sigma_y^{\,2}\bar{k}^2. \tag{3.14}$$

The maximum bid price B is now defined in terms of the preferences

of the decision maker (through the measure of the degree of risk

aversion, $r(a)$); the expected value and variance of return on the

investor's original portfolio, $\bar{k}$ and $\sigma_k^{\,2}$; the expected value and

variance of per-acre net farm income, $\bar{y}$ and $\sigma_y^{\,2}$; the correlation

coefficient between portfolio return and land income, ρ; the

investor's beginning net worth, x; and the investor's marginal income

tax rate, t. Specification of the values of these variables allows

the calculation of the maximum bid price for an acre of farmland of

any potential investor.[1]

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[1]Although the expression 3.12a leads to the determination of an
investor's maximum bid for a single acre of land, larger acreages
may be considered by multiplying $\bar{y}$ and σ_y by the appropriate number
of acres.

Comparative Statics

The actual values of the variables in the bid-price Equation 3.12 are related to the land itself and the characteristics, capabilities, and expectations of the specific decision maker in question. A qualitative evaluation of the influence of these variables on the maximum bid price for an acre of land can be carried out by taking the partial derivatives of B with respect to $\bar{y}$, σ_y, ρ, $r(a)$, σ_k, $\bar{k}$, t and x. Thus,

$$\frac{\partial B}{\partial \bar{y}} = \frac{D^{\frac{1}{2}}\bar{k}+\sigma_k^2+(1-t)r(a)[\rho\sigma_k\sigma_y\bar{k}+\sigma_k^2(\bar{k}x-\bar{y})]}{D^{\frac{1}{2}}(\sigma_k^2+\bar{k}^2)} \gtreqless 0 \qquad (3.15)$$

where $D = \bar{k}^2 + 2(1-t)r(a)\phi + (1-t)^2 r(a)^2 \theta$.[1]

The sign of $\partial B/\partial \bar{y}$ is indeterminate unless the assumption is made that

$$\bar{k}x-\bar{y} > 0 \qquad (3.16)$$

in which case $\partial B/\partial \bar{y}$ is positive in sign. Inequality 3.16 represents the difference between total expected portfolio return per period and expected net per acre land income per period. Since it was assumed that x is large relative to B in order to take a Taylor expansion, the assumption in 3.16 is plausible.

---

[1] Requiring the solution for $\bar{B}$ to be real causes the sign of D to be positive. Further ϕ and θ are defined by Equations 3.13 and 3.14 respectively.

$$\frac{\partial B}{\partial \sigma_y} = \frac{\rho \sigma_k (D^{\frac{1}{2}} - \bar{k})}{D^{\frac{1}{2}} (\sigma_k^2 + \bar{k}^2)} \qquad (3.17)$$

$$+ \frac{(1-t) r(a) [(\rho^2 - 1) \sigma_k^2 \sigma_y + \rho \sigma_k \bar{k}(\bar{y} - x\bar{k}) - \sigma_y \bar{k}^2]}{D^{\frac{1}{2}} (\sigma_k^2 + \bar{k}^2)} \gtrless 0$$

Assuming 3.16, the sign of $\partial B / \partial \sigma_y$ hinges on the signs of ρ and

$(D^{1/2} - \bar{k})$. Under reasonable assumptions about the sizes of the

variables in the model, it may be concluded that

$$(D^{\frac{1}{2}} - \bar{k}) < 0. \text{[1]} \qquad (3.18)$$

Thus, assuming 3.16 and 3.18, the sign of $\partial B / \partial \sigma_y$ is negative.

$$\frac{\partial B}{\partial \rho} = \sigma_k \sigma_y \left[\frac{(D^{\frac{1}{2}} - \bar{k}) + (1-t) r(a) (\bar{k}(\bar{y} - x\bar{k}) + \rho \sigma_k \sigma_y)}{D^{\frac{1}{2}} (\sigma_k^2 + \bar{k}^2)} \right] \gtrless 0 \qquad (3.19)$$

The assumptions in 3.16 and 3.18 contribute to the possibility that

$\partial B / \partial \rho$ is negative in sign. However, even under these assumptions,

$\partial B / \partial \rho$ is ambiguous.

$$\frac{\partial B}{\partial r(a)} = \frac{(\bar{k} - D^{\frac{1}{2}})}{(1-t) r(a)^2 (\sigma_k^2 + \bar{k}^2)} + \frac{\phi + (1-t) r(a) \theta}{D^{\frac{1}{2}} r(a) (\sigma_k^2 + \bar{k}^2)} \gtrless 0 \qquad (3.20)$$

---

[1] $D^{1/2}$ will be less than $\bar{k}$ if $2(1-t) r(a) \phi + (1-t)^2 r(a)^2 \theta < 0$.
If $0 < \rho < 1$, then $\phi < 0$. The sign of θ is indeterminate; however,
$r(a)^2$ is very small. Thus, if $0 \leq \rho \leq 1$ and $r(a)^2$ is sufficiently small,
then $(D^{1/2} - \bar{k}) < 0$.

Under the Assumption 3.18, the sign of the first term in $\partial B/\partial r(a)$

is positive and that of the second term is negative.

$$\frac{\partial B}{\partial \sigma_k} = \frac{\rho\sigma_y(\bar{k}^2-\sigma_k^{\ 2})+2\sigma_k\bar{k}(x\bar{k}-\bar{y})}{(\sigma_k^{\ 2}+\bar{k}^2)^2}$$

$$+ \frac{2\sigma_k(\bar{k}-D^2) + \frac{1}{2}D^{-\frac{1}{2}}\partial D/\partial\sigma_k(\sigma_k^{\ 2}+\bar{k}^2)}{(1-t)r(a)(\sigma_k^{\ 2}+\bar{k}^2)^2} \gtrless 0 \; . \qquad (3.21)$$

where

$$\frac{\partial D}{\partial \sigma_k} = 2(1-t)r(a)\{2\sigma_k(\bar{y}-x\bar{k})-\bar{k}\rho\sigma_y$$

$$+ (1-t)r(a)[\sigma_k(2x^2\sigma_k^{\ 2}+(\rho^2-1)\sigma_y^{\ 2}+2\bar{k}\ \bar{y}x-\bar{y}^2)$$

$$+ \rho\sigma_y\bar{k}(\bar{y}-x\bar{k})]\}$$

The sign of $\partial D/\partial\sigma_k$ is indeterminate. However, all other terms in

