AE90002 January 1990

OPTIMAL FARM FINANCIAL STRUCTURE INCLUDING LAND RENTAL

Bruce L. Dahl and David L. Watt

Presented at the
Southern Agricultural Economics Association
Annual Meeting, Little Rock, Arkansas
February 1990

Department of Agricultural Economics
North Dakota State University
Fargo, ND 58105

ABSTRACT

Two optimal control models were developed to examine optimum farm financial structure considering owning versus renting land, the attitude of the operator toward risk, and possible bankruptcy. A North Dakota cash grain operation was modeled under different real interest, asset appreciation, and inflation rates. Analysis of an environment of high inflation, asset appreciation, and returns with low real interest cost suggest a farm portfolio of owned land financed with debt and by renting owned land to other farmers. Negative or low inflation, asset appreciation and returns with high real interest cost suggest a no-debt portfolio dependant on rented land.

OPTIMAL FARM FINANCIAL STRUCTURE INCLUDING LAND RENTAL

Bruce L. Dahl and David L. Watt*

The financial crisis in agriculture has been a reoccurring theme. In the latest cycle, farmers in the boom times of the 1970's expanded debt because real interest rates were negative. Lenders were extremely liberal when financing investments, up to the point of promoting loan volume instead of loan quality (GAO 1987).

According to Hughes, Richardson and Rister (1985), farmers are more capital intensive in the 1980's because of the continuing increases in average farm size and capital requirements to own and/or operate a farm. Studies of the 1980's by Knutson, Richardson, and Jolly (1985); Hughes and Penson (1985); and Perry et al. (1985) suggest three main reasons for hardship in this period: macroeconomic policies, farm policies, and individual management decisions. Because macroeconomic variables impact the profitability and survivability of their enterprises, it is important for farmers to be more conscious of how to react to changes in macroeconomic variables.

This article describes a mathematical model of farm firm growth that examines optimal farm financial structure considering owning versus renting land under different inflation, asset appreciation, and real interest rates while considering risk. A study of optimum farm financial structure by Lowenberg-DeBoer and Boehlje considered rented land but did not consider the risk attitude of the operator in determining the optimum structure for a portfolio of farm assets. In our study, two formulations of returns were used to explore farm growth, penalizing farm income for financial risk or the possibility of bankruptcy and the operator's attitude toward risk under different inflation, asset appreciation, and real interest rates over a 50-year planning horizon.

Review of Literature

Modigliani and Miller (1958) extended traditional price theory to indicate the optimum level of investment was affected by risk. Thus, a method for ordering uncertain investment choices is required. Stochastic dominance orders choices by comparing the cumulative distribution functions of possible income from investments. If distributions for variances are normally distributed, then EV analysis is equivalent to second degree stochastic dominance.

In addition to uncertainty of returns in the analysis of farm growth, Modigliani and Miller (1958), Stiglitz (1974), and others have advanced the existence of an optimal debt strategy if the costs of leveraging a firm increase as the debt-equity ratio increases or if there is the possibility of bankruptcy. EV analysis has been used extensively to examine the effects of leverage on farm growth and optimum debt strategies in a static setting

*Dahl and Watt are research assistant and associate professor, respectively, at North Dakota State University, Fargo, ND 58105

(Barry, Baker, and Sanint (1981); Robison, Barry, and Burghardt (1987); Featherstone, Moss, Baker, and Preckel (1988)).

A theoretical approach to examining the effects of bankruptcy on optimal debt in a dynamic setting was developed by Collins (1985). He developed a farm growth model using control theory that incorporated the cost of possible bankruptcy by including a solvency premium in the discount rate. This further discounted income to reflect the possibility of bankruptcy and loss of future income because the farm was no longer in operation.

Watt and Larson (1987) estimated the probability of bankruptcy with a Monte Carlo simulation of an average North Dakota farm. This probability was found to be dependent on the real interest rate and the debt-equity ratio of the farm. From this analysis, solvency premiums were estimated. This premium is the probability of going out of business multiplied by the debt-equity ratio and represents the additional discounting of income to reflect the possibility of going out of business and the loss of future income.

Larson (1987) developed a modified Collins model to examine firm growth and determine the optimal leverage for a firm under various macroeconomic conditions and risk. This model incorporated EV analysis into a dynamic setting and used an infinite time horizon to allow analytical solution. The model developed examined the debt-equity structure of the farm and did not differentiate assets by class or risk.

Finally, treatment of unrealized asset appreciation has been a much debated issue over the last few decades. Lowenberg-Deboer (1986, p. 4) states "in the traditional methods of analyzing the individual purchase decision, capital gains have not been recognized until they are realized". Bhatia (1972, p.866) argued that in a world of perfect capital markets, unrealized capital gains would be a perfect substitute for current income. Plaxico and Kletke (1979) formalized this argument in their analysis, stating that only those gains viewed as permanent should be viewed as substitutes. In this paper, models are described which include asset appreciation as current income or as equity.