$\partial B/\partial\sigma_k$ are positive under Assumptions 3.16 and 3.18, increasing

the possibility that $\partial B/\partial\sigma_k$ is positive in sign.[1]

$$\frac{\partial B}{\partial \bar{k}} = \frac{\sigma_k^{\ 2}(\bar{y}-2x\bar{k})-\bar{y}\bar{k}^2-2\rho\sigma_k\sigma_y\bar{k}}{(\sigma_k^{\ 2}+\bar{k}^2)^2} + \frac{\frac{1}{2}D^{-\frac{1}{2}}\partial D/\partial\bar{k}-1}{(1-t)r(a)(\sigma_k^{\ 2}+\bar{k}^2)}$$

$$+ \frac{(\bar{k}-D^2)(r'(a)x(1-t)(\sigma_k^{\ 2}+\bar{k}^2)+2r(a)\bar{k})}{(1-t)r(a)^2(\sigma^2+\bar{k}^2)^2} \gtrless 0 \qquad (3.22)$$

---

[1]This of course assumes that expected portfolio return, $\bar{k}$, is greater than its standard deviation, σ_k.

where

$$\frac{\partial D}{\partial \bar{k}} = 2\{\bar{k}+(1-t)^2 r'(a)x(\phi+(1-t)r(a)\theta)$$

$$+ (1-t)r(a)[(1-t)r(a)(\rho\sigma_k\sigma_y(\bar{y}-2x\bar{k}) + \bar{y}x\sigma_k^2-\sigma_y^2\bar{k})$$

$$- \rho\sigma_k\sigma_y-x\sigma_k^2]\}$$

The sign of $\partial D/\partial\bar{k}$ is indeterminate. The first term of $\partial B/\partial\bar{k}$ is negative in sign by Assumption 3.16, the second is indeterminate, and the sign of the last term depends on the sign of $r'(a)$. Given Assumption 3.18, the sign of the third term of Equation 3.22 is indeterminate or positive according to whether $r'(a)<0$ (decreasing risk aversion over wealth) or $r'(a) \geq 0$ (increasing or constant risk aversion over wealth).

$$\frac{\partial B}{\partial t} = \frac{[r(a)+ar'(a)][D^{\frac{1}{2}}-\bar{k}-D^{\frac{1}{2}}((1-t)r(a)\phi+(1-t)^2 r(a)^2\theta)]}{(1-t)^2 r(a)^2 (\sigma_k^2+\bar{k}^2)} \gtrless 0 \quad (3.23)$$

Given Assumption 3.18, the sign of $\partial B/\partial t$ is in general ambiguous.[1]

$$\frac{\partial B}{\partial x} = \frac{r'(a)\bar{k}[(k-D^2)+D^{-\frac{1}{2}}(1-t)r(a)(\phi+(1-t)r(a)\theta)]}{r(a)^2(\sigma_k^2+\bar{k}^2)}$$

$$+ \frac{D^{-\frac{1}{2}}[(1-t)r(a)(x\sigma_k^4-\rho\sigma_k\sigma_y\bar{k}^2+\bar{ky}\sigma_k^2)-\bar{k}\sigma_k^2]+\sigma_k^2}{(\sigma_k^2+\bar{k}^2)} \gtrless 0 \quad (3.24)$$

---

[1] In the special case of a Cobb-Douglas utility function of the form $u(a) = \alpha a^\beta$, where $0<\beta<1$, $\partial B/\partial t$ is zero since $r(a) + ar'(a) = 0$.

Both terms of $\partial B/\partial x$ are indeterminate in sign.

The conclusions to be drawn from the comparative statics analysis are minimal. Each partial derivative is formally ambiguous. However, under reasonable assumptions about the sizes of the variables in the model, the signs of $\partial B/\partial \bar{y}$ and $\partial B/\partial \sigma_y$ may be established as positive and negative respectively. Investors with the highest expected net income per acre and the lowest variability of that income will be favored in the bidding process. These same assumptions lend weight to the possibility that $\partial B/\partial \sigma_k$ is positive in sign and $\partial B/\partial \rho$ is negative. The conclusion may be made that a bidding advantage will possibly accrue to investors whose original portfolio returns have the greatest variability and are the least correlated with land income. However, nothing can be said about the signs of $\partial B/\partial r(a)$, $\partial B/\partial \bar{k}$, $\partial B/\partial t^1$ and $\partial B/\partial x$, even by recourse to the assumptions 3.16 and 3.18. Thus, the impacts of the investor's degree of risk aversion, expected portfolio return, marginal tax rate and net·worth on his maximum bid cannot be ascertained without further information.

Comments on the Model

Inspection of Equations 3.12a and 3.12b suggests two imporatnt observations with respect to the previous literature on the future ownership of farmland. In the first instance, and as recognized in

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[1]Except of course that $\partial B/\partial t = 0$ with a Cobb-Douglas utility function.

the development of previous bid-price models, the relationship between

the per-acre return an investor can expect from farmland and his

willingness to purchase that land as reflected in a maximum

bid price is by no means simple except in the case of a zero degree

of risk aversion (Equation 3.12b). Since it is plausible to

expect that most investors have some reaction to risk, a bid-

price model taking account of risk aversion (Equation 3.12a) contributes

to the ability to compare bidding potentials.

Secondly, the effect of the tax rate is rather difficult to

explore in the case of a nonzero degree of risk aversion unless the

investor's preferences may be described by a Cobb-Douglas utility

function. In that special case, changes in the tax rate do not

affect the bid price. This neutral effect of income taxes is consistent

with the findings of Adams (1976).

In the case of a nonzero degree of risk aversion, the tax

effect is more straightforward. As given in Equation (3.12b), the

investor's marginal income tax rate does not appear in the calculation

of the bid price. In the absence of risk aversion, the bid price is

the value of the stream of expected land income, discounted at the

investor's expected opportunity cost in terms of the return available

on original portfolio. A high-income bidder's after tax income from

land will be less than that of a low-income bidder due to the

progressive structure of federal income tax rates. However, by

purchasing land, the high income bidder is forgoing some payment

of taxes at the same higher rate on his alternative sources of asset

income, i.e., original portfolio return.

Thus, if investors are risk neutral, the progressivity of income

tax rates lends no bidding advantage to low-income bidders unless

high-income bidders hold a portion of their portfolios in the form

of tax-exempt municipal bonds. Even if this is the case, we might

expect that the gross-of-tax return on a portfolio containing

municipal bonds might be lower than the gross-of-tax return on a

portfolio without municipals. This is due to the typically

lower yields found on municipals compared to comparable investments

because of the tax exempt status of municipal securities.

Summary

The specification of the model in Equation 3.3 is derived from

the previously cited bid-price models of Harris and Nehring and Harris

and Hampel. However, in the present formulation, the taxation of

the opportunity costs of land acquisition is accounted for and the

investor is assumed to finance the land purchase by the liquidation of

a cross section of his original portfolio. The specification of the

variables relating to investor and land characteristics in Equations

3.12a or 3.12b allows the calculation of an investor's maximum bid-

price for an acre of land.

On wholly a priori grounds, the qualitative implications of the

model are ambiguous. Reasonable empirical assumptions shed some

light on the comparative statics analysis, but even with these

assumptions a great deal of ambiguity remains. Therefore, a numerical

specification of the model is necessary to gain further insight into the relationships between the maximum bid price and the variables of the model. The next chapter presents, in part, an "empirical comparative statics" procedure, the results of which will not be as general as those of a more traditional comparative statics approach. However, the results of the empirical application will allow the formation of some tentative conclusions not possible with the usual qualitative analysis.

CHAPTER IV. A NUMERICAL SPECIFICATION

OF THE MODEL

This chapter presents a numerical example of the solution of the

maximum bid-price model developed in the preceding chapter. The purpose

of the numerical analysis is to gain an understanding of the relationship

between each variable of the model and the bid price.

The maximum bid-price equation, Equation 3.12a, is solved with

representative or typical values of the variables of the model. The

impact of the variables on the bid-price is then ascertained by iterating

each variable around its typical value and noting the resultant change

in the bid-price solution. This "empirical comparative statics" procedure

serves as a reasonable if not perfect substitute for the more traditional

type of qualitative analysis. The results of this numerical analysis

will not be completely general. However, such results do aid in the

understanding of bid-price determination since the comparative statics

section of the preceding chapter demonstrates that unambiguous general

conclusions do not exist.

Data Sources

The numerical analysis in this study is presented as an example

rather than as a test of the bid-price model. However, because any

conclusions drawn from a numerical specification of the model must be

regarded as possibly unique to that particular specification, a close

correspondence between the data employed and an actual land acquisition

process is desirable. Therefore, the gathering of data for this study was directed, inasmuch as was practicable, to the context of an investor considering the purchase of an acre of farmland in Iowa in 1970. Various data sources were used in an attempt to describe the situation confronted by such an investor. The solution of Equation 3.12a required estimates for $\bar{y}$, σ_y, $\bar{k}$, σ_k, ρ, x, t, and $r(a)$.

Expectation and variability of net farm income

The expected value and standard deviation of per-acre net farm income, $\bar{y}$ and σ_y, were derived from an annual time series constructed for 1965 to 1969. Net farm income per Iowa farm for each year in the time series was obtained from the Farm Income Supplement to the 1971 Farm Income Situation. These income levels were divided by the average number of acres per farm as found in the 1966, 1968 and 1969 issues of the Iowa Annual Farm Census to provide a time series of per-acre net farm income. On this basis, $\bar{y}$ was estimated at $31.55 per acre with a σ_y of $3.94.

Expectation and variability of portfolio return

In order to arrive at estimates for the expected value and standard deviation of the rate of return on the investor's portfolio, $\bar{k}$ and σ_k, it was necessary to construct a hypothetical portfolio. The investors portfolio was assumed to be equally divided among long-term United States government securities, corporate bonds, preferred stock, and common stock. The expected value and standard deviation of the rate

of return on portfolio were estimated from a 1965 to 1969 time series

of overall portfolio returns computed from data on the yields of the

components of the portfolio obtained from the June, 1970 issue of the

Federal Reserve Bulletin. This procedure resulted in estimates for $\bar{k}$

and σ_k of 5.586% and 0.64% respectively.

Correlation coefficient

The correlation coefficient between portfolio return and net farm

income per acre, ρ, was estimated from the 1965 to 1969 time series

constructed for per-acre net income and portfolio return. This esti-

mate for ρ is 0.527.[1]

Net worth

A measure of the investor's beginning-of-period net worth, x,

was chosen on the basis of data reported in the study by Harris and

Nehring (1976). Using the five farm-size categories of the 1969

Census of Agriculture, Harris and Nehring calculated an average net

worth for each of the farm-size classes. The levels of net worth

reported were $234,167 for class 0, $117,489 for class I, $99,953 for

class II, $98,568 for class III, and $47,616 for class IV. Since

seventy percent of all Iowa farms fell into classes I, II, and III;

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[1]The use of these estimates for $\bar{k}$, σ_k, and ρ implies that the in-
vestor owns no land, i.e., the decision maker is probably not a farm
operator. However, iteration analysis may be used to consider different
values for these variables. Further, these values represent the lower
limit of the opportunity cost of land acquisition to a land owner with
knowledge of the capital markets.

and since application of the present model is not restricted to investor's who are farm operators; a net worth of $100,000 was selected for the numerical application of this study. Thus, the investor envisaged here represents the bulk of the Iowa farming sector, or he could be any individual with a net worth of approximately $100,000.

Marginal tax rate

The investor's marginal income tax rate, t, was likewise deduced from data reported in the Harris and Nehring study. They reported marginal income tax rates of 43% for class 0, 32% for class I, 28% for class II, 25% for class III, and 24% for class IV. For reasons similar to those which led to the selection of the net worth figure, a marginal income tax rate of 30% has been used in this study.