Held and Helmers (1981) examined the effects of asset appreciation by simulating a farm firm over a 15 year period. They found asset appreciation and increased income provide major incentives for producers to expand land purchases. As purchases of land became more levered, they found an increasing possibility of failure. They conclude that the choices of survival and farm growth must be balanced. This study did not consider the operator's attitude toward risk.

Lowenberg-DeBoer and Boehlje (1986) developed a modified Vickers model to examine the effects of farmland price changes on farm size and financial structure. They found that in an environment of large capital gains, farmers will tend to enlarge their farms and incur higher debt loads. Capital losses have the opposite effect. Also, government programs may have indirect impacts on farm size and debt use through their effect on capital gains. This model did not include the impact of inflation or differentiate risk in a form portfolio.

Model Development

The two models described in this study employ optimal control theory to more easily track and interpret the portfolio decisions of farm operators. Control theory has been widely used in the economics literature to analyze the growth of the corporate firm (Takayama 1985). Further, Zilberman (1982) has identified farm and production management as an area where dynamic control theory could significantly improve the quality of results. Finally, this method embodies all of the key consumption, production, savings, and intertemporal investment decisions of the firm.

Ockwell and Batterham (1982) defined their objective function for farm firm growth as the maximization of the present value of terminal net worth and the discounted value of consumption. They state that this is consistent with the theoretical basis advanced by Fisher and Hirshleifer. This study adopts the same general objective.

The performance function for this study is the maximization of discounted terminal net worth and consumption of risk adjusted farm income from a portfolio of farm assets. Consumption of farm income was defined as a family living draw equal to a basic allowance plus a percentage of farm income. EV portfolio theory was then introduced to reflect the attitude of the operator toward risk and to order risky choices in the farm asset portfolio. This technique approximates second degree stochastic dominance when distributions are normally distributed or the decision maker has a quadratic utility function (King and Robison 1984). It is reasonable to assume that annual returns to total assets in a specific farming operation are normally distributed. However, rent cost, interest cost, and real estate cost are non-negative by definition. Since variances of rent, interest, and real estate taxes are more than two standard deviations from zero, the effect of the truncated tail of the distribution is minor and the results closely approximate second degree stochastic dominance.

Risk Adjusted Farm Growth Model With Linear Returns

The first model (linear model) developed is the optimum risk adjusted farm growth model with linear returns. In this model, income is a function of the value of land farmed. Income for any time period of the farm is described below:

$$I(t) = Ra * (Lo(t)+Lr(t)) - Tx * Lo(t) - R * Lr(t) - r * D(t) - F \quad (1)$$

where

I(t) is income in time (t),
Ra is returns per dollar value of land farmed,
Lo(t) is the dollar value of land owned in time (t),
Lr(t) is the dollar value of land rented in time (t),
Tx is property taxes on land owned,
R is the cost of rented land,
r is the interest rate paid on debt,
D(t) is the capital account which is interpreted as debt when it is a positive value and signifies cash in the bank when negative, and
F is family living.

Variance of returns to equity due to increases or decreases in the value of returns, real estate taxes, rent, interest cost, and asset appreciation for this study is defined as:

$$S^2RE = s^2_{Ra} + s^2_{Tx} + s^2_{R} + s^2_{D} + s^2_{AA} - 2*s_{RaTx} - 2*s_{RaR} - 2*s_{RaD} - 2*s_{RaAA} - 2*s_{TxR} - 2*s_{TxD} - 2*s_{TxAA} - 2*s_{RD} - 2*s_{RAA} - 2*s_{DAA} \quad (2)$$

where

s^2_{Ra} is variance of returns to farm production assets,
s^2_{Tx} is variance of real estate taxes,
s^2_{R} is variance of rent cost,
s^2_{D} is variance of interest rate paid on debt,
s^2_{AA} is variance of asset appreciation,
s_{RaTx} is the covariance of returns and real estate taxes,
s_{RaR} is the covariance of returns and rent cost,
s_{RaD} is the covariance of returns and interest cost,
s_{RaAA} is the covariance of returns and asset appreciation,
s_{TxR} is the covariance of real estate taxes and rent cost,
s_{TxD} is the covariance of real estate taxes and interest cost,
s_{TxAA} is the covariance of real estate taxes and asset appreciation,
s_{RD} is the covariance of rent and interest cost,
s_{RAA} is the covariance of rent and asset appreciation, and
s_{DAA} is the covariance of interest cost and asset appreciation.