Risk aversion

A measure of the investor's degree of risk aversion, r(a), requires the estimation of the parameters of the investor's utility function. As Harris and Nehring note, few studies have reported the estimation of utility functions for farm operators. The notable exception is the study by Lin, Dean and Moore (1974), in which the utility functions of six large-scale California farmers were estimated. Three of these estimated functions are quadratic and are characterized by varying degrees of risk aversion. Three utility functions of California farmers cannot be considered representative of farm and nonfarm investors in the market for Iowa farmland. However, lacking anything

better, for this study the measure of the degree of risk aversion was derived from that quadratic utility function reported by Lin, Dean, and Moore which exhibits neither the highest or the lowest degree of risk aversion:

$$u(A) = 70.01 + 1.30A - 0.0064A^2, \quad R^2 = .98 \qquad (4.1)$$

where A represents the investor's after-tax income from original portfolio measured in thousands of dollars. The risk-aversion function was derived by solving Equation 3.6 with the first and second derivatives of Equation 4.1 to give

$$r(A) = \frac{0.0128}{1.3 - 0.0128A} \qquad (4.2)$$

In order to explore the impact of the form of the utility function on the relationships between the bid price and the other variables of the model, a Cobb-Douglas utility function was also employed. In an attempt to isolate the role only of the mathematical form rather than the position of the utility function, a Cobb-Douglas function was fitted to the scatter of points generated by varying after-tax income from \$1,000 to \$200,000 in Equation 4.1. This procedure resulted in the utility function:

$$u(A) = 19.267A^{0.5895}, \quad R^2 = .99 \qquad (4.3)$$

The corresponding risk-aversion function is given by

$$r(A) = 0.4105A^{-1} \qquad (4.4)$$

Both utility functions exhibit risk aversion over the entire range. However, the quadratic form is characterized by increasing risk aversion over income $(r'(A)>0)$, and the Cobb-Douglas function has the property of decreasing risk aversion over income $(r'(A)<0)$.[1]

The Impacts of Investor and Land Characteristics on Bid Price

In order to explore the relationships between the variables of the model and the investor's maximum bid price for an acre of land, the bid-price equation derived in the previous chapter, Equation 3.12a, was solved using initially the values of the variables discussed in the previous section. A solution for the bid price was obtained using both the Cobb-Douglas form of the utility function, Equation 4.3, and the quadratic form, Equation 4.1. The bid-price solution was $566.10 with the Cobb-Douglas utility function and $564.93 using the quadratic version. The risk-neutral bid price for the same data set, obtained from Equation 3.12b, was $564.80.

After obtaining these solutions for the investor's maximum bid price, series of bid-price solutions were obtained by iterating each variable from below to above its initial value. As each variable ranged about its initial value, all other variables remained fixed at

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[1]Again, although the parameters of these utility functions describe the preferences of a single California farmer, a wide variety of utility functions may be generated from these forms by iteration.

their initial values. Summaries of the effects of these iterations on

the bid price are presented in Table 4.1 for the Cobb-Douglas case and

Table 4.2 for the quadratic case. In each table, the values for the

variables discussed previously in the data sources section are listed

under the "Initial value" column.

Since the values of the risk-aversion functions depend upon the

values of x, $\bar{k}$, and t, it was not possible to directly vary the value

of $r(A)$ in rows 8 of Tables 4.1 and 4.2. However, given a Cobb-Douglas

utility function of the form

$$u(A) = \alpha A^{\beta}, \quad 0 < \beta < 1 \tag{4.5}$$

and a corresponding risk-aversion function:

$$r(A) = (1-\beta)A^{-1} \tag{4.6}$$

the range of values for $r(A)$ reported in Table 4.1 was computed by

iterating β from 0.9 to 0.1. This shows the effect on the bid price

of an increase in risk aversion since in Equation 4.6 $r(A)$ is

inversely related to β. Similarly, given a quadratic utility function

of the form

$$u(A) = \gamma + \alpha' A - \beta' A^{2} \tag{4.7}$$

with

$$r(A) = \frac{2\beta'}{\alpha' - 2\beta' A} \tag{4.8}$$

the range of values for $r(A)$ reported in Table 4.2 is the result of

Table 4.1. Summary of iteration results, Cobb-Douglas utility function[a]

Variable	Initial value	Range of iteration	Range of bid price (dollars per acre)	Percentage change in bid price
(1) Portfolio return, $\bar{k}$ (percent)	5.586	2.0 to 10.0	1,632.04 to 315.48	-80.070
(2) Net land income, $\bar{y}$ (dollars per acre)	31.55	20.0 to 80.0	358.21 to 1,438.11	301.471
(3) Variability of portfolio return, σ_k (percent)	0.64	0 to 3.0	564.79 to 631.13	11.746
(4) Variability of land income, σ_y (dollars per acre)	3.94	0 to 25.0	567.86 to 556.35	-2.027
(5) Correlation coefficient, ρ	0.52	-1 to 1	571.16 to 564.53	-1.161
(6) Net worth, x (1,000 dollars)	100	50 to 500	566.09 to 566.11	0.004
(7) Marginal tax rate, t (percent)	30	10 to 90	566.10 to 566.10	0
(8) Risk aversion, r(A)	0.10498[b]	0.02557 to 0.23017[c]	565.12 to 567.66	0.449

[a]Where $u(A) = \alpha A^{\beta}$.

[b]Given the initial values: $\alpha = 19.267$, $\beta = 0.5895$.

[c]These values were derived by varying β from 0.9 to 0.1.

Table 4.2. Summary of iteration results, quadratic utility function[a]

Variable	Initial value	Range of iteration	Range of bid price (dollars per acre)	Percentage change in bid price
(1) Portfolio return, $\bar{k}$ (percent)	5.586	2.0 to 10.0	1,579.28 to 315.50	-80.023
(2) Net land income, $\bar{y}$ (dollars per acre)	31.55	20.0 to 80.0	385.05 to 1,432.73	272.089
(3) Variability of portfolio return, σ_k (percent)	0.64	0 to 3.0	564.80 to 570.58	1.023
(4) Variability of land income, σ_y (dollars per acre)	3.94	0 to 25.0	565.10 to 563.98	-0.198
(5) Correlation coefficient, ρ	0.527	-1 to 1	565.42 to 564.78	-0.113
(6) Net worth, x (1,000 dollars)	100	50 to 500	564.87 to 565.56	0.112
(7) Marginal tax rate, t (percent)	30	10 to 90	564.97 to 564.82	-0.027
(8) Risk aversion, r(A)	0.01024[b]	0.00155 to 0.01464[c]	564.82 to 644.98	0.028

[a]Where $u(A) = \gamma + \alpha'A - \beta'A^2$.

[b]Given the initial values: $\alpha' = 1.3$, $\beta' = 0.0064$.

[c]These values were derived by varying β' from 0.001 to 0.009.

iterating β' from 0.001 to 0.009. This β'-iteration also represents

an increasing degree of risk aversion.

The iteration results summarized in Tables 4.1 and 4.2 indicate

that, using either the Cobb-Douglas on the quadratic utility function,

the bid price is positively related to: (a) the investor's expec-

tation of net per-acre land income, $\bar{y}$; (b) the variability of portfolio

return, σ_k; (c) the investor's net worth, x; and (d) the investor's

degree of risk aversion, r(A). Under the same conditions, the bid-

price is negatively related to: (a) the investor's expectation of

portfolio return, $\bar{k}$; (b) the variability of net per-acre land income,

σ_y; and (c) the correlation coefficient between land income and

portfolio return, ρ. As previously noted, the investor's marginal

income tax rate, t, has no effect on bid-price if his preferences

are described by a Cobb-Douglas utility function. The bid-price is

inversely related to the tax rate if the quadratic utility function

is used to represent investor preferences.

A comparison of the results in Tables 4.1 and 4.2 reveals that

the form of the utility function employed in the bid-price solution

can have a noticeable effect on the results of the iteration analysis.

Since the Cobb-Douglas utility function was derived by fitting a power-

function form to the scatter of points generated by varying the income

level in the quadratic utility function reported by Lin, Dean, and

Moore; the two estimated utility functions trace out essentially the

same curve in income-utility space over the relevant range.[1] Thus, the results in Tables 4.1 and 4.2 differ chiefly because of the form rather than the position of the utility function. In addition to the differing results in terms of the impact of the marginal tax rate, the use of the Cobb-Douglas utility function results in a greater measure of the degree of risk aversion, r(A), than does the quadratic form. The initial value of r(A) using the Cobb-Douglas function was 0.10498. The corresponding figure when the quadratic form was substituted was 0.01024. This difference in the size of r(A), for a given level of its arguments, helps to explain why the iteration results of the risk-related variables show a greater impact on bid price in Table 4.1 (Cobb-Douglas) than in Table 4.2 (quadratic). The percentage changes in the bid price that result from the same iterations for σ_k, σ_y, and ρ under the two utility functions are greater when the Cobb-Douglas form is used.

The only variable which shows a stronger impact on the bid price using the quadratic as opposed to the Cobb-Douglas utility function is the investor's net worth, x. This result stems from the fact that a quadratic utility function exhibits increasing risk aversion over income (r'(A)>0), and a Cobb-Douglas function has the property of decreasing risk aversion over income (r'(A)<0). Thus, since the

[1]Recall that Lin, Dean, and Moore reported an R^2 of 0.98 for the fit of the quadratic function to the original data and the R^2 for the Cobb-Douglas fit to the Lin, Dean, and Moore function was 0.99.

investor's after-tax income is given by $a = \overline{x}\overline{k}(1-t)$, with the quadratic

utility function, as x is increased from \$50,000 to \$500,000, the

degree of risk aversion increases. The same x-iteration leads to a

reduction in the degree of risk aversion in the Cobb-Douglas case.

A careful inspection of the results appearing in Tables 4.1 and

4.2 reveals that they represent a special case in terms of the risk

relationships of portfolio return and land income. At the initial

values of the variables of the model, it is apparent that the addition

of an acre of land to the investor's portfolio reduces his risk

exposure. With either utility function, an increase in the investor's

degree of risk aversion (row 8 in both tables) led to an increase in

the bid price. Rows 6 and 7 of Table 4.2 indicate that an increase

in net worth or a decrease in the tax rate, both of which imply an

increase in risk aversion when the quadratic utility function is used,

also resulted in increased bid prices for land. Further, it may be

recalled that, given the initial values for all variables of the

model, the two bid-price solutions corresponding to the two utility

functions both exceeded the risk-neutral bid price. There is no

reason to believe that the addition to the investor's portfolio of an

acre of land might not, under different conditions, increase the

overall risk exposure of the investor and thus reduce the bid price.

The effect on the investor's risk exposure of the substitution of an

acre of land for a cross section of the original portfolio depends

on the values of $\overline{k}$, σ_k, $\overline{y}$, σ_y, and ρ. Therefore, in order to

construct a more general example, the variables of the model were

varied two at a time. This pairwise iteration procedure allows an investigation of the impact on bid price of one of the variables under varying conditions in terms of another variable.

The results of the pairwise iterations are summarized in Tables 4.3 and 4.4 corresponding to the Cobb-Douglas and quadratic utility functions respectively. These tables present the percentage changes in bid price that resulted from iterating two variables at a time around their initial values. As each pair of variables was made to move over a specified range, all other variables were fixed at their initial values. As was the case for the single iterations, the β and β' parameters of the two utility functions were varied in a manner which simulates an increasing level of risk aversion. Thus, for example, the information contained in the third row of the second column of Table 4.3 indicates that with a Cobb-Douglas utility function, and with all variables other than σ_k and $\bar{y}$ fixed at their initial values, the following results were found: (a) if $\bar{y}$ was set at $10, as σ_k was varied from 0% to 3% the bid price increased by 8.234%, (b) if, however, $\bar{y}$ was set at $80, the bid price showed an increase of 12.664% as σ_k varied from 0% to 3%.

The information reported in Tables 4.3 and 4.4 allows a more thorough analysis of the impact of each variable on bid price than do the results of the single iteration procedure reported in Tables 4.1 and 4.2. Each row in Tables 4.3 and 4.4 shows the effect on bid price of iterating one of the variables over the indicated range given differing conditions in terms of each of the other variables.