Income from equation (1) and variance of returns to equity, equation (2), were combined to form a portfolio of risk adjusted income. Further, a solvency premium (b) from Larson (1987) was adapted to account for the possibility of bankruptcy. The portfolio of farm income is then discounted both by the real rate of interest and a solvency premium to reflect the possibility of going out of business. The performance function for the risk adjusted farm growth model with linear returns is:

$$\text{MAX } J = \{ e^{-r*tf} * E(tf) + C * \int_0^{tf} e^{-(r+b)t} * I(t) - A * S^2RE \, dt \} \quad (3)$$

where

$I(t)$ is farm income in year t from equation 1,
S^2RE is variance of returns to equity from equation 2,
$E(tf)$ is equity at the final time period,
tf is the final time period,
r is the real rate of interest,
C is the marginal propensity to consume farm income,
b is the solvency premium, and
A is the absolute risk aversion coefficient.

State variables for the linear model are the amount of short term assets owned, land owned, land rented, and a capital account. Control variables are the amount of land purchased or sold and the change in the amount of land rented. In the linear model, the value of machinery and other short term assets (M(t)) is a constant proportion of the value of acres farmed. North Dakota farmers maintained a fairly constant ratio of non-land assets to value of land farmed for the years 1971-1988 (Agricultural Statistics). This ratio of one to three (33%) is used for the linear model.

Machinery depreciated in market value 17.9% per year on average for the years 1979-1987 (Agricultural Statistics). Projected savings from federal, North Dakota state, and social security taxes using the existing tax laws amounts to 7.6% of machinery owned per year. Analysis of the years 1979-1987 show that farmers in North Dakota held about 47.5% of short term assets in the form of machinery (Agricultural Statistics). Net depreciation on the proportion of machinery in short term assets is therefore 10.3% a year and is required to be replaced in that proportion. Income re-invested in the farm can be used to purchase assets, reduce debt, or increase the amount of cash in the bank. The amount of land owned and rented is controlled by the decision maker's decision to purchase or sell land and rent more or less acres.

The control problem then is to maximize (3) subject to:

$$\dot{M}(t) = .33U1(t) + .33U2(t) \tag{4}$$

$$\dot{Lo}(t) = U1(t) \tag{5}$$

$$\dot{Lr}(t) = U2(t) \tag{6}$$

$$\dot{D}(t) = 1.33U1(t) + 1.33U2(t) + Dep*M(t) - S* I(t) \tag{7}$$

$M^*(0)= M(0)$ $\quad$ $Lr^*(0) = Lr(0)$

$Lo^*(0) = Lo(0)$ $\quad$ $D^*(0) = D(0)$

$P1^*(tf) = e^{-r*tf}$ $\quad$ $P3^*(tf) = 0$

$P2^*(tf) = e^{-r*tf}$ $\quad$ $P4^*(tf) = -e^{-r*tf}$

where
U1(t) is the change in land owned,
U2(t) is the change in land rented,
S is the propensity to reinvest income in the farm,
Dep is depreciation of machinery in short term assets,
P1 is the costate for short term assets,
P2 is the costate for land owned,
P3 is the costate for land rented, and
P4 is the costate for debt or cash in the bank.

Risk Adjusted Farm Growth Model With Non-Linear Returns

The second model is the risk adjusted farm growth model with non-linear returns. Income is derived from machinery and other short term assets, and land farmed in factor proportions following Cobb-Douglas. A factor share ratio of one to three reflects traditional ownership in values of short term assets (machinery etc.) and land farmed. Income for any time period of the farm is described below:

$$I(t)' = Ra*M(t)^{.25}(Lo(t)+Lr(t))^{.75} - Tx * Lo(t) - R * Lr(t) - r * D(t) - F \tag{12}$$

This model also uses the same solvency premium and definition of variance of returns to equity as the linear model. State variables are again the value of land owned, land rented, short term assets, and a capital account. Control variables are the amount of short term assets purchased or sold, land purchased or sold, and change in land rented. The performance function for this non-linear model is:

$$\text{Max } J = \{e^{-r*tf} * E(tf) + C * \int_0^{tf} e^{-(r+b)t} * I(t)' - A * S^2RE \, dt\} \quad (13)$$

subject to:

$$\dot{M}(t) = U1(t) - dep * M(t) \quad (14)$$

$$\dot{Lo}(t) = U2(t) \quad (15)$$

$$\dot{Lr}(t) = U3(t) \quad (16)$$

$$\dot{D}(t) = U1(t) + U2(t) + U3(t) - S * I(t)' \quad (17)$$

$M^*(to) = M_o$ $\quad$ $Lr^*(to) = Lr_o$

$Lo^*(to) = Lo_o$ $\quad$ $D^*(to) = D_o$

$P1^*(tf) = e^{-r(tf)}$ $\quad$ $P3^*(tf) = 0$

$P2^*(tf) = e^{-r(tf)}$ $\quad$ $P4^*(tf) = -e^{-r(tf)}$

where
U1 is the change in short term assets,
U2 is the change in land owned, and
U3 is the change in land rented.