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Table 4.3. Percentage changes in bid price for pairwise iterations, Cobb-Douglas uti[

	Given the values:									
	$\bar{k}$		$\bar{y}$		σ_k		σ_y		ρ	
	1%	11%	$10	$80	0%	3%	$0	$25	-1	1
$\bar{k}$ 1% to 11%			-92.023	-92.307	-90.908	-99.779	-92.396	-91.549	-92.605	-92.17
$\bar{y}$ $10 to $80	733.202	703.522			700.034	732.779	699.961	748.047	687.262	713.22
σ_k 0% to 3%	4118.757	2.385	8.234	12.664			13.380	3.001	16.479	10.28
σ_y $0 to $25	-10.952	-1.034	-6.417	-0.792	-0.073	-9.220			3.631	-3.77
ρ -1 to 1	-6.083	-0.594	-3.633	-0.455	0	-5.322	0	-7.151		
x^a $50 to $450	0.601	0.003	0.006	0.005	0.004	0.065	0.002	0.115	0.012	0
t 10% to 90%	0	0	0	0	0	0	0	0	0	0
β 0.9 to 0.1	44.548	-0.035	-0.878	0.816	-0.004	27.281	1.059	-2.950	2.204	-0.09

[a] In thousands.

.ons, Cobb-Douglas utility function

values:

	ρ		x^a		t		β	
$25	-1	1	$50	$450	10%	90%	0.9	0.1
-91.549	-92.605	-92.172	-92.254	-92.300	-92.280	-92.280	-91.240	-93.942
748.047	687.262	713.224	706.907	706.901	706.930	706.930	701.655	715.356
3.001	16.479	10.280	11.707	11.776	11.746	11.746	2.599	30.240
	3.631	-3.779	-2.089	-1.976	-2.027	-2.027	-0.495	-4.442
-7.151			-1.154	-1.166	-1.161	-1.161	-0.284	-2.528
0.115	0.012	0			0.004	0.004	0	0.005
0	0	0	0	0			0	0
-2.950	2.204	-0.096	0.446	0.451	0.449	0.449		

Table 4.4. Percentage changes in bid price for pariwise iterations, quadratic utilit

		Given the values:								
		$\bar{k}$		$\bar{y}$		σ_k		σ_y		ρ	
		1%	11%	$10	$80	0%	3%	$0	$25	-1	]
$\bar{k}$	1% to 11%			-90.933	-90.932	-90.909	-91.416	-90.932	-90.934	-90.931	-90.
$\bar{y}$	$10 to $80	700.566	700.727			699.994	703.084	700.011	704.422	698.718	701.
σ_k	0% to 3%	6.420	0.464	0.715	1.104			1.167	0.262	1.436	0.
σ_y	$0 to $25	-0.186	-0.206	-0.625	-0.077	-0.007	-0.901			0.354	-0
ρ	-1 to 1	-0.107	-0.118	-0.362	-0.045	0	-0.532	0	-0.719		
x^a	$50 to $450	1.063	-0.021	-0.201	0.193	0	5.120	0.250	-0.664	0.522	-0
t	10% to 90%	-0.288	0.007	0.050	-0.047	0	-1.179	-0.060	0.169	-0.127	0
β'	0.001 to 0.009	0.317	-0.007	-0.056	0.052	0	1.313	0.067	-0.186	0.140	-0

[a]In thousands.

iterations, quadratic utility function

Given the values:

σ_y $0	σ_y $25	ρ -1	ρ 1	x^a $50	x^a $450	t 10%	t 90%	β' 0.001	β' 0.009
-90.932	-90.934	-90.931	-90.932	-90.921	-91.017	-90.939	-90.912	-90.654	-90.942
700.011	704.422	698.718	701.264	700.330	703.493	700.861	700.084	700.089	700.950
1.167	0.262	1.436	0.896	0.498	5.643	1.335	0.140	0.154	1.470
		0.354	-0.368	-0.099	-1.010	-0.257	-0.028	-0.030	-0.283
0	-0.719			-0.057	-0.599	-0.149	-0.016	-0.018	-0.163
0.250	-0.664	0.522	-0.023			0.147	0.012	0.014	0.165
-0.060	0.169	-0.127	0.005	-0.012	-0.147			-0.004	-0.037
0.067	-0.186	0.140	-0.005	0.014	0.165	0.037	0.004		

In many cases, the intensity and direction of the impact of a variable on bid price was found to depend on the form of the utility function and on the values of the other variables of the model.

Expected portfolio return

The iteration from 1% to 11% of the investor's expectation of the rate of return on portfolio, $\bar{k}$, represents a change in the expected opportunity cost of land acquisition. This increase in $\bar{k}$ had a potent negative impact on bid price regardless of either the form of the utility function or the values of the other variables of the model.

Expected net income from land

The iteration from $10 to $80 of the investor's expectation of net per-acre land income had a strong positive effect on bid price regardless of the form of the utility function or the values of the other variables of the model.

Variability of portfolio return

The impact on bid price of varying the standard deviation of portfolio return, σ_k, was positive under all conditions. However, the size of the percentage change in bid price resulting from the σ_k-iteration depended on the form of the utility function used, and on the levels of the other variables. In general, the impact of varying σ_k on bid-price was greater in the Cobb-Douglas case (Table 4.3) than in the quadratic case (Table 4.4). A similar result was noted in the discussion of the single iteration procedure.

Using the Cobb-Douglas utility function, the effect on bid price of a _ceteris paribus_ increase in σ_k from 0% to 3% was:

a) stronger with $\bar{k}$ set at 1% than with $\bar{k}$ set at 11%. For a given range of iteration of σ_k, the lower the value of $\bar{k}$, the greater is the change in the riskiness of portfolio return implied by that σ_k-iteration. Thus, the strength of the impact of a given iteration of σ_k on bid price varies inversely with the value of $\bar{k}$.

b) stronger when $\bar{y}$ was set at $80 than when $\bar{y}$ was $10. For a given increase in σ_k, the lower the relative riskiness of land income, the greater is the impact of the increase in σ_k on bid price. Since the pairwise iterations of σ_k and $\bar{y}$ were performed with σ_y set at its initial value of $3.94, the higher value of $\bar{y}$ implies a lower coefficient of variation for land income. Thus, increasing the value of $\bar{y}$ strengthens the impact of σ_k on bid price.

c) stronger when σ_y was set at $0 than when σ_y was set equal to $25. The greater the coefficient of variation for net land income, i.e., the larger the value of σ_y with $\bar{y}$ fixed, the weaker is the impact of σ_k on bid price.

d) stronger with ρ equal to -1 than with ρ equal to 1. With $\bar{y}$ and σ_y set at their initial values, an increase in the correlation coefficient lessens the ability of a land acquisition to reduce the overall risk exposure of the investor. Therefore, the effect on the σ_k-iteration of an

increase in ρ is analogous to the effect of an increase in

the relative riskiness of land income. Increasing the value

of ρ reduces the impact on bid price of a change in σ_k.

e)   about the same when x was \$50,000 as when x was \$450,000.

f)   unaffected by changing the value of t.

f)   stronger with a β of 0.1 than with a β of 0.9. The greater

the investor's degree of risk aversion, the stronger is his

reaction to an increase in σ_k.

The corresponding results of varying σ_k using the quadratic utility

function were similar to Cobb-Douglas case except for the impacts of

net worth and the tax rate. Using the quadratic utility function,

the effect on bid price of increasing σ_k rom 0% to 3% was:

a)   stronger with x equal to \$450,000 than with x equal to

\$50,000. Since the quadratic form of the utility function

implies that the investor is increasingly risk averse over

income, he reacts more sharply to increased portfolio risk

at high as opposed to low net worth levels.

b)   stronger with t set at 10% than with t set at 90%. Since the

investor's after-tax income is inversely related to the tax

rate, and risk aversion is directly related to after-tax

income, the investor's degree of risk aversion and his marginal

tax rate are inversely related. Thus, increasing t reduces the

investor's response to the increase in σ_k.

Variability of per-acre net farm income

The effect on bid price of increasing the standard deviation of net land income, σ_y, was negative under all conditions except when the correlation coefficient was negative. Using the Cobb-Douglas form of the utility function, the impact on bid price of a _ceteris paribus_ increase in σ_y from $0 to $25 was:

a) stronger with $\bar{k}$ equal to 1% than with $\bar{k}$ equal to 11%. Since σ_k was fixed as its initial value of 0.64% during the pairwise iteration of σ_y and $\bar{k}$, the lower value of $\bar{k}$ corresponds to a greater coefficient of variation for portfolio return. The investor's response to an increase in σ_y is more intense, the lower the value of $\bar{k}$, i.e., the greater the relative riskiness of portfolio return.

b) stronger with $\bar{y}$ set at $10 than with $\bar{y}$ set at $80. For a given increase in σ_y, the lower the value of $\bar{y}$, the wider is the range of riskiness of land income implied by that increase in σ_y. Therefore, the strength of the investor's reaction to a change in σ_y is inversely related to the value of $\bar{y}$.

c) stronger when σ_k was 3% than when σ_k was 0%. The greater the riskiness of portfolio return, the more intense is the investor's reaction to a change in σ_y.

d) positive when ρ was set at -1 and negative when ρ was equal to 1. With a negative correlation coefficient, the ability of the addition of an acre of land to portfolio to reduce the

investor's risk exposure is positively related to the variability of land income. With a positive value for ρ, however, an increase in σ_y increases the investor's overall risk exposure with land added to portfolio. Thus, the change in bid price resulting from an increase in σ_y will be opposite in sign to ρ.

e) about the same regardless of whether the investor's net worth was $50,000 or $450,000.

f) unaffected by the tax rate.

g) stronger with a β of 0.1 than with a β of 0.9. The intensity of the investor's response to an increase in σ_y is positively related to his degree of risk aversion.

The differential impacts of the σ_y-iteration on bid price using the quadratic utility function were similar to, although less severe than the Cobb-Douglas case with the exception of the variables x, $\bar{k}$, and t. The increasing risk aversion over income property of the quadratic utility function accounts for the dissimilarity of the effects of $\bar{k}$ and x on the investor's reaction to an increase in σ_y using the Cobb-Douglas and quadratic utility functions. The effect of the σ_y-iteration on bid price using the quadratic function was more intense with t at 10% than with t at 90%. This tax effect also resulted from the fact that a higher after-tax income level results in a greater degree of risk aversion in the quadratic case.

Correlation coefficient

The impact of the correlation coefficient, ρ, on bid price was negative under all conditions unless either σ_k or σ_y was set equal to zero. When σ_k or σ_y was set equal to zero, a change in ρ had no effect on bid-price. The effects of the other variables and the utility functions on the strength of the relationship between ρ and bid price are analogous to their impacts on the relationship between σ_y and bid price discussed in the preceding subsection.

Investor's net worth

The impacts on bid price of the investor's net worth, x, were zero or positive but negligible when the Cobb-Douglas utility function was employed. Using the quadratic utility function, the effects on bid price of an increase in x were more varied. The impact on bid price of an increase in x from $50,000 to $450,000 using the quadratic utility function was:

a) positive $\bar{k}$ was 1%, $\bar{y}$ was $80, σ_k was 3%, σ_y was 0, and ρ was -1. All of these results indicate that x is positively related to bid price under conditions of a high relative riskiness of portfolio return. As x increases, the degree of risk aversion increases with the quadratic form of the utility function.

b) nonpositive when $\bar{k}$ was 11%, $\bar{y}$ was $10, σ_k was 0%, σ_y was $25, and ρ was 1. These cases all represent situations in which the addition of an acre of land to portfolio is likely to

increase the investor's risk exposure.

c) positive but minor given either the upper or lower values of

t and β'.

Marginal tax rate

As previously noted, the value of the investor's marginal income

tax rate, t, has no effect on bid price if the Cobb-Douglas utility

function is used. Using the quadratic utility function, the effects

of the other variables on the relationship between t and bid price

were opposite in sign to the corresponding effects on the relation-

ship between x and bid price discussed in the previous subsection. As

the investor's degree of risk aversion is directly related to x, it

is inversely related to t. Thus, as t was increased from 10% to

90%, the signs of the bid-price changes were the opposite of the

corresponding changes obtained by increasing x from \$50,000 to \$450,000.