The models were solved numerically using the method of Steepest Decent (Kirk 1970).

The data obtained for solution of both models are the financial and macroeconomic conditions for a representative North Dakota grain farmer (Tables 1-2). Total market value of farm assets and total farm debt were obtained from Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1977-1987. The GNP Implicit Price Deflator series was obtained from the Report of the Council of Economic Advisors to the President 1989. Real asset appreciation values were calculated for the years 1980 to 1986 and entered into an analysis for farm level variance and covariance. Individual farm data were obtained from Rourke (1988).

Mean values for farm level variance and covariance for returns, real estate taxes, rent, interest rates, and asset appreciation were calculated by taking the mean of 31 individual farm level variance and covariance matrices for the years 1980-1986. Mean values of covariances were not significantly different from zero. Mean values for covariance of returns-taxes, returns-rent, rent-interest rate, and rent-asset appreciation were significant at the 80 percent level. Mean values of covariances were retained so that information would not be lost.

Real family living expense averaged between $21,000 and $22,000 in 1982 dollars for the years 1978 - 1988. A target real family living expense of $22,000 was adopted. The marginal propensity to re-invest income in the farm was assumed to be 85 percent. The marginal propensity to consume farm income is assumed to be the remaining 15 percent of farm income and is available for family living expense in addition to the target family living expense.

The asset structure for the representative farm is listed in Table 3.

Results

In the risk adjusted farm growth model with linear returns, asset appreciation is treated as a substitute for income and is contained in returns. Figure 1. shows the solution for an environment of low inflation, asset appreciation, and high real interest cost. Maximum utility of income and terminal net worth occurs by holding little debt and renting land early, then taking on more debt and buying more land later. Land is sold early to reduce the debt-equity position and provide the strength to grow larger later. Debt use is low as land rented dominates the amount of land farmed. As more land is purchased and the farm grows in size, debt use increases. As this farmer approaches retirement, debt is paid off; and a positive cash balance accumulates.

Two variations of the risk adjusted farm growth model with non-linear returns were developed. The first treated asset appreciation as a part of returns. The second variation of the model assumes asset appreciation affects only the state values of short term assets and land owned. Asset appreciation is considered equity and can not be spent unless the asset is sold. Short term assets are able to be bought or sold as a separate decision from purchasing land or renting land.

The solution for the non-linear model with asset appreciation in returns is shown in Figure 2. This model was also examined in the same environment of low inflation, asset appreciation, and high real interest cost. Optimum utility is achieved by allowing the value of land investment to fluctuate slightly till year 10, then purchasing land in successive years to retirement. Debt use, measured as debt-equity ratio, averages .35 for the first 30 years of the planning horizon. The amount of debt increases till year 25, then is paid off and a cash surplus accumulates as the farmer approaches retirement. Land rented follows the same basic pattern as the linear model, but at a slightly higher level. Machinery and short term assets have an initial sell-off to adjust to the optimum amount of short term assets. It then increases until year 40. As the farmer nears retirement, short term assets decline. This may imply that the farmer allows machinery to depreciate near retirement. In this model, the farmer buys more land, retains a higher level of debt till debt is paid off, rents marginally more land, and depends less on short term assets as a percent of farm assets.

The solution for the risk adjusted model with non-linear returns with asset appreciation considered as equity is shown in Figure 3. Again, examined in the same environment, the optimum utility from consumption of income and terminal net worth is achieved by maintaining the value of land investment at about the initial value till year 10, then land is purchased in each year. The value of land owned increases, both from purchases and asset appreciation. Rented land comprises more than 50% of the land farmed until year 24 when owned land becomes dominant. The value of land is higher than the other non-linear model and again, rented land declines and moderates as the operator approaches retirement. The value of short term assets held increases until year 43 and then declines until retirement. This again suggests that it may be optimal for the farm operator to allow his machinery to depreciate in the last few years as he approaches retirement. Debt use increases the first four years, then debt is paid off. This farmer carries little or no debt for the years 10 to 27. Cash in the bank starts accumulating after year 27. The farmer retires with $4,959,534 in the bank. This farmer also generates earnings through renting land and relies more on savings and less on debt to finance the purchase of land.

Comparison of the two forms of asset appreciation in the model with non-linear returns shows that when unrealized capital gains are considered income, there is more dependance on owned land and the use of debt. The treatment of asset appreciation as income results in a farmer borrowing heavily against unrealized capital gains. When farmers consider unrealized capital gains as income and rely more on owned land and debt, if conditions change, farmers, their loans, and the farming community become more susceptible to insolvency due to large losses of equity. Thus a farm policy that encourages land ownership and higher debt loads with land ownership as the goal, then protection from declines in asset values and foreclosures should be considered.

A sensitivity analysis was performed on variables in the non-linear model with asset appreciation considered a substitute for equity. This analysis shows higher levels of returns, higher inflation and asset appreciation, and lower real interest cost each influence the farm operator to structure his farm with owned land financed by debt. These effects together magnify the result and influence the farmer to purchase land, finance it with debt, and rent to other operators. This scenario is appropriate for the late 1970's. Lower returns, lower or negative inflation and asset appreciation, and higher real interest cost each influence the farm operator to move toward a portfolio of all rented land and that uses no debt. Again these factors collectively magnify the effect. This scenario suggests that the farmers in trouble in the 1980's could have been rationally responding to the macroeconomic environment of the 70's and 1) did not realize the environment had changed, or 2) were caught by changing conditions and unable to respond. It also suggests that inflation and asset appreciation are negatively correlated to land ownership by outside investors.

Summary

Two forms of a general farm growth model were developed to examine optimal farm structure while considering rented or owned land, the possibility of bankruptcy, and the operator's attitude toward risk. These models suggest two things. First, in the current environment of high real interest cost, low inflation, and asset appreciation, farmers, depending on their own risk attitude and initial conditions, should concentrate on renting land and strive to keep debt use low, and land purchases should be limited to when purchases can be financed out of retained earnings. Second, if more of unrealized capital gains are treated as income, farmers will respond by increasing farm size and incurring debt. Further, use of different values for the operator's attitude toward risk in these farm growth models provides a possible explanation why two farmers with the same opportunities will obtain different farm size and structure over time.

Further empirical study needs to be done to elicit risk attitudes and to determine if there are changes with increases in the age and wealth of the farmer or if the changes in objectives of the farm operator suggests the appearance of the change in risk attitude.

TABLE 1. EXPECTED FINANCE AND RISK VARIABLES FOR THE REPRESENTATIVE NORTH DAKOTA GRAIN FARM WITH LINEAR RETURNS

Item	Value
Rate of Return	0.1466
Variance	0.02043084
Standard Deviation	0.14293649
Annual Appreciation in Farm Asset Values[a]	0.0157
Variance	0.00305349
Expected Inflation Rate[b]	0.0370
Interest Rate	
Combined 75% Long 25% Short	0.12097333
Variance	0.00001556
Standard Deviation	0.00394462
Solvency Premium[c]	0.025803
Real Estate Taxes Per Dollar Land Value	0.00441465
Variance	0.00002042
Land Rental Rate Per Dollar Land Value	0.06284690
Variance	0.00043955
Family Target Consumption	$22,000
Risk Aversion Coefficient	0.0000007
Marginal Propensity To Reinvest Farm Income	0.85
Covariance	
Returns - Real Estate Taxes	0.00015019
Returns - Rent	0.00099996
Returns - Interest Rate	-0.00002295
Returns - Asset Appreciation	0.00056175
Real Estate Taxes - Rent	0.00003921
Real Estate Taxes - Interest Rate	0.00000024
Real Estate Taxes - Asset Appreciation	-0.00000348
Rent - Interest Rate	-0.00000617
Rent - Asset Appreciation	-0.00015467
Interest Rate - Asset Appreciation	0.00001689

[a]Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1977-1987.
[b]Council of Economic Advisors to the President 1989.
[c]Larson and Watt.

SOURCE: Individual farm data from Rourke (1988).

TABLE 2. EXPECTED FINANCE AND RISK VARIABLES FOR THE REPRESENTATIVE NORTH DAKOTA GRAIN FARM WITH NON-LINEAR RETURNS

Item	Value
Rate of Return	0.195
Variance	0.05554620
Standard Deviation	0.23568241
Annual Appreciation in Farm Asset Values[a]	0.0157
Variance	0.00305349
Expected Inflation Rate[b]	0.0370
Interest Rate	
Combined 75% Long 25% Short	0.12097333
Variance	0.00001556
Standard Deviation	0.00394462
Solvency Premium[c]	0.025803
Real Estate Taxes Per Dollar Land Value	0.00441465
Variance	0.00002042
Land Rental Rate Per Dollar Land Value	0.06284690
Variance	0.00043955
Family Target Consumption	$22,000
Risk Aversion Coefficient	0.0000007
Marginal Propensity To Reinvest Farm Income	0.85
Covariance	
Returns - Real Estate Taxes	0.00024764
Returns - Rent	0.00164879
Returns - Interest Rate	-0.00003784
Returns - Asset Appreciation	0.00092625
Real Estate Taxes - Rent	0.00003921
Real Estate Taxes - Interest Rate	0.00000024
Real Estate Taxes - Asset Appreciation	-0.00000348
Rent - Interest Rate	-0.00000617
Rent - Asset Appreciation	-0.00015467
Interest Rate - Asset Appreciation	0.00001689

[a]Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, 1977-1987.
[b]Council of Economic Advisors to the President 1989.
[c]Larson and Watt.