The degree of risk aversion

The impacts on bid price of varying the β and β' parameters of the

Cobb-Douglas and quadratic utility functions respectively were similar

in sign to the corresponding impacts discovered when net worth was

increased using the quadratic utility function. Thus, the changes

in bid price that resulted from varying β from 0.9 to 0.1 and β' from

0.001 to 0.009 had the same signs as the corresponding changes in bid

price that resulted from increasing x from \$50,000 to \$450,000 in the

quadratic case. This finding is explained by the fact that an increase

in x with the quadratic utility function implies an increase in the

degree of risk aversion, and the β and β' parameters were varied in such a way as to indicate increasing risk aversion.

Summary

A numerical specification of the bid-price model was necessary to explore the relationships between the bid-price and the variables of the model. Various data sources were used in an attempt to describe as accurately as possible an actual land acquisition situation. The measures of the variability of portfolio return and land income, σ_k and σ_y respectively, estimated for this study probably understate the risks faced by an individual investor. Since σ_y was estimated from a time series of the Iowa average of per-acre net farm incomes, the variability of per-acre income encountered by individual farming units probably exceeds the estimate for σ_y. The estimate for σ_k was derived from the annual average of returns on all securities for each of the four components of the hypothetical portfolio. Since the return on each component in the portfolio is the average of returns on all similar securities in the United States for any year, the variability of the returns of the components of a portfolio held by an individual investor is likely to lead to a variability of portfolio return greater than the estimate for σ_k derived from national averages. Since one of the contributions of a bid-price model is to account for risk in the explanation of an investor's valuation of an asset, conservative estimates for σ_y and σ_k were appropriate in order not to overstate the case.

The impacts of the variables of the model on bid price were investigated. With the exception of expected portfolio return, $\bar{k}$, and expected land income, $\bar{y}$, the effect of each variable on bid price was found to depend primarily on (a) the form of the utility function and (b) the relative riskiness of land income and portfolio return. The variables $\bar{k}$ and $\bar{y}$ had strong impacts on bid price regardless of other considerations.

CHAPTER V. SUMMARY AND CONCLUSIONS

Future developments in the ownership structure of United States

farmland may have far reaching implications for both the farming

industry and rural society. Under the assumption that farm ownership

in the future is likely to be vested in those individuals or corpo-

rations who are currently willing to pay the highest price for farm-

land, a per-acre maximum bid-price model for farmland may serve as a

useful tool in addressing the future ownership question.

Past statistical studies have suggested the variables that in-

fluence farmland valuation. However, these studies have tended to

summarize the operation of entire markets rather than relating the

important variables to individual investor decisions. Research in-

vestigating the future firm-size structure of the farming industry

has identified factors that might provide differing incentives to

ownership to investors in various farm-size classes. The quanti-

tative development of such research has been limited, however, to com-

parisons of rates of return obtained by various farm-size classes.

Such comparisons of rates of return cannot be translated into

comparisons of the willingness to purchase land without considering

the ramifications of asset risk and investor risk aversion. Developers

of bid-price models have attempted an integration of the various factors

impinging upon land valuation, including asset risk and risk aversion,

into a comprehensive measure of the willingness to purchase farmland.

However, these bid-price models are limited in applicability and suffer

in the forms of their original specification.

A generalized maximum bid-price model was developed in this study. An investor's maximum bid for an acre of farmland was related to variables describing the land under consideration and the investor's initial situation. These variables are: expectation and variability of the rate of return on investor's original portfolio, expectation and variability of net per-acre farm income, the correlation between portfolio return and net land income, investor's net worth, investor's marginal income tax rate, and investor's degree of risk aversion. After constructing the maximum bid-price model, a comparative statics evaluation of the effects of the variables on bid price was pursued.

Since the comparative statics conclusions were rather ambiguous, a numerical specification of the model was provided to further explore the relationships between bid price and the variables of the model. The data collection for this numerical application was conducted in such a manner as to fairly accurately reflect an actual land acquisition situation in Iowa. However, since no estimated utility functions for Iowa farmers were found, two forms of the utility function of a large-scale California farmer were used. The results of the numerical specification suggest that, in addition to net per-acre farm income and rate of return on portfolio, the relative riskiness of these two returns and the form of the investor's utility function are the most important sources of bid-price variation.

This study was intended to provide a general exposition of the construction and characteristics of a bid-price model rather than an

application to a particular facet of the future ownership issue. However, the results of the numerical application of the model suggest an interesting hypothesis. An important source of bid-price variation was found to stem from the impact of the addition of land to the portfolio on the investor's risk exposure. The influence of a land purchase on risk exposure was found to be greater when the variabilities of land and portfolio returns differed, and when the correlation between these two returns was less than perfect. The results of this study therefore suggest that, other things being equal, investor's who hold a diversified portfolio are likely to enjoy a bidding advantage over investor's whose wealth is held largely in the form of farmland similar to that under consideration.

The applicability of the bid-price model developed in this study is perhaps limited because of the sensitivity of the bid-price solution to the form and parameters of the investor's utility function. For the model to be relevant to the consideration of a particular facet of the ownership issue, say the farm-size aspect, it would be necessary that either: (a) a single robust utility function could be estimated for all farm-size classes, or (b) a reliable utility function corresponding to each farm-size class could be obtained. Because of the current paucity of research that reports estimated utility functions, this question of the applicability of the bid-price model must remain at issue.

Results of the model indicate the importance of various areas of

economic research. In addition to the estimation of utility func-
tions, a respecification of the model to capture the sophistica-
tion of the financing of land purchases would be useful. The present
model requires the assumption that land purchases are financed by
the liquidation of a cross section of the investor's initial port-
folio. As such, the model is not directly applicable to investors
whose entire wealth is held in the form of farmland. The reformula-
tion of the model to allow the consideration of portfolio growth through
debt and equity issuance would obviate this problem.

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