SOURCE: Individual farm data from Rourke (1988).

TABLE 3. BALANCE SHEET FOR REPRESENTATIVE NORTH DAKOTA FARM

Item	Value[a]
Assets	
Land Owned	$293,619
Machinery and Other Short Term Assets	$125,836
Total Assets	$419,455
Liabilities	
Long Term Debt	$ 82,530
Short and Intermediate Debt	$ 27,510
Total Liabilities	$110,040
Operators Net Worth	$309,415
Financial Ratios	
Debt-Asset Ratio	.26
Debt-Equity Ratio	.36

[a]In 1986 dollars, based on 1978-1988 data

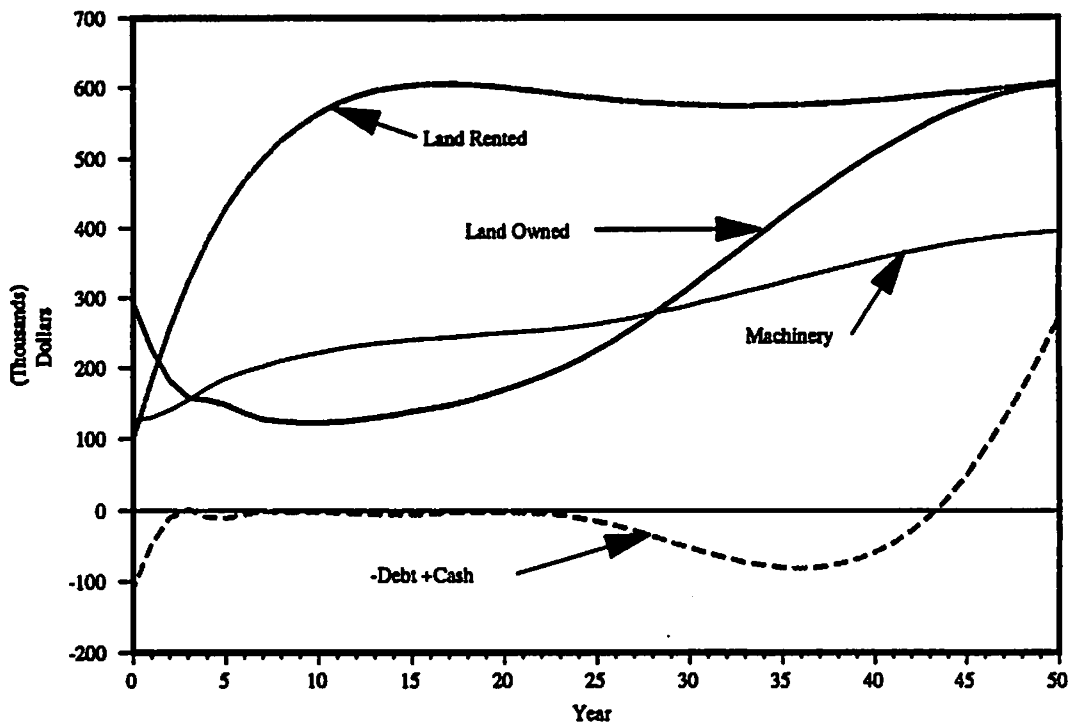

Figure 1. Optimum Timepath for Risk-Adjusted Farm Growth Model With Linear Returns.

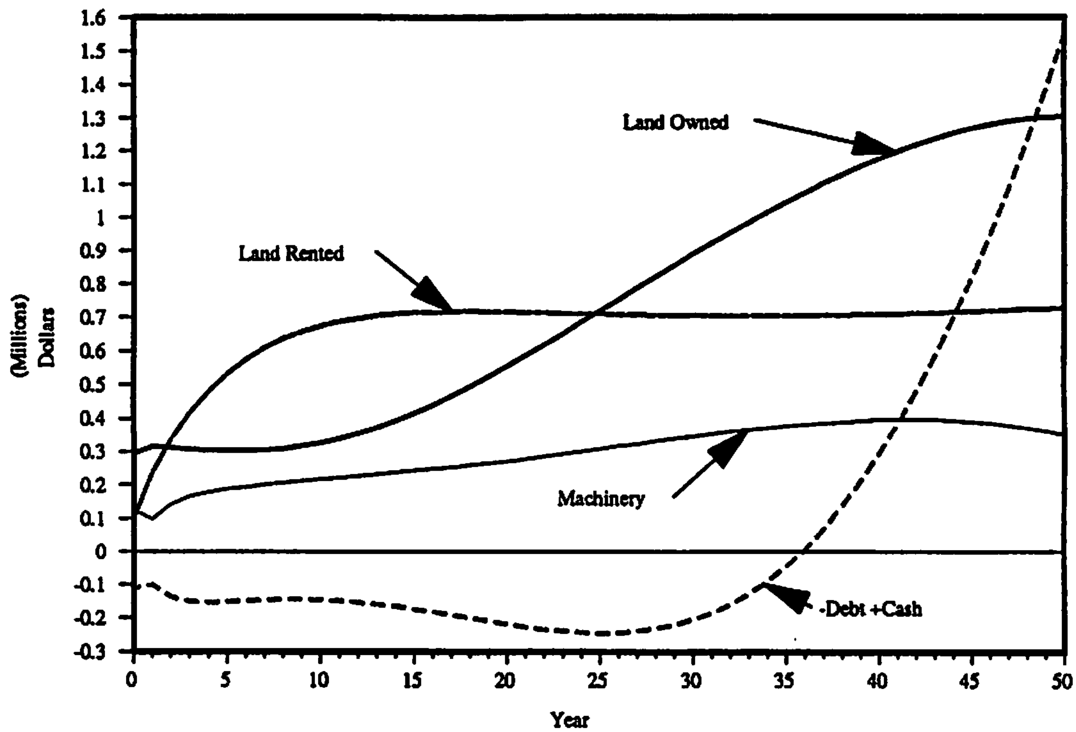

Figure 2. Optimum Timepath For Risk-Adjusted Farm Growth Model With Non-Linear Returns - Asset Appreciation as Income.

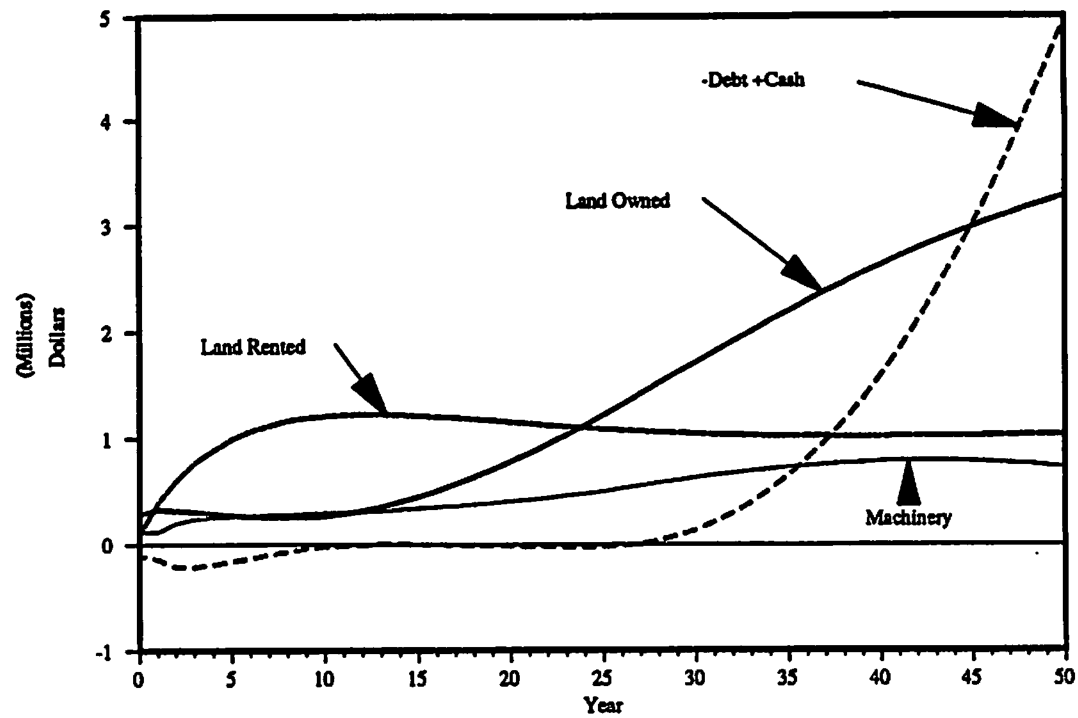

Figure 3. Optimum Timepath for Risk-Adjusted Farm Growth Model With Non-Linear Returns - Asset Appreciation as Equity.

References

Barry, Peter J., C. B. Baker, and Luis R. Sanint, "Farmers' Credit Risks and Liquidity Management. "American Journal of Agricultural Economics, 62:2, May 1981, pp. 217-227.

Bhatia, Kul. "Capital Gains and the Aggregate Consumption Function." American Economic Review. 62:5, December 1972, pp. 866-79.

Collins, Robert A., "A Dynamic Model of the Debt-Equity Structure of a Proprietary Firm," Risk Analysis for Agricultural Production Firms: Concepts, Information Requirements and Policy Issues, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, Staff Paper 85-85, November 1985, pp. 284.

Council of Economic Advisors to the President. "Economic Report of the President." U.S. Government Printing Office, 1989.

Featherstone, Allen M., Charles B. Moss, Timothy G. Baker and Paul V. Preckel. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Losses." American Journal of Agricultural Economics. 70:3, August 1988, pp. 572-579.

General Accounting Office. Farm Credit - Actions Needed on Major Management Issues. April 1987. GAO/GGD-87-51.

Held, Larry J. and Glenn A. Helmers. "Growth and Survival in Wheat Farming: the Impact of Land Expansion and Borrowing Constraints". Western Journal of Agricultural Economics. Vol. 3, No.2, December 1981, pp. 207-216.

Hughes, D. W. and J. B. Penson, Jr. "Effects of Selected Macroeconomic Policies on Agriculture: 1984-1990." Agricultural Finance Review. 45, 1985, pp. 81-91.

Hughes, D. W., J. W. Richardson, and M. E. Rister. "Effects of Sustained Financial Stress on the Financial Structure and Performance of the Farm Sector." American Journal of Agricultural Economics. 67:5, December 1985, pp. 1116-1122.

King, Robert P. and Lindon J. Robison. "Risk Efficiency Models," Risk Management in Agriculture, Peter J. Barry Editor, Iowa State University Press, Ames, Iowa, 1984, pp. 69-81.

Kirk, Donald E. Optimal Control Theory: An Introduction. Prentice Hall, Inc. Englewood Cliffs, New Jersey. 1970. pp. 452.

Knutson, R. D., J. W. Richardson, and B. Jolly. Price and Income Policies. Mimeographed. College Station TX: Department of Agricultural Economics, Texas A&M University, 1985.

Larson, James A. "Optimal Farm Financial Structure Considering Risk and Macroeconomic Variables." unpublished M.S. thesis, North Dakota State University, June 1987.

Lowenberg-Deboer, J. The Micro-Economic Roots of the Farm Crisis. Praeger Press, New York, N.Y. 1986.

Lowenberg-DeBoer, J. and Michael Boehlje. "The Impact of Farmland Price Changes on Farm Size and Financial Structure". American Journal of Agricultural Economics. Vol. 68:4, November 1986, pp. 838-848.

Modigliani, Franco and Merton H. Miller. "The Cost of Capital, Corporation Finance and the Theory of Investment." American Economic Review. 48:3, June 1958, pp. 261-297.

Ockwell, A. P. and R. L. Batterham. "The Influence of Credit on Farm Growth." Review of Marketing and Agricultural Economics. 50:3, December, 1982. pp 247-264.

Perry, G. M., M. E. Rister, J. W. Richardson, and D. J. Leatham. "The Effects of Equity Position, Credit Policy, and Capital Gains on Farm Survival." Agricultural Finance Review. 45, 1985, pp. 58-71.

Plaxico, James and Darrel Kletke. "The Value of Unrealized Farm Land Capital Gains." American Journal of Agricultural Economics. 61:2, May 1979, pp. 327-330.

Robison, Lindon J., Peter J. Barry, and William Burghardt. "Borrowing Behavior under Financial Stress by the Proprietary Firm: A Theoretical Analysis." Western Journal Of Agricultural Economics. 12:2, December, 1987, pp. 144-151.

Rourke, Gary. "Capital Structure and Financial Management Practices of North Dakota Farmers." Unpublished Masters thesis, North Dakota State University, Fargo, 1988.

Stiglitz, Joseph E. "On the Irrelevance of Corporate Financial Policy." American Economic Review. 64:6, December 1974, pp. 851-866.

Takayama, Akira. Mathematical Economics. Cambridge University Press. New York, New York. 1985. pp. 737.

U.S. Department of Agriculture; Economic Research Service. Agricultural Statistics, Various Issues. U.S. Government Printing Office.

U.S. Department of Agriculture; Economic Research Service, Economic Indicators of the Farm Sector: State Income and Balance Sheet Statistics, issues 1977-1987. Agricultural Information Bulletin, U.S Government Printing Office, Washington.

Watt, David L. and James A. Larson. "Behavioral Responses of Farmers to Risk". Selected Paper, American Agricultural Economics Association. Annual Meeting. 1987.

Zilberman, David. "The Use and Potential Of Optimal Control Models in Agricultural Economics." Western Journal of Agricultural Economics. 7:2, December 1982, pp. 395-406.

OPTIMAL.SS
DLW:mmu/JAN